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Supporting Interest in Science – Comparison of Students' Situational Interest and Intrinsic Motivation in a Regular School Class and in an Out-of-School Student Lab

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Abstract: In Germany, more than 300 student labs have been founded at universities, science centres or companies. In these out-of-school learning environments, students can conduct scientific inquiry with authentic equipment, thereby fostering students' interest in the fields of science, technology, engineering and mathematics (STEM). Out-of-school student labs are noted for their positive effects on students' motivational variables. Nevertheless, there has been no research that directly compares a regular class and an out-of-school student lab with respect to motivational variables. Therefore, we asked one sample of students about their situational interest and a second sample of students about their intrinsic motivation, comparing a regular biology class and a workshop in an out-of-school student lab. Our first sample comprised 197 students (58.2% female, M_{age} = 16.80 years, SD_{age} = 0.80 years). Our second sample comprised 187 students (64.7% female, M_{age} = 16.94 years, SD_{age} = 0.88 years). Students in basic-level biology courses as well as students in advanced-level biology courses reported higher situational interest and higher intrinsic motivation in the student lab, with medium to high effect sizes. Consequently, both the less and more educated students benefit from visiting the student laboratory. As one task of school education is to foster students' interest, our results underline that out-of-school labs provide valuable support for the school system.

Keywords: STEM Education, Out-of-School Student Lab, Situational Interest, Intrinsic Motivation

1. Introduction

Since 2000, the Organisation for Economic Co-Operation and Development (OECD) has conducted the Programme for International Student Assessment (PISA). The study aims to support the participating countries in developing human resources, which can be defined as "the process through which a society augments the skills, education, and productive abilities of its people" [1]. The PISA study surveys the preparedness of 15-year-olds for adult life by investigating their reading literacy, mathematical literacy, and scientific literacy [2]. In the international comparison of scholastic performance, German students were ranked in the middle. The results were lower than expected and led to shockwaves in the German educational landscape, affecting the political discourse, curriculum development processes, and academic discourse regarding education [3]. As one means of supporting science education, student labs were established all over Germany. In these out-of-school learning environments, students have the opportunity to conduct hands-on experiments in biology, chemistry, physics, or interdisciplinary areas. More than 300 labs have been established, and the number continues to increase [4]. The out-of-school student labs intend to foster students' interest in science for two main reasons. First, to improve the students' scientific literacy and second, to encourage students to pursue professions in STEM fields (science, technology, engineering, and mathematics) [5]. Both aspects play an important role in the development of countries' human resources. These societal and economic functions should mainly be within the purview of schools, with out-of-school student labs playing a complementary role in supporting the school system [5].

But how do the effects of out-of-school-learning environments differ from the effects of school environments? In Germany, much research has been done on the effects of educational programmes in out-of-school student labs on motivational variables. In the field of physics, Engeln showed that the lab characteristics 'challenge', 'authenticity', and 'understandability' have a higher impact on situational interest (SI) than 'openness' and 'collaboration' [6]. Guderian and Pawek found a short-term improvement in interest, but interest decreased in the long-term [7, 8]. In the field of chemistry, Brandt found similar results, with students reporting higher intrinsic motivation in their regular chemistry class at school after repeated visits to an out-of-school student lab [9]. Zehren's study supported these findings, as combining regular classes with out-of-school-student labs led to higher student intrinsic motivation in learning chemistry and higher interest in STEM professions and the subject chemistry at school [10]. Itzek-Greulich compared students' achievement-emotions in the three different learning environments 'out-of-school student lab', 'school', and 'combined setting' (all dealing with the same content), finding higher values in the treatment groups than in a control group without an intervention [11]. Huwer tested a lab-on-tour model and found an increase in the current motivation in 10-12-year-old students but not in 14-15-year-old students. In the field of biology [12], Glowinski identified individual interest as a predictor for epistemic interest in topics in molecular biology as well as in experiments [13]. Röllke found an increase in students' intrinsic motivation and SI when new media were used as part of the teaching concept at an out-of-school student lab [14]. In line with the results above, Glowinski and Damerau found a short-term increase in interest after students visited a student lab [13, 15]. More specifically, a decrease was observed in the epistemic component and in the feeling component but not in the value component of interest [15].

Summarising, out-of-school student labs are known for their positive effects on motivational variables, although the underlying constructs as well as the theoretical understanding are diverse and require further examination. Therefore, our current study aims to address a basic open research question in the field of motivational variables: What is the difference between students' SI and intrinsic motivation in regular classes at school and in out-of-school student labs? To answer this question, we compared students' perceptions of their own SI and intrinsic motivation in a molecular genetics class at school and in an experimental workshop at an out-of-school student lab.

2. Theoretical Background

2.1. Out-of-School Student Labs

In English-speaking countries, science labs have historically been an integral part of science education [16]. These labs are all located within schools, with specific designs that can vary greatly [16]. Practical work in the laboratory should help students to understand scientific concepts and applications, to acquire practical scientific skills, problem-solving skills, and scientific thinking, and to develop interest and motivation [16].

In Germany, experimenting in out-of-school labs has a certain tradition. The first student labs were founded as early as the 1980s and 1990s, and there has been a great increase in the number of student laboratories since 2000 [4]. The main reason may be the fundamentally high priority given to natural and engineering sciences in this industrialised nation and the recognition that innovations happen at a high technical level. To understand the complex range of knowledge, technical and interdisciplinary aspects must be combined. These competencies can be fostered by authentic and stimulating contacts with science and technology as well as by practical learning experiences [17]. Thus, through the engagement of individual actors as part of a bottom-up movement, extracurricular learning locations at universities, research centres, museums, industrial companies, and other places emerged [5]. Hofstein and Mamlok-Naaman described the following common goals for all student labs: promoting interest and open-mindedness for natural sciences and technology among students, providing a contemporary picture of these subjects including their significance for our society, and providing insights into fields of activity and job profiles in the natural sciences and technology [18]. In all out-of-school student labs, children and adolescents experiment independently in suitably equipped laboratories which are mostly located outside of school [5]. These learning locations can offer experiences that are not possible at school, allowing students to become more familiar with authentic science [5]. When students perform experiments in an out-of-school student lab, they are separated from the everyday school culture. And by adhering to the ordinary practices of the culture students perform authentic scientific inquiry [19].

2.2. Situational Interest

Interest can be defined as personality-specific preferences for a certain area of knowledge or activity [20]. These motivational dispositions are firmly anchored in the person's value system and thus represent a relatively stable personality trait. This form of interest is known as individual interest. Interest-oriented actions can be regarded as the implementation of these dispositions. Some of these actions take place in specific situations that have their own interestingness and can trigger interested attention [20]. This situational interest (SI) is the result of the interaction between personal and situational factors [21]. In principle, it can be triggered independent of the person's individual interest, but it interacts with it [20]. Knogler et al. [22] showed that both constructs are discrete factors, yet there is a mutual influence. Individual interest cannot significantly predict SI in every situation. Nevertheless, in longitudinal studies, a quarter to a third of the variance in SI can be explained by individual interest [22]. Additionally, individual interest can develop from SI in a multi-stage process. Under special conditions, the curiosity that has arisen from external stimulus factors further develops into a willingness to engage in longer-term interaction. In a further step, a relationship between the person and the object independent of external stimuli can develop and thus, an individual interest [21]. Since people's interest has to be captured in a first step and has to be held in a second step, Mitchell suggested the term 'catch component' for interest stimulated by learning conditions like the use of group work, computers or puzzles and 'hold component' for interest that is maintained by clarifying the importance of the content and the internal involvement of the learner [23]. Linnenbrink-Garcia et al. found three factors of SI, which influence each other [24]. Comparable to the catch-component and hold-component, they found triggered SI, evoked by the presentation of the learning material, and maintained SI, determined by the content of the learning material. The authors further separated maintained SI into two distinct factors: the feeling component refers to a person's enjoyment of the material, and the value component refers to a person's estimation of the material.

Out-of-school student labs should be able to evoke triggered interest relatively easily because of the authentic lab situation, the supervision by scientists, and the practical work in small groups. Experimenting in an authentic learning environment outside of school should also foster students' positive feelings towards the learning object, thus positively impacting the feeling component of maintained SI. The realistic context and therefore the emphasis on the relevance of the content should have a positive impact on the value component of maintained SI.

For that reason, our first hypothesis is:

H1: Learners report higher SI in an experimental workshop in an out-of-school student lab than in a regular class at school.

2.3. Intrinsic Motivation

Motivation can be defined as a product of a person and a situation [25]. The situational factors are stimulating incentives, which can be inherent in the activity itself or in the outcome of the action. Inducements that lie in the activity itself are intrinsic and can be evoked both by the activity itself (i.e. by enjoying the action) as well as by the object (i.e. interest in the thing). Extrinsic incentives, on the other hand, are the consequences of the action (i.e. material rewards, approaching long-term goals) [25]. According to Krapp's framework for structuring pedagogically significant components of learning motivation, motivation is also influenced by the social environment [26]. This aspect is the central justification for the continuum from extrinsic to intrinsic motivation proposed by Deci and Ryan [27]. People incorporate external values such as goals and behavioural norms into their personal value system to feel connected to other people. This possible process of internalisation of originally extrinsic stimuli leads to a continuum from externally regulated to introjected and identified regulation. As a further step, the integration of socially mediated behaviours into the individual self of the person can lead to integrated regulation. This quality of behaviour comes closest to intrinsic motivation. Here, actions are carried out in a completely self-determined manner, whereas in external regulation, they are externally determined [27]. Intrinsic motivation represents the prototype of self-determined behaviour. According to self-determination theory, all individuals have a natural tendency to develop their personality in order to perfect it [28]. This happens both through an individual's independent inner development and through the individual's aspiration for equality with other people. The integration of both aspects is necessary for the healthy development and well-being of humans. The structure of the self can be viewed as the ever-evolving product of processes of this organismic dialectic. The individual generates the necessary energy for this development by satisfying emotions and basic physiological and psychological needs. In self-determination theory, the basic psychological needs (need for competence, autonomy, and relatedness to other persons) are viewed as central prerequisites for the integration process [28]. To support students' self-determination, the students should work independently for long periods of time with no solutions specified; regulations, criticism, and pressure should be avoided; students' achievements should be praised; students' questions should be answered; and the students' point of view should be considered [29]. These elements are easily incorporated in out-of-school laboratories because the students themselves are active when experimenting. In addition, performance does not have to be assessed and the supervisors do not assume a typical teaching role but rather serve as role models in the STEM area.

Therefore, our second hypothesis is:

H2: Learners report higher intrinsic motivation in an experimental workshop in an out-of-school student lab than in a regular class.

3. Material

To analyse the hypothesized difference between regular classes and out-of-school student labs, we developed an experimental workshop to be held in a student lab. We chose the field of molecular biology, as the curriculum (e.g. in North-Rhine Westphalia/Germany) [30] requires the application of molecular genetic methods (e.g. polymerase chain reaction, gel electrophoresis, etc.) that are interdisciplinary with regard to chemistry and physics. This content to be taught in senior high school classes is complex, and hands-on activities are hard to realise at school.

The out-of-school student lab in our study is located at a

Center for Biotechnological Research at a university in Germany and thus is a close representation of authentic science. The student lab has a range of equipment typical for molecular genetic labs (e.g. micropipettes, gel electrophoresis chambers, thermal cyclers, etc.). Up to 24 students can experiment at eight group tables. As schools cannot provide comparative high-quality equipment due to the cost and the challenges involved in its use, this lab offers students experience that is not possible at school. Following Dopico et al., we applied the previously mentioned methods to design a workshop addressing a real problem, 'molecular genetic detection of animal species in sausage products' [31], see Roellke et al. for more details [32]. The content was selected based on the curriculum and on students' previous knowledge, as postulated by Lee and Butler [33]. We implemented the one-day course by following the teaching concept of cognitive apprenticeship according to Collins et al. [34]. The tutors modelled their activities and created scaffolds in the role of a master. They introduced the students to the context, to the use of the lab equipment, to the theoretical background, and to the progression of the experiments. In group discussions, they related the content to students' previous knowledge. Alternating practical sessions with these theoretical sessions, the students conducted the experiments autonomously in groups, while the tutors kept themselves in the background. Through this method, the students should gain sufficient experience and knowledge to perform authentic scientific inquiry independently despite having limited factual and procedural knowledge [33].

4. Methods

4.1. Study Design

To assess the SI in the molecular genetics class and in the workshop in an out-of-school student lab, we surveyed the same 197 upper secondary-school students. The participants were on average 16.80 years old (*SD* = 0.80 years, 58.2% female).

With another sample of 188 secondary-school students, we assessed the students' intrinsic motivation in their molecular genetics class and in the workshop in an out-of-school student lab. The participants in this sample were on average 16.94 years old (*SD* = 0.88 years, 64.7% female). Both samples answered the first questionnaire referring to molecular genetics class before the beginning of the workshop and filled in the second questionnaire referring to the out-of-school student lab after the end of the one-day workshop.

In the German school system, students in upper secondary school have the opportunity to choose biology either as a basic-level course (objective: basic propaedeutic education, course volume: 3 hours/week) or as an advanced-level course (objective: deepened propaedeutic education, course volume: 5 hours/week; students elect two subjects for advanced level courses). Both levels deal with the same content areas, but the advanced level aims to provide a stronger interconnection between the contents, models, and theories with the intention of fostering students' ability to self-reliantly apply, transfer, and reflect on the knowledge in variable situations [30]. Most students select their courses based on their personal interest [35]. As SI is predicted by individual interest, we were also interested in whether there were differences in the motivational variables between students from basic-level biology courses and students from advanced-level biology courses.

In the first sample, regarding the assessment of the SI, 69 students attended a basic-level biology course at school, and 128 students attended an advanced-level biology course.

In the second sample, regarding the assessment of intrinsic motivation, 65 students attended a basic-level course, and 123 students attended an advanced-level course.

4.2. Test Instruments

We recorded students' SI by utilizing scales from [24], differentiating between the subscales 'triggered SI', 'maintained SI, feeling component', and 'maintained SI, value component'. We used 14 items, with 4 to 5 items in each subscale. We assessed students' intrinsic motivation through three items from the subscale 'interest/ enjoyment' from the *Intrinsic Motivation Inventory* [36]. Table 1 shows the scales and example items. The students rated the statements on a five-point Likert scale from 1 ('I don't agree') to 5 ('I completely agree').

Table 1. *Example items regarding the molecular genetics class/the workshop for the subscales of situational interest (SI) according to [24] and the subscale 'interest/enjoyment' from the Intrinsic Motivation Inventory (IMI) according to [36] with internal consistency (Cronbach's α) in the pre-test (first value) and the post-test (second value).*

Subscale	Example Items	Cronbach's α
Triggered SI	The molecular genetics class/the workshop was entertaining.	0.812/0.765
Maintained SI 'feeling'	I like what I learned in the molecular genetics class/ the workshop.	0.881/0.878
Maintained SI 'value'	What I did during the molecular genetics class/ the workshop is important to me.	0.809/0.793
IMI subscale 'interest/ enjoyment'	The activities in the molecular genetics class/ the workshop were fun to do.	0.787/0.818

4.3. Statistical Analyses

Due to the central limit theorem ([37], p. 235], we assumed our data to be normally distributed. We calculated *t*-statistics to reveal differences in students' SI and intrinsic motivation at school and in the student lab. Furthermore, we analysed whether students from basic-level biology courses differed from students from advanced-level biology courses regarding their SI and intrinsic motivation. For this purpose, we conducted univariate analyses of variance (ANOVAs). We considered effects of $p \leq .05$ as statistically significant ([38], p. 614). For a better comparison, all effect sizes are reported as Cohen's *d*. Cohen suggested the following values to classify an effect as large or small: $d = 0.2$ (small), $d = 0.5$ (medium), $d = 0.8$ (large) [37, p. 115]. We used IBM SPSS, version 27 for all analyses.

5. Results

In the following, we present the results of our study. We start by describing the results for SI followed by those for intrinsic motivation. For both constructs, there were no gender differences.

5.1. Situational Interest

In general, the students' overall SI was significantly lower in the regular biology class at school ($M_{school} = 3.43$, $SD_{school} = 0.67$) than in the student lab ($M_{lab} = 3.75$, $SD_{lab} = 0.60$), $t(196) = -7.53$, $p < .001$, $d = 0.60$. Similar results could be found for the subscales 'triggered SI' ($M_{school} = 3.51$, $SD_{school} = 0.72$, $M_{lab} = 3.92$, $SD_{lab} = 0.67$, $t(196) = -7.52$, $p < .001$, $d = 0.76$), 'maintained SI, feeling component' ($M_{school} = 3.49$, $SD_{school} = 0.74$, $M_{lab} = 3.91$, $SD_{lab} = 0.68$, $t(196) = -7.84$, $p < .001$, $d = 0.74$), and 'maintained SI, value component' ($M_{school} = 3.26$, $SD_{school} = 0.75$, $M_{lab} = 3.36$, $SD_{lab} = 0.70$, $t(196) = -2.22$, $p = .03$, $d = 0.65$).

The results of the within-group comparisons of students from basic level biology courses and from advanced level courses, respectively, are reported in Table 2. Both groups reported significantly higher levels of overall SI, 'triggered SI', and 'maintained SI, feeling component' in the student lab than in a regular biology class at school. For 'maintained SI, value component', the same tendency can be identified in the reported values.

***Table 2.** Results of the t-tests concerning students' reported situational interest (SI) and its subscales in a regular school class ('school') and a student lab ('lab') split in terms of basic-level (Basic) and advanced-level (Advanced) biology courses.*

Factor	**Categories**	**School**		**Lab**		***t***	***p***	**Cohen's *d***
		M	***SD***	***M***	***SD***			
overall SI	Basic	3.06	0.73	3.53	0.61	-6.21	<.001	0.63
	Advanced	3.63	0.56	3.87	0.56	-4.80	<.001	0.57
triggered SI	Basic	3.06	0.73	3.68	0.62	-6.70	<.001	0.77
	Advanced	3.76	0.59	4.05	0.66	-4.51	<.001	0.74
maintained SI, feeling	Basic	3.15	0.82	3.72	0.72	-5.98	<.001	0.78
	Advanced	3.68	0.61	4.01	0.64	-5.33	<.001	0.70
maintained SI, value	Basic	2.97	0.76	3.12	0.75	-2.01	.050	0.65
	Advanced	3.42	0.71	3.49	0.63	-1.28	.201	0.65

Note. Effect sizes are reported as Cohen's *d*, $d = 0.2$ (small), $d = 0.5$ (medium), $d = 0.8$ (large). *M* = mean, *SD* = standard deviation.

The results of the intergroup comparisons of students from basic-level and advanced-level biology courses revealed that students from advanced-level biology courses reported significantly higher levels of overall SI ($F(1, 195) = 37.72$, $d = 0.88$) and its three subscales 'triggered SI' ($F(1, 195) = 52.99$, $d = 1.04$), 'maintained SI, feeling component' ($F(1, 195) = 25.77$, $d = 0.73$), and 'maintained SI, value component' ($F(1, 195) = 17.20$, $d = 0.59$) for regular classes at school than students from basic-level biology courses reported, all p <.001. This was also true for the student lab (overall SI: $F(1, 195) = 15.50$, $d = 0.57$; 'triggered SI': $F(1, 195) = 14{,}72$, $d = 0.55$; 'maintained SI, feeling component' $F(1, 195) = 8{,}41$, $d = 0.41$; 'maintained SI, value component': $F(1, 195) = 13{,}10$, $d = 0.52$, all p <.001, except for 'maintained SI, feeling component' ($p = .004$). For the means and standard deviations, see Table 2.

5.2. Intrinsic Motivation

In general, students' intrinsic motivation was significantly higher in the student lab than in the regular biology class, with a medium effect size (see Table 3). This was also true for the subsamples resulting from the splitting of the overall sample into students from basic-level and advanced-level biology courses, with medium to large effect sizes (see Table 3).

***Table 3.** Results of t-tests concerning the students' intrinsic motivation in a regular school class ('school') and a student lab ('lab') split by basic-level (Basic) and advanced-level (Advanced) biology courses.*

		School		**Lab**		***t***	***p***	***d***
		M	***SD***	***M***	***SD***			
Overall sample		3.42	0.82	4.15	0.73	-13.90	<.001	0.71
Subsamples	Basic	2.96	0.86	3,82	0,75	-8.56	<.001	0.82
	Advanced	3.67	0.68	4.32	0.67	-11.26	<.001	0.64

Note. Effect sizes are reported as Cohen's *d*, $d = 0.2$ (small), $d = 0.5$ (medium), $d = 0.8$ (large). *M* = mean, *SD* = standard deviation.

An intragroup comparison revealed that students from advanced-level biology courses reported significantly higher intrinsic motivation than students from basic-level biology courses did. This was the case at school $F(1, 185) = 39.11$, $p < .001$, $d = .92$) as well as in the student lab ($F(1, 185) = 22.12$, $p < .001$, $d = 0.69$). For means and standard deviations, see Table 3.

6. Discussion

In our study, we wanted to clarify the effects of students visiting out-of-school student labs in comparison to attending a regular class on motivational variables. We discriminated between students who had taken basic-level biology courses in comparison to advanced-level biology courses in upper secondary school. Because both course types have to cover identical content, we taught both groups with the same workshop at the student lab. The tutors in this out-of-school learning environment assessed the students' previous knowledge and gave the students individual support for the tasks in the workshop. Nevertheless, we assumed differences in motivational variables as the advanced-level course in school is more intensive. Therefore, students with higher individual interest should be more likely to choose the advanced-level course, which predicts situational interest to a certain extent (see Chapter 2.2).

We hypothesized that learners report higher SI (*H1*) and higher intrinsic motivation (*H2*) in an experimental workshop in an out-of-school student lab than in regular class at school. Our results support these hypotheses. In both course types, students reported higher SI and higher intrinsic motivation with regard to the out-of-school lab.

More specifically, we found great differences in intrinsic motivation, in triggered interest, and in the feeling component of maintained SI and smaller differences in the value component of maintained SI. This is in line with the theoretical background for different reasons.

First, (intrinsic) motivation refers solely to the situation without considering content (see Chapter 2.1), and triggered interest is stimulated by learning conditions, which also does not emphasise content (see Chapter 2.2). Hence, both constructs describe similar states of things, and both should be stimulated by the authentic learning environment in out-of-school student labs.

Second, maintained SI reveals if the professional content beyond the immediate situation was interesting for the students. In the development of interest, this is the step of maintaining interest after the step of capturing interest and thus should be harder to influence.

For both components of maintained SI, differences between the school class and the out-of-school student lab are reasonable. The feeling component of maintained SI should be higher in an out-of-school lab than at school, as positive feelings towards the content may be evoked by the hands-on activities. The value component of maintained SI can be discussed from two perspectives. On the one hand, in the workshops the students worked on current scientific questions and this authentic context should foster their appreciation of the content, leading to a high assessment for the value component. On the other hand, the students' estimation of the content is presumed to be harder to influence than the enjoyment of contents. In addition, it must be noted that the visit to the out-of-school student lab took place just once for a one-day period. So it is not surprising that one sample in our study – the advanced-level course students – revealed no significant differences between both learning environments, and the other sample – the basic-level course students – showed significant differences with small effect sizes.

With regard to the advanced-level courses and the basic-level courses, the results collectively show the expected differences. In particular, the lead of basic-level courses in terms of the value component of maintained SI in the student lab was surprising. Overall, students in basic-level courses as well as those in advanced-level courses benefited from the opportunity to learn in out-of-school student labs.

7. Limitations

In our study, we only had knowledge about the workshops in the out-of-school student lab. We did not know any details about the regular class in molecular genetics. School lessons may have been quite different in our samples. Nevertheless, the results for the out-of-school learning environment show explicit advantages over the school environment.

8. Conclusions

As students are more motivated and more interested in a workshop in a student lab than in school lessons, these out-of-school learning environments successfully support and complement the school system. In classrooms at school, students' interest should be fostered as well. Since learning at a student lab has proven to be motivating and increase interest, the teaching strategies might be transferred to the classroom. For example, in a study of Roellke et al., an inquiry-based workshop originally designed for an out-of-school student lab was held at school as well [39]. Identical tutors taught the students with the same equipment in both places, and no significant difference was found in flow experience and in situational interest. Itzek-Greulich et al. obtained similar results: They found no significant differences in state motivation when students did lab work in a student lab, at school, or in a combined setting [40]. In the future, more research should be done on the influence of different learning environments and the transferability of teaching concepts from out-of-school labs to school.

Summarising, we conclude that all students – irrespective of their previous education in the subject - should be given more opportunities to perform authentic lab work.

References

[1] Prasad, S. B., & Negandhi, A. R. (1968). Human Resource Development for Economic Growth. In S. B. Prasad & A. R. Negandhi (Eds.), *Studies in Social Life. Managerialism for Economic Development: Essays on India* (pp. 139–150). Springer. https://doi.org/10.1007/978-94-011-7499-2_11

[2] OECD (2000). Measuring Student Knowledge and Skills: The PISA 2000 Assessment of Reading, Mathematical and Scientific Literacy. Advance online publication. https://doi.org/10.1787/9789264181564-en

[3] Ertl, H. (2006). Educational standards and the changing discourse on education: the reception and consequences of the PISA study in Germany. *Oxford Review of Education*, *32* (5), 619–634. https://doi.org/10.1080/03054980600976320

[4] Haupt, O. J., & Hempelmann, R. (2015). Eine Typensache! [A question of the classification]. In LernortLabor - Bundesverband der Schülerlabore e.V. (Ed.), *Schülerlabor-Atlas 2015: Schülerlabore im deutschsprachigen Raum* (pp. 14–21). Stuttgart: Klett MINT.

[5] Haupt, O. J., Domjahn, J., Martin, U., Skiebe-Corrette, P., Vorst, S., Zehren, W., & Hempelmann, R. (2013). Schülerlabor - Begriffsschärfung und Kategorisierung [Student lab - term definitions and categorisation]. *MNU*, *66* (6), 324–330.

[6] Engeln, K. (2004). *Schülerlabors: authentische, aktivierende Lernumgebungen als Möglichkeit, Interesse an Naturwissenschaften und Technik zu wecken [Student labs: Authentic, activating learning environment as chance to trigger interest in science and technology]*. Berlin: Logos Verlag.

[7] Guderian, P. (2006). *Wirksamkeitsanalyse außerschulischer Lernorte - Der Einfluss mehrmaliger Besuche eines Schülerlabors auf die Entwicklung des Interesses an Physik [Analysis of the effectiveness of out-of-school learning environments: The influence of repeated visits of a student lab on the development of interest in physics]*. Ph.D. thesis. Berlin: Humboldt-Universität.

[8] Pawek, C. (2009). *Schülerlabore als interessefördernde außerschulische Lernumgebungen für Schülerinnen und Schüler aus der Mittel- und Oberstufe [Student labs as interest fostering out-of-school learning environments for students from high school]*. Ph.D. thesis. Kiel: Christian-Albrechts-Universität.

[9] Brandt, A. (2005). *Förderung von Motivation und Interesse durch außerschulische Experimentierlabors [Support of motivation and interest by out-of-school science laboratories]*. Cuvillier Verlag.

[10] Zehren, W. (2009). *Forschendes Experimentieren im Schülerlabor [Inquiry-based learning in the out-of-school student lab*. Ph. D. thesis. Saarbrücken: Universität des Saarlandes.

[11] Itzek-Greulich, H. (2014). *Einbindung des Lernorts Schülerlabor in den naturwissenschaftlichen Unterricht [Integration of an out-of-school student lab in science class]*. Ph. D. thesis. Tübingen: Eberhard Karls Universität.

[12] Huwer, J. (2015). *Nachhaltigkeit + Chemie im Schülerlabor: Forschendes Experimentieren im Kontext einer naturwissenschaftlich-technischen Umweltbildung [Sustainability and chemistry in the out-of-school student lab: Scientific inquiry in the context of scientific-technical environmental education]*. Ph.D. thesis. Saarbrücken: Universität des Saarlandes.

[13] Glowinski, I. (2007). *Schülerlabore im Themenbereich Molekularbiologie als Interesse fördernde Lernumgebung [Student labs in the subject area of molecular biology as interest fostering learning environments]*. Ph.D. thesis. Kiel: Christian-Albrechts-Universität.

[14] Röllke, K. (2019). Was kann ein Schülerlabor leisten? Konzeptionierung des Schülerlabors teutolab-biotechnologie als Lehr-Lern-Labor mit Angeboten zur Breiten- und zur Begabtenförderung von Schülerinnen und Schülern [What can an out-of-school student lab accomplish? Conception for the teutolab-biotechnology as a lab for teaching and learning with offers to nurture talents as well as all round promotion for students]. Ph.D. thesis. Bielefeld: Universität Bielefeld.

[15] Damerau, K. (2012). *Molekulare und Zell-Biologie im Schülerlabor - Fachliche Optimierung und Evaluation der Wirksamkeit im BeLL Bio [Molecular and cell biology in a student lab - professional optimisation and evaluation of the effects in BeLLBio]*. Ph.D. thesis. Wuppertal: Bergische Universität.

[16] Hofstein, A., & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice*, *8* (2), 105–107.

[17] Euler, M. (2001). Lernen durch Experimentieren [Learning through experimentation]. In U. Ringelband, M. Prenzel, & M. Euler (Eds.), *IPN-Materialien. Lernort Labor: Initiativen zur naturwissenschaftlichen Bildung zwischen Schule, Forschung und Wirtschaft* (pp. 13–42). Kiel: IPN.

[18] Dähnhardt, D., Haupt, O., & Pawek, C. (2009). Neugier wecken, Kompetenzen fördern: Wie Schülerlabore arbeiten [Arouse curiosity, promote skills: How student laboratories work]. In D. Dähnhardt, O. J. Haupt, & C. Pawek (Eds.), *Kursbuch 2010: Schülerlabore in Deutschland* (pp. 12–29). Tectum Verlag.

[19] Brown, J. S., Collin, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, *18* (1), 32–42.

[20] Krapp, A. (1992). Interesse, Lernen und Leistung: Neue Forschungsansätze in der Pädagogischen Psychologie [Interest, learning, and performance: New research approaches in pedagogical psychology]. *Zeitschrift Für Pädagogik*, *38* (5), 747–770.

[21] Krapp, A. (1998). Entwicklung und Förderung von Interessen im Unterricht [Development and promotion of interests in the classroom]. *Psychologie, Erziehung, Unterricht*, *44*, 185–201.

[22] Knogler, M., Harackiewicz, J. M., Gegenfurtner, A., & Lewalter, D. (2015). How situational is situational interest? Investigating the longitudinal structure of situational interest. *Contemporary Educational Psychology*, *43*, 39–50.

[23] Mitchell, M. (1993). Situational Interest: Its Multifaceted Structure in the Secondary School Mathematics Classroom. *Journal of Educational Psychology*, *85* (3), 424–436.

[24] Linnenbrink-Garcia, L., Durik, A. M., Conley, A. M., Barron, K. E., Tauer, J. M., Karabenick, S. A., & Harackiewicz, J. M. (2010). Measuring Situational Interest in Academic Domains. *Educational and Psychological Measurement*, *70* (4), 647–671.

[25] Heckhausen, J., & Heckhausen, H. (2009). Motivation und Handeln: Einführung und Überblick [Motivation and Action: Introduction and Overview]. In J. Heckhausen & H. Heckhausen (Eds.), *Motivation und Handeln* (pp. 1–9). Heidelberg: Springer.

[26] Krapp, A. (1993). Die Psychologie der Lernmotivation: Perspektiven der Forschung und Probleme ihrer pädagogischen Rezeption [The psychology of motivation for learning: Perspectives from research and problems of pedagogical reception]. *Zeitschrift Für Pädagogik*, *39* (2), 187–206.

[27] Deci, E. L., & Ryan, R. M. (1993). Die Selbstbestimmungstheorie der Motivation und ihre Bedeutung für die Pädagogik [The self-determination theory of motivation and its meaning for pedagogy]. *Zeitschrift Für Pädagogik*, *39* (2), 223–238.

[28] Ryan, R. M., & Deci, E. L. (2002). Overview of Self-Determination Theory: An Organismic Dialectical Perspective. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 3–33). Rochester, NY: University of Rochester Press.

[29] Reeve, J. (2002). Self-Determination Theory Applied to Educational Settings. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 183–203). Rochester, NY: University of Rochester Press.

[30] MSW NRW. (2014). *Kernlehrplan für die Sekundarstufe II Gymnasium/Gesamtschule in Nordrhein-Westfalen - Biologie [Curriculum for Upper Secondary School/Comprehensive School in North Rhine-Westphalia - Biology]*. Schriftenreihe Schule in NRW. https://www.schulentwicklung.nrw.de/lehrplaene/upload/klp_SII/bi/GOSt_Biologie_Endfassung.pdf

[31] Dopico, E., Linde, A. R., & Garcia-Vazquez, E. (2013). Learning gains in lab practices: Teach science doing science. *Journal of Biological Education*, *48* (1), 46–52. https://doi.org/10.1080/00219266.2013.801874

[32] Röllke, K., Kamp, P., & Grotjohann, N. (2018). Was steckt wirklich in der Wurst? Molekulargenetische Tierartendifferenzierung. BU praktisch - *Das Online-Journal für den Biologieunterricht, 1 (1),* 1-22. https://doi.org/10.4119/bupraktisch-1080

[33] Lee, H. S., & Butler, N. (2003). Making authentic science accessible to students. *International Journal of Science Education*, *25* (8), 923–948. https://doi.org/10.1080/09500690305023

[34] Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive Apprenticeship: Teaching the Crafts of Reading, Writing, and Mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453–494). Erlbaum.

[35] Abel, J. (2002). Kurswahl aus Interesse? Wahlmotive in der gymnasialen Oberstufe und Studienwahl [Course choice out of interest? Motives for choice in the upper secondary school and choice of study]. *Die Deutsche Schule*, *94* (2), 192–203.

[36] McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, *60* (1), 48–58. https://doi.org/10.1080/02701367.1989.10607413

[37] Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5^{th} edition). SAGE.

[38] Döring, N., & Bortz, J. (2016). *Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften*. Springer Verlag.

[39] Röllke, K., Maak, A. - L., Wenzel, A., & Grotjohann, N. (2020). Experimental Workshops in Student Labs and at School – What Influence do Location and Personality Traits have on Learners' Motivational Variables? Pedagogical Research, 5 (1), em0050. doi: 10.29333/pr/63380.

[40] Itzek-Greulich, H., Flunger, B., Vollmer, C., Nagengast, B., Rehm, M., & Trautwein, U. (2017). Effectiveness of lab-work learning environments in and out of school: A cluster randomized study. *Contemporary Educational Psychology*, *48*, 98–115. https://doi.org/10.1016/j.cedpsych.2016.09.005