New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION

Situational Interest in Medical Contexts for Chemistry Education: Construction of a Survey Instrument

Elisabeth Dietel[1,2], Timm Wilke[2]

Friedrich-Schiller-Universität Jena,
Institute for Inorganic and Analytical Chemistry,
Chemistry Education Department,
Germany[1]

Carl von Ossietzky Universität Oldenburg,
Institute for Chemistry,
Chemistry Education Department,
Germany[2]

Abstract

Interest is an important asset for students' learning success and achievement. Even though teachers mostly cannot influence their students' individual interests, they can use interesting topics to stimulate situational interest in learning situations as a first step of interest genesis [1]. Creating contexts is one promising way to enhance personal relevance and everyday relations as triggers for situational interest. Using insights from different interest studies [2,3], medicine could represent a unique intersection of topics that seem interesting for young people of all gender. Besides their interestingness, medical aspects offer great overlaps with important curriculum contents in chemistry education. Despite the long-known potential of medicine as an interesting topic, it has only punctually been pursued further for usage in chemistry lessons away from few university level courses.
In this article, we present the process to narrow down the rather broad topic of "medicine" for chemistry education to create special medical contexts appropriate for different school levels, namely "breaking and healing bones", "blood circulation" and "wound dressings and closure". Further, we address the above-mentioned research gap by constructing a survey instrument for measuring situational interest in selected medical aspects that are directly connected with curriculum contents. All three contexts are joint together as the bigger theme "injury, blood and wounds". For measuring students' interest structures, we designed an online questionnaire based on studies concerning the interestingness of learning contexts in chemistry education [4] and consisting of three different parts: (1) analyzing individual interest in chemistry, (2) introducing students to our medical contexts using self-made videos, and (3) measuring the interestingness and the familiarity of the presented context as well as analyzing potential interest in learning using these contexts. Having analyzed the data from the pilot study of our questionnaire, we draw first conclusions on how interesting our contexts are for students and how to optimize the instrument for the main survey.

Keywords: *medicine, situational interest, context-based learning, situated expectancy-value theory*

1. Introduction

Whether it is concerning the structure and function of our body, its injuries or how it is healed and maintained healthy – medical topics are highly relevant to the daily lives of students. Several studies have already shown that medicine is an interesting subject area for all genders [2,3]. It has been well established that interest positively influences various factors of learning, e.g. motivation, involvement, attention, and performance [5]. According to the Situated Expectancy-Value Theory (SEVT) by Eccles et al. [6], the interestingness, usefulness, and relevance of tasks predict performance-related behaviour. Unfortunately, however, subjects such as chemistry and physics are often considered abstract, dry and useless by students [7], which contributes - even more than in other subjects - to a loss of interest over time at school, especially among girls. Medicine therefore opens a wide range of opportunities to design gender-equitable and interesting learning environments. One of the origins for the rather negative perception of chemistry may be an unfavourable choice of contexts in which the learning content is taught, especially if students gain the impression that the learning content is barely relevant for their personal lives [8]. Even if medicine and chemistry appear to be clearly separate subject areas at first glance, most medical backgrounds can be seen as the interplay of complex biochemical reactions and physical phenomena. At the same time, there are connections to other

important areas of research such as technology or pharmaceutics. The project presented is therefore dedicated to the question of how a promising field such as medicine, which is universally perceived as interesting and relevant, can be transformed into contexts for chemistry lessons. We do not only aim to examine approaches for the design of three specific medical contexts, but also explain how we plan to construct a survey instrument for measuring the situational interest in the contexts.

2. Theoretical Background

Fields of interest differentiate during adolescence as a normal development away from universal childhood curiosity towards individual dispositions which is accompanied by a general average decline in interest in individual school subjects, as most subjects no longer meet the individualized wishes of students [9]. However, the decline in interest in the natural sciences of chemistry and physics is particularly severe, especially among girls [7]. This is a problem that needs to be addressed regarding the declining number of first-year students in Science, Technology, Engineering, and Mathematics (STEM) and the lack of women in scientific research [10]. It is not possible for school education to directly influence individual interests. According to the model of Hidi et al. (see Fig. 1), the development of interest begins with the awakening of situational interest, which is ideally retained and can possibly eventually develop into a permanent disposition [1]. But even without full internalization, situational interest is of particular importance for learning, as it has a positive effect on motivation, attention, involvement, and ultimately also performance by increasing the subjective task value (STV) [5,6].

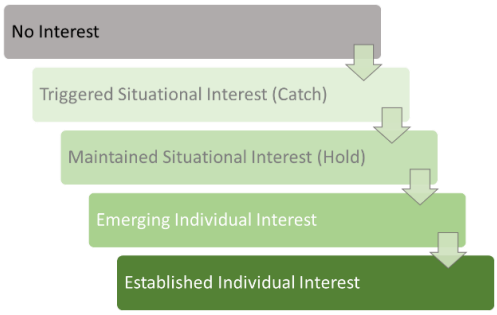

Fig. 1. Four-Phase Model of Interest Development [1].

Interest itself can be considered regarding different conceptualizations and theories. Fig. 2 illustrates the most important theories and relations used for this framework. Emphasizing the educational-psychological approach and therefore the Person-Object-Theory of Interest, both the stable tendency to interact with an object and a current activity can contribute to the psychological state of being interested in something [11]. Interest is divided into emotional-related and value-related valences [12]. The value-related component plays a key role in designing learning environments, as interest and STV are predictive for achievement-related behaviour within the SEVT [6]. Accordingly, it is particularly advantageous to design learning environments with the potential to trigger situational interest, and to emphasize the relevance of the learning contents [13,14].

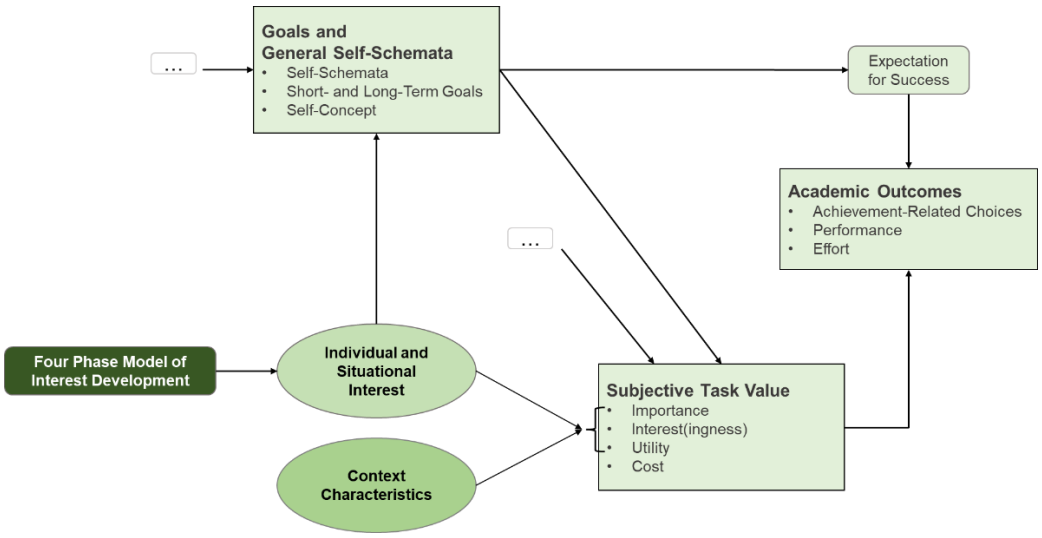

Fig. 2. Theoretical Framework [1,4,6].

One way of constructing relevant and authentic lesson contents is to use contexts. The effects of appropriate contexts have already been investigated for German chemistry lessons. It can be stated that context-based materials, when used correctly, can positively influence the learning process, especially when contexts are perceived as authentic and relevant, and when contexts contain everyday problems for pupils with little individual interest. For pupils with a higher level of individual interest, special contexts proved to be more conducive to learning. [4]
Within this theoretical framework, the question therefore arises as to how exactly suitable contexts can be selected and designed to trigger situational interest and increase the STV. Interest studies report that areas of interest differ significantly between genders and age groups. One of the few subject areas that emerge from all study results as equally interesting for all target groups is medicine. [2,3]
Not only do medical topics possess the ability to arouse interest, using medicine as a context also includes the opportunity to put career-related gender stereotypes into perspective. Even if the number of women studying STEM subjects slowly increases, health care professions still are on top of the list of typical female careers, while technical professions are considered male career domains [15]. Clarifying connections of medical areas to physical and technological topics such as radiation, diagnostic imaging, surgical technology, and orthotics can either help drawing the interest of boys away from stereotypical technology professions towards the field of medicine or promoting girls' interest in technology and natural sciences beyond biological subjects. Especially using the aspect of danger could be promising to enhance boys' interest in medical contexts [3]. Thus, medicine could in more than one way be beneficial for interesting, gender-equitable teaching and should be examined further regarding context-based learning. However, the studies in question do not specify which medical content is considered interesting. Above all, there is a lack of studies on the possible use of these findings in the classroom.

3. Research Questions

Previous research has shown that contextualized learning materials with interesting topics can have beneficial effects on learning and performance if students realize the personal relevance of the context and a high value of the task. Since medicine as a "universally" interesting subject area offers a promising opportunity to create contexts with interdisciplinary relations but specified medical contexts are yet to be considered a research gap, the following research questions arise:

1. Which contexts with a medical background can be designed for chemistry lessons?
2. How can a survey instrument for measuring the interestingness of medical contexts be constructed?

4. Research Design and Methods

The following section presents an approach to narrow down the wide range of interfaces between medicine and chemistry considering advice from experts. According to the Model of Educational Transfer Research [16], interlocking scientific research and didactic expertise results in a student-friendly reconstruction of different medical phenomena and facts. As depicted in Fig. 3, the

methodological approach of the project does not only include Educational Transfer Research and Didactic Reconstruction, but also takes aspects of Design Based Research [17] into account by including survey results regarding the interestingness of different contexts into the next circle of optimization.

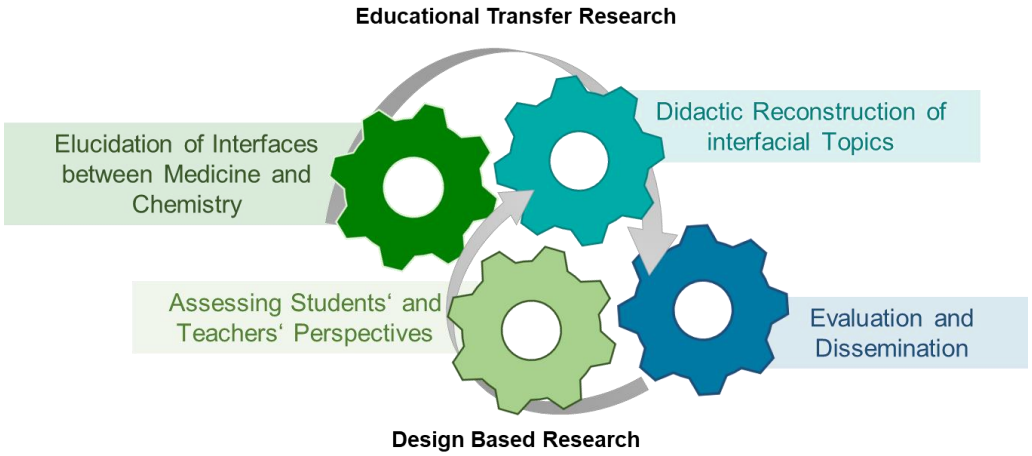

Fig. 3. Methodological Framework [16,17].

4.1 Choosing Interfaces between Chemistry and Medicine and Constructing Contexts

New topics for educational settings must meet requirements such as a connection to the respective subject curriculum, teachability and reducible complexity, few seductive details that require too much background knowledge, and relevance to the everyday lives of students. For chemistry lessons in particular, topics must also be suitable for the integration of experiments.

To crystallize which overlaps between medicine and chemistry are suitable contexts in chemistry lessons, interfaces were first collected. For this purpose, experts working at the Faculty of Chemistry and the University Hospital of the Friedrich-Schiller-University Jena were interviewed. The resulting answers were grouped thematically in such a way that they belong together in terms of chemical content. Isolated topics to which at least five medical aspects could not be assigned were excluded.

The topics filtered by grade level were then presented to a group of ten teachers who are responsible for developing the chemistry curriculum in Thuringia, Germany. The experts were asked to list subject content that could be taught in the classroom using the medical topic. They were also asked to indicate which core concepts and competencies could be developed using this topic. A six-point Likert scale was used to assess the appropriateness, exemplarity, and relevance to everyday life of each medical topic. Finally, an evaluation should be made regarding the medical topic’s general suitability for chemistry lessons.

After deriving three specified medical topics from the assessment of the teachers’ expert group, one topic each was assigned to one grade level, which means levels 7/8 (beginning lessons, initial experiences in chemistry), 9/10 (lower secondary level, covering all core chemistry contents) and 11/12 (upper secondary level, advanced and deepened content, graduation preparation). Respective topics from the curriculum were identified and each medical area was put together as a storyline for a learning context, including ideas for experiments that link chemical and medical contents.

4.2 Assessment of Situational Interest

Because of the close relation and correlation of individual and situational interest regarding the theoretical framework of the psychological construct of interest, individual interest in chemistry and chemistry-related self-concept are as well constructs to be measured. Items for assessing these were implemented based on the Program for International Student Assessment (PISA) [18]. Referring to the rather limited research concerned with context-based learning especially in chemistry education, a number of items for surveying situational interest was derived from the work of Habig et al. [4], but was adapted with major changes to match the medical topics.

Table 1. Structure of the questionnaire.

Part 1.1	Part 1.2	Context presentation	Part 2
gender, grade level, career interests	individual interest	pre-recorded video	interestingness, familiarity

Aiming for surveying situational interest after a short presentation of each context without influencing or biasing the answers to the items for individual items, the questionnaire was subdivided in three different parts as Table 1 shows. In a first part, socio-demographic data like age, gender, career interests in medical or chemical fields, and grade level were collected. Additional to that, individual interest and chemistry-related self-concept were measured in this part. After that, a short video was embedded for each context. The video was assembled as a PowerPoint presentation in which photos, formula, and chemical equations were shown to link medical and chemical aspects of the contexts. The presentations were backed with audio. The videos were between three and four minutes long. Using filtering questions, every participant was only shown the video fitting their grade level. In a third part of the questionnaire, both items for measuring the interestingness of the context presentations and assessing the familiarity of the medical topics were implemented. The questionnaire was presented via SoSci Survey.

5. Results and Discussion

5.1 Choosing Interfaces between Chemistry and Medicine and constructing Contexts

The 62 answers of 35 professional experts were grouped thematically and categorized into five major themes after excluding isolated answers. Sorting the results was complicated by answers from fields of narrow medical specialization. Some unique answers are depicted in Table 2.

Table 2. Examples of excluded isolated interfaces.

Medical phenomenon	Chemical background
neurodegenerative disease	protein folding
biodistribution of nanoparticles	surface charge
targeted drug delivery	chemical interaction on a receptor surface

It emerges from this selection of answers that experts seem to have thought about rather outstanding phenomena from their own professional field showing the extremely wide range of the general area “medicine”. These difficulties entail the necessity to use the answers clustered into five major themes as an inspiration to expand them to include more everyday medical phenomena. As shown in Table 3, the expanded major themes can be connected to different fields of the chemical curriculum.

Table 3. Five major themes for potential medical contexts presented to the teacher group.

Major Medical Theme	Chemical Curriculum Content
Blood and Respiration Circulation	air consistency, oxygen-transport proteins (haemoglobin), carbon monoxide and carbon dioxide, carbonate chemistry, blood buffer, blood analysis
Healthy Nutrition	carbohydrates, proteins, fats, minerals, ionic substances, toxins
Digestion	pH value, acids, bases, acidic or alkaline cleavage of chemical bonds (hydrolysis), enzymes
Pharmaceuticals	structure and reactions of organic molecules (natural and synthetic drugs), steroids, nanomedicine in drug delivery
Injuries, Surgery and Wound Dressings	chemical structure of pain killers (e.g. ASS), narcotics, polymer chemistry

Regarding the federal structure of the German educational system, it must be considered that the Thuringian curriculum used here is to be seen as an example [19]. Other federal states differ slightly in their chemical curriculum, but superordinate topics stay the same for all curricula.
It appears that considering the evaluation of the teacher group, scientific competence (scientific knowledge) and assessment competence are the most assigned competences for all five themes.

Scientific knowledge-gaining and scientific communication are mentioned occasionally. Concerning the three core concepts from central German educational standards [20], all themes are estimated to support the core concept „structure and characteristics of substances and particles“ as well as some aspects of the core concept „chemical reaction“. The core concept “energetics” is only mentioned once. Highly mentioned contents are “ionic substances” (grade levels 7/8), “pH-value, acids and bases, buffers” (grade levels 9/10), “carbon monoxide and carbon dioxide” (grade levels 9/10), “complexes” (grade levels 11/12), and “polymers” (grade levels 11/12). Therefore, it seems that all five themes show the potential to integrate adequate elements of high-quality, competence-oriented chemistry lessons. To conclude which themes are the most promising for constructing learning contexts, the overall assessments (see Fig.) 4 of appropriateness, exemplarity, relevance, and total evaluation are considered as well.

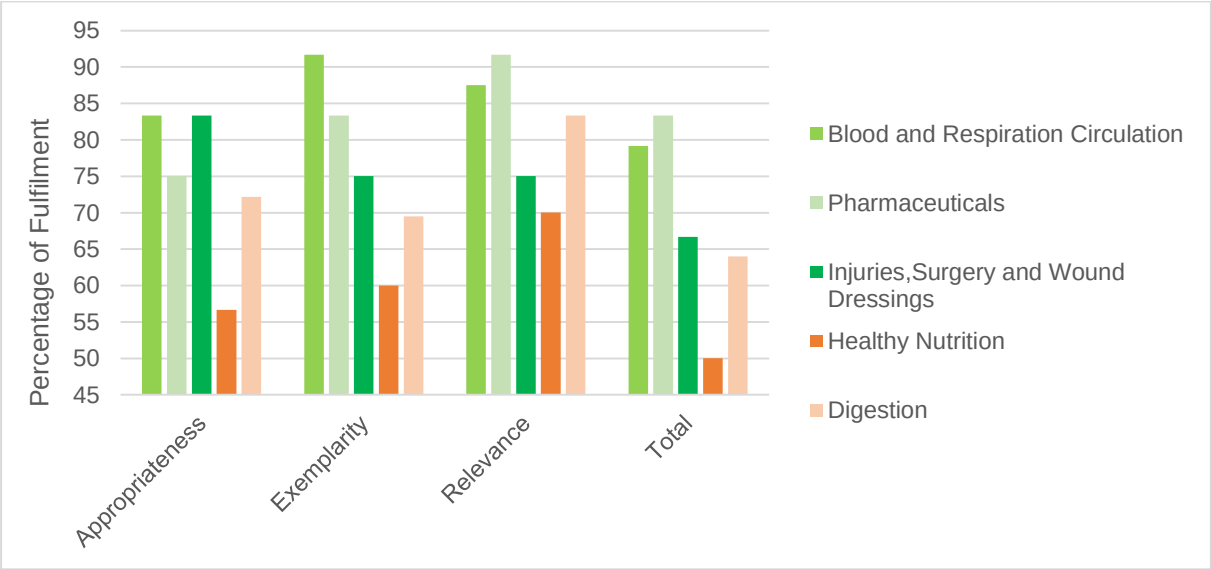

Fig. 4. Context ratings of the teachers.

The major themes “blood”, “pharmaceuticals”, and “surgery” are rated highest and therefore could be used to construct differentiated contexts. The themes “nutrients” and “digestion” are rated lower and are in large parts already allocated in the biology curriculum. Thus, they are excluded from the further design process. Regarding the linkages between medical themes and the curriculum (see Table 3), it is necessary to combine both perspectives to specialize promising contexts to address a suitable amount of curricular content and at the same time containing enough authentic everyday phenomena. Referencing back to common studies about gender differences in adolescents’ interests [2,3], male students often prefer topics related to dangerous, hazardous, and technical things while female ones prefer caring or biological aspects. Therefore, context ideas with relations both to injury, surgery, or medical technology and to health care or healing were constructed combining the highest rated major medical themes and the curriculum contents mentioned by the teachers. Table 4 gives an overview of the three resulting contexts and possible experiments (exp.) joining all approaches under the title “injury, blood and wounds”.

Table 4. Overview of the resulting context design approaches.

Context and Grade Level	Content and Experiments
7/8 – Breaking and Healing Bones	ionic substances (e.g. calcium, phosphate, sulphate, comparison to other ions), ion detection, x-ray and computer tomography, iodine as a contrasting agent examining the components of bones (exp.) [21] producing bone substitute materials (exp.) [21] examining plaster bandages (exp.)
9/10 – Blood Circulation	structure of haemoglobin (iron ions, complexes), structure of carbon monoxide and carbon dioxide, acid-base-balance, pH value, carbonate chemistry, buffers

	modelling the oxygen transport in the blood (exp.) modelling the blood buffer (exp.) modelling blood gas analysis (exp.)
11/12 – Wound Dressings and Closure	polymers (polypropylene, polyesters, polysaccharides, proteins), (poly)ester cleavage, polymer degradation, gel formation and swelling behaviour degradation of surgical sutures (exp.) [22] calcium alginate formation (exp.) comparison between hydrogel bandages and cotton bandages (exp.)

5.2 Assessment of Situational Interest

After conducting a first (N = 83) and a second (N = 144) piloting of the questionnaire, two relevant psychological constructs could be verified as different scales with good reliabilities ranging between 0.8 and 0.9 (Cronbach's α). It emerges from the data that especially younger students seem to struggle with items concerning their self-concept. This could arise from PISA items being designed for 9th grade students. Therefore, the self-concept was excluded from further considerations. With the first scale, individual interest in chemistry as a school subject is assessed. The second scale portrays the interestingness of the medical contexts and therefore the situational interest. The results show that the students perceive the medical contexts as rather interesting as the mean values for interestingness are in the upper third of the Likert scale. It also emerges that the contexts are perceived as rather familiar.

6. Conclusion

In this article, we presented ideas for interesting and authentic medical contexts for chemistry education including a tool for surveying their interestingness. It cannot be ruled out that there are more promising medical context ideas that have not been in scope of this research so far. To further examine the potential of the medical contexts presented here, the following main future research prospects arise from the data collected so far.

1. The first draft of the storylines for implementing the medical contexts in real chemistry lessons will be developed into contextualized learning materials including experiments, fictional patient data, and contextualized tasks.
2. The survey instrument will constantly be evaluated and optimized, clearing limitations arising from the piloting data.
3. Having the survey instrument for assessing the situational interest in medical contexts ready to use, it is of interest to deeper investigate the relationship between individual interest and interestingness. This could concern mediating factors or predictive effects on other related psychological constructs.

Eventually, teacher trainings regarding the implementation of our medical contexts will be developed. Even interdisciplinary projects and non-formal educational settings can play a role in future research. We are convinced to be able to design authentic and interesting contextualized learning environments for chemistry education throughout different grade levels.

References

[1] Hidi, S., Renninger, K. A. (2006). The Four-Phase Model of Interest Development. Educational Psychologist 41/2, 111–127.
[2] Hoffmann, L., Häußler, P., Lehrke, M. (1998). Die IPN-Interessensstudie Physik. Kiel.
[3] Sjoberg, S., Schreiner, C. (2005). How do learners in different cultures relate to science and technology? Results and perspectives from the project ROSE (the Relevance of Science Education). Asia-Pacific Forum on Science Learning and Teaching 6/2.
[4] Habig, S., Blankenburg, J., van Vorst, H., Fechner, S., Parchmann, I., Sumfleth, E. (2018). Context characteristics and their effects on students' situational interest in chemistry. International Journal of Science Education 40/10, 1154–1175.
[5] Harackiewicz, J. M., Smith, J. L., Priniski, S. J. (2016). Interest Matters: The Importance of Promoting Interest in Education. Policy insights from the behavioral and brain sciences 3/2, 220–227.

[6] Eccles, J. S., Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. Contemporary Educational Psychology 61, 101859.
[7] Sarabi, M. K., Gafoor, K. A. (2018). Student Perception on Nature of Subjects: Impact on Difficulties in Learning High School Physics, Chemistry and Biology. Online Submission 8/1, 42–55.
[8] Holbrook, J. (2003). Rethink science education. Asia-Pacific Forum on Science Learning and Teaching 4/2, 1–13.
[9] Daniels, Z. (2008). Entwicklung schulischer Interessen im Jugendalter. Zugl.: Potsdam, Berlin, Univ., Diss., 2004. Waxmann, Münster.
[10] Zandt, F. (2024). MINT mangelt es an Frauen. Statista.
[11] Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. Eur J Psychol Educ 14/1, 23–40.
[12] Schiefele, U. (1991). Interest, Learning, and Motivation. Educational Psychologist 26/3, 299–323.
[13] Hulleman, C. S., Harackiewicz, J. M. (2009). Promoting interest and performance in high school science classes. Science (New York, N.Y.) 326/5958, 1410–1412.
[14] Ochsen, S., Bernholt, S., Bernholt, A., Parchmann, I. (2022). Chemie finde ich eigentlich interessant, aber manchmal auch nicht – Zusammenhänge zwischen Merkmalen des Chemieunterrichts und dem situationalen Interesse von Lernenden. Unterrichtswiss 50/3, 425–451.
[15] Suhr, F. (2023). Frauenberufe, Männerberufe? Statista.
[16] Fruntke, A., Behnke, M., Stafast, L. M., Träder, T., Dietel, E., Vollrath, A., Weber, C., Schubert, U. S., Wilke, T. (2022). Targeted Drug Delivery: Synthesis of Smart Nanocarriers for School Chemistry Education. J. Chem. Educ.
[17] The Design-Based Research Collective (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. Educational Researcher 32/1, 5–8.
[18] Frey, A., Taskinen, P., Schütte, K., Prenzel, M., Artelt, C., Baumert, J., Blum, W., Hammann, M., Klieme, E., Pekrun, R. (2015). PISA 2006 Skalenhandbuch. Dokumentation der Erhebungsinstrumente.
[19] Thüringer Ministerium für Bildung, Wissenschaft und Kulter (2012). Lehrplan für den Erwerb der allgemeinen Hochschulreife. Chemie.
[20] Sekretariat der Ständigen Konferenz der Kultusinister der Länder der Bundesrepublik Deutschland (2020). Bildungsstandards im Fach Chemie für die Allgemeine Hochschulreife.
[21] Dietel, E., Wilke, T. (2023). "Setting Chemistry in Motion: Medical Aspects of Bones and Movement in Chemistry Education", New Perspectives in Science Education, Conference Proceedings 2023, 53-58.
[22] Dietel, E., Wilke, T. (2023). "Stitch by Stitch: Medical Aspects of Polymers in Surgical Suture Materials for Chemistry Education", New Perspectives in Science Education, Conference Proceedings 2023, 59-63.