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Student labs on a university campus as a type of out-of-school learning environment: Assessing the potential to promote students' interest in science

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Student labs are out-of-school learning environments that are assumed to promote students' interest in science. They are characterised by aspects of situated and authentic learning, a prominence of application contexts presented by scientists, and a high amount of practical work. Research has shown the potential for promoting students' interest in science for each of these aspects when implemented separately as a teaching approach in science education. This study aims to explore, whether (i) these aspects can be shown to be separately effective on students' interest even when realised jointly in the learning environment and, if so, (ii) which reciprocal effects can be shown with regard to students' attributes (prior individual interest, self-concept, gender) and the degree of pre-visit instruction in school. A questionnaire was developed based on interest theory and theories of interest development. A total of 378 upper secondary students completed the questionnaire. A factor analysis indicated the students' interest in the lab to be three-dimensional with the factors having a strong relation to (1) experiments, (2) application contexts of research, and (3) authentic learning environments. Structural equation modelling dictated significant interrelationships between students' interest in the student lab and students' attributes (e.g. prior individual interest in science), the degree of pre-visit instruction in school and the quality of instruction in the student lab. The analytical framework used in this study is based on theories of interest development by considering the basic needs as mediator variables and offers a means of assessing students' interest in out-of-school settings.

Keywords: basic needs, interest, out-of-school setting, practical work, student lab

Introduction

Due to the ongoing decline in students' interest in pursuing scientific careers for the past several years, the promotion of attitudes towards and interest in the sciences and learning science is of special relevance (Osborne, Ratcliffe, Collins, Millar, & Duschl, 2003). Results of PISA 2006 show a high proportion of students with little interest in science even among high achieving learners (PISA, 2007). Outreach programmes are assumed to meet these challenges of science

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education, and they seem to promote students' disposition to engage in science topics (Markowitz, 2004). In Germany, many initiatives have been started in the last 10 years to further extra-curricular partnerships between research institutions and schools. These are usually realised in specific student labs on a university campus and are aimed at upper secondary students. In the area of molecular biology about 40 student labs in Germany provide out-of-school experiences in gene technology methods such as PCR and gel electrophoresis. These methods are embedded in application contexts like proof of paternity or a fictitious diagnosis of genetic disorders like Chorea Huntington. In this way, participants become familiar with contexts and the areas in which scientific knowledge can be applied to everyday life. Doing practical work in a student lab under scientists' guidance is an integral part of the visit to the university where students take part as a whole class together with their teacher and which usually lasts one day. The stay provides an abundance of learning opportunities that most students cannot be offered in their schools. The main goal of these types of out-of–school settings is to enhance students' interest in science. Although many of these programs have evoked positive acceptance, there is a lack of studies investigating whether the potential of student labs to promote students' interest can be related to these described characteristic aspects of the out-of-school environment and which factors are crucial to support students' interest.

The Character Of Student Labs As Out-Of-School Learning Environments And Recommendations For Research

With regard to educational objectives, student labs comply with the general aims of out-of-school settings. A common goal of out-of-school settings is to provide experience with tasks that allow explorations and do not overstrain. It is crucial that they are generally not graded and that the expected outcomes focus less on knowledge development and more on science as an experience (Martin, 2004; Nasir, Rosebery, Warren, & Lee, 2006). Therefore, these out-of-school learning settings are supposed to be especially effective in promoting motivational and affective aspects (Falk & Dierking, 1992; Kern & Carpenter, 1986; Orion & Hofstein, 1991). Research in science learning in out-of-school settings has emerged by setting out specific research issues and questions. The multifaceted character of these learning environments requires the consideration of all possibly relevant variables. Adequate frameworks are presented by many authors (Brody, Bangert, & Dillon, 2007; Falk & Dierking, 1995; Rennie, 1994; Schauble, Leinhardt, & Martin, 1997), among these the contextual model of learning (Falk & Dierking, 2000; Falk & Storksdieck, 2005). This model has been shown to be well suited for studying the complexity of informal learning environments, taking into account the learning environment, the social interaction, and the personal context (considering knowledge, prior interest, and motivation as precursors to the actual engagement in a setting). A further and crucial aspect with regard to out-of-school activities is the question of whether and how the out-of-school experience can be best integrated into the regular classroom lessons (Hofstein & Rosenfeld, 1996). In general, pre-visit instruction with regard to out-of-school activities has been shown to be crucial in the effectiveness of these settings (Beiers & McRobbie, 1992; Fraser, McRobbie, & Giddings, 1993; Hidi & Anderson, 1992; Jarvis & Pell, 2005). In this study, the research exploring the role of student labs in science education will consider and investigate the special conditions of these out-of-school settings and relate these with students' interest as the expected outcome of this type of learning environment.

Related Research

In this section, we will first describe theories of interest and interest development. Then empirical findings on the characteristic aspects of student labs will be described paying special regard to their relevance for students' interest and motivation.

Interest

Interest is described as a "person-object-conception of interest" (POI) (Krapp, 1999a, 2002). While individual interest means a long-lasting preference for a certain topic, situational interest is caused by the interestingness of a certain situation, e.g. interesting aspects of learning environments or educational settings (Krapp, Hidi, & Renninger, 1992). Interest always results from a current interaction between individual and situational factors, whereas interest can be initiated in some cases primarily by the situational context (situational interest) and in other cases primarily by an individual disposition (individual interest) (Bergin, 1999; Hidi & Renninger, 2006). Even though interest typically has been studied as a predictor for students' learning outcome, there are a growing number of studies which explore the conditions of interest development in educational settings (Krapp, 1999a). In addition, interest can also be seen as a mediator in the sense that interest puts the participant in a position to tackle and follow an intended task (Hidi & Renninger, 2006).

Basic needs (competence, autonomy, social relatedness) and their relevance for interest development

Whether situational interest will evolve into an individual interest or not depends on conditions described in models of interest development (Hidi & Renninger, 2006; Krapp, 2002; Mitchell, 1993). Only a few research approaches tackle the question how the course of interest development is controlled by conditions and functional principles at the level of actual psychological processes during action and learning (Krapp, 2005). Three *basic needs* (feeling of competence, autonomy, and social relatedness) were identified as basic emotional experiences (Deci & Ryan, 1993) and could be shown to be "important not only for well-being, but also for a variety of developmental processes, including interest development" (Krapp, 2005). In the context of learning the three basic needs can be specified as follows. Competence refers to the desire to feel efficacious and is described as a feeling which is related to successfully managed interactions and tasks and developed ability. Autonomy refers to the desire to be self-initiating but is restricted in learning situations to be dependent on the belief to be capable of successfully mastering impending tasks. And finally, social relatedness refers to the desire to feel connected to and be accepted by significant others. In the context of classroom learning, especially in activity-based learning environments basic needs are assumed to be relevant. When subjects are asked about their feeling during the past sequence of learning activities they normally refer spontaneously to experiences that are obviously related to the system of basic needs, for example the feeling to be able to meet the requirements of a learning task, to do something that meets the own goals and personal wishes or to be socially accepted in the learning group. For Krapp (2005), there is no easy answer to the way basic needs are linked to the processes of interest development. In a first step of empirical analysis it seems necessary to prove the general hypothesis that need-related experiences have an impact on the development of interest for different kinds of learning environments. The suggestion of Krapp, that the predisposition to reengage with a particular content of interest will only be realised if these basic needs are fulfilled, also fits with the four-phase model of interest development described by Hidi & Renninger (2006). In a study on a vocational education programme scales for the three basic needs were developed and could be shown to be adequate to map the relation between interest and basic needs (Krapp, 2005). Taking into account the theoretical implications of the interest theories described above, the following sections focus on student lab characteristics as possible triggers for promoting students' interest.

Practical work

Practical work plays a crucial role in the visit to a student lab. While many studies in educational research indicate that there is a positive relationship between the use of laboratory instruction in science education and students' achievement in science knowledge, their science process skills, and their interest in the sciences (Berry, Gunstone, Loughran, & Mulhall, 2001; Freedman, 1997; Gibson & Chase, 2002; Hofstein, 2004; Hofstein, Ben-Zvi, & Samuel, 1976; Tobin & Gallagher, 1987), they are also doubtful about the generally assumed effectiveness of labwork (Abrahams & Millar, 2008; Gardner & Gauld, 1990; Hodson, 1993; Hofstein & Lunetta, 1982, 2004). Research studies found strong evidence that labwork enhances students' interest and they analysed interest in labwork as a multidimensional construct (Ben-Zvi, Hofstein, Samuel, & Kempa, 1977; Hofstein, 2004; Hofstein et al., 1976). Instruments for the measurement of interest in and attitudes towards practical work were developed and were found to be sensitive to different aspects of laboratory work, e.g. integration, cohesiveness, open-endedness, value of practical work, material environment, and involvement being relevant for students' affective outcomes (Fraser & Giddings, 1995; Fraser & Griffith, 1992; Henderson, Fisher, & Fraser, 1998).

Authentic learning environments

Student labs are a type of out-of-school setting which explicitly place students in the role of being a scientist. Several studies describe the motivating effects of situated learning in authentic contexts (Goldman, Mayfield-Stewart, Bateman, & Pellegrino, 1998) whereas it is noteworthy that there is no consensus on the definition of authentic science tasks (see review by Buxton (2006)) and there are many ways of implementing them in the science classroom. Some approaches focus on the adoption of scientists' practices in order to help students learn scientists' attitudes, and how to work with their tools and techniques (Edelson, Gordin, & Pea, 1999). Other approaches make use of everyday problems to develop students' attitudes relevant for lifelong learning (Edelson, 1998; Lee & Songer, 2003). Lee and Songer and Edelson point out the difficulties and challenges for implementing authentic science in science education. Their guidelines for successfully utilising authentic contexts point out that these real-world situations must map closely to students' content understandings and curricular activities and that students need specific guidance because of the complexity of authentic inquiry.

Purpose of the study

Student labs are a new learning environment in science education integrating several aspects that show great potential for enhancing students' interest in science as described before. This study aims to elucidate whether selected student lab characteristics (practical work, research contexts, authentic learning environment) effect students' interest each in a different way or as a whole. From the individual perspective, students' experiences of the basic needs were investigated as presumed predictors for evolving interest. Including the characteristics of the learning environment and students' attributes, an instrument was developed to assess students' situational interest, which is seen as a first step in interest development.

The study concentrated on the following research questions:

- Can the student lab characteristics described (practical work, authentic learning environment) be identified as separate efficacy factors causing students' situational interest?
- Which attributes of students (prior individual interest, self-concept, gender) trigger situational interest?
- What influences do the "basic needs" have as mediator variables promoting interest, based on the theories of interest and interest development?
- Which reciprocal effects are shown by the student's situational interest in lab characteristics with the degree of pre-visit instruction about the subject?

Design of the study

The study was conducted as a one-shot case study by taking general aspects concerning the assessment of out-of-school learning environments into consideration. According to recommendations for assessing out-of-school learning environments described above, student attributes (individual interest, self-concept, gender, grade), variables of the student lab (grade of insight into authentic research, quality of instruction), and the degree of pre-visit instruction in school were assessed. Our research design did not include an assessment of students' knowledge outcomes because the student labs are an out-of-school setting with a focus on affective outcomes that is usually "not constrained by the need to succeed in terms of mark" (Renninger, 2007). Therefore, a knowledge test would have affected the external validity of the study. Pretest-posttest designs are restrictive because the need to define outcomes prospectively provides little opportunity to get unexpected or additional outcomes and research findings remain limited (Rennie, Feher, Dierking, & Falk, 2003). In addition, trying to define control-groups for out-of-school learning settings becomes difficult because tightly controlled studies increase the 'artificiality of the research situation' and interfere with the external validity and generalisability of the findings (Rennie, 1994).

Method

Sample

A total of 378 upper secondary students from 28 biology classes participated in the study. Measurements took place after the students visited the student lab. The students were aged 17-19 (M = 18.3, SD = .76). According to the common distribution in German upper secondary biology classes, about 60 % of the students were female.

Students' programme in the student lab

The student lab is located on a university campus. It was established to be used for upper secondary students' out-of-school programmes. Students stay for six hours on one day together with their teacher. The lab is mastered by a university scientist. Students' experimental activities in the professionally equipped lab have a dominant part during the one-day stay. They work in small groups and conduct experiments in the area of molecular biology. In detail, they perform a PCR and DNA electrophoresis in a special application context, e.g. a simulated forensic problem or a fictitious proof of paternity. Usually German students do not have the possibility to work in a professionally equipped lab in their schools. Consequently, handling a research pipette is a new experience for them. The participants follow the provided written instructions and are supported by the scientist. In addition, the scientist provides some information about the research done in the affiliated institute.

Questionnaire

A questionnaire was developed including 48 items and using a four-point Likert-type scale (1 *"absolutely not true*", 2 "*somewhat true*", 3 "*quite true*", 4 "*absolutely true*"). The scoring direction was reversed for several items. Ten questions had to be answered in an open-response format. Analyses were conducted using SPSS (Vers.13) and M*plus* (Vers.5) (Muthén & Muthén, 2009) for path analyses.

Interest in the out-of-school setting. The instrument measures students' perceptions and their situational interest in the characteristic aspects of the student lab. Items were formulated with a focus on conducting experiments (based on SLEI, (Fraser et al., 1993)) , gaining insights into research and application contexts, and interest in being in a university research lab as an out-of-school setting. Items are shown in Table 3, in the result section. Items were developed including expert-rating and tested in a pre-study in five different student labs with 198 students aiming to ensure validity.

Student attributes. The students' attributes were included representing students' individual interest, their science-related self-concept, and their grade in the sciences. Item examples for the scales are given in Table 1. Items were formulated based on various studies (Krapp, 2005; Oion & Hofstein, 1991; Hofstein et al., 1976).

Degree of pre-visit instruction in school. The degree of pre-visit instruction about the subject of the experiments was described in a scale with 4 items (Table 1).

Attending variables of the student lab. Students' encounters with authentic research and the quality of the scientist's instruction while doing practical work are indicated as attending variables (Table 1). Although most scales have a satisfactory reliability, the Cronbach's alpha of the scale concerning the insight into authentic research points out a weak reliability for this scale. In a pre-study concerning five different student labs, it could be statistically proved that students' rating of "quality of instruction" and "insight of authentic research" differed between the different types of student labs according to expert rating. The instrument could be shown to be sensitive to the differences in the degree of "insight in authentic research" and "quality of instruction".

Basic needs. The basic needs were assessed as mediator variables because of the preliminary described theoretical model of interest development. They were formulated according to the established scales of Deci & Ryan (1993) and the cited scales in Krapp (2005) (Table 2).

In the statistical analyses, they were investigated as mediating variable and, therefore, related to both the exogenous variables and students' situational interest as measured outcome. The analytical framework is shown in Figure 1. As presented in Figure 1, we hypothesised that a positive perception of the basic needs as mediating variables should lead to increases in situational interest in the student lab.

Together with the independent variables individual interest, self-concept, grade and pre-visit instruction the scale representing students' perception of the insight in authentic research and the scale representing students' perception of the quality of instruction are shown on the left side of the analytical framework. They all together represent the exogenous variables in this model, while students' situational interest and the basic needs are endogenous variables and the basic needs are investigated as mediating variables.

Table 1. Exogenous variables with scale name, reliability, description, and sample items

Scale (number of items)		Cronbach's alpha	Description	Sample item
Student attributes	Individual interest (4)	α = .68	Individual interest in sciences	I am interested in science subjects even in my leisure. Science is fun. I usually use different sources (TV, books, internet) to inform myself about science subjects.
	Self-concept (4)	α = .81	Science-related self-concept	Although I try hard, science is difficult for me. I am not talented in science.
Pre-visit instruction (4)		α = .64	Integration of the stay in the student lab into regular classroom lessons	We talked about the experiments we conducted in the student lab in our classroom lessons before While conducting experiments, I could use knowledge I got in school. The experiments we conducted were not linked to the subjects we work on in our science class in school.
Variables student lab	Insight in authentic research (3)	α = .47	Degree of insight in authentic research	I got some information about actual research topics in this research institute. I got an impression about a scientist's daily work.
	Quality of instruction (3)	α = .66	Support by scientists	The scientists gave sufficient support while doing practical work The scientists answered our questions well. After each experimental step, we dicussed the results with the scientist.

Table 2. Scale Description Basic Needs

Scale (number of items)	Cronbach's alpha	Description	Sample item
Competence (5)	α = .67	Student experience of competence	I understood quite well what to do while conducting experiments. I felt overstrained while handling the experimental equipment.(-) I followed the instruction, without always knowing what experimental step I was doing. (-)
Autonomy (3)	α = .62	Student experience of autonomy	I had no chance to realise my own ideas while conducting experiments. (-) I had no chance to make enough decisions on my own. (-) I would have liked to plan or vary some experiments in the student lab. (-)
Social relatedness (3)	α = .59	Social relatedness and communication	We discussed the experiments while conducting them. I enjoyed to work together with my peers. I explained something concerning the experiment to my neighbor or something was explained to me.

Note. (-) = item reversed

Results

The results are presented according to the research questions.

Factors representing students' situational interest

As a first step we analysed the items assessing the students' situational interest in characteristics of the learning environment. Results of the factor analysis are given in Table 3. The exploratory factor analysis with varimax rotation was initially performed without specifying the number of factors to extract, since there was no expected factor structure. The factor analysis and reliability analysis resulted in a clear factor structure and led to the underlying structure of the three main components of students’ interest which turned out to be interpretable. The three factors explain 44.3 % of the variance (Factor 1: 19.7%; Factor 2: 13.7%; Factor 3: 10.9%).

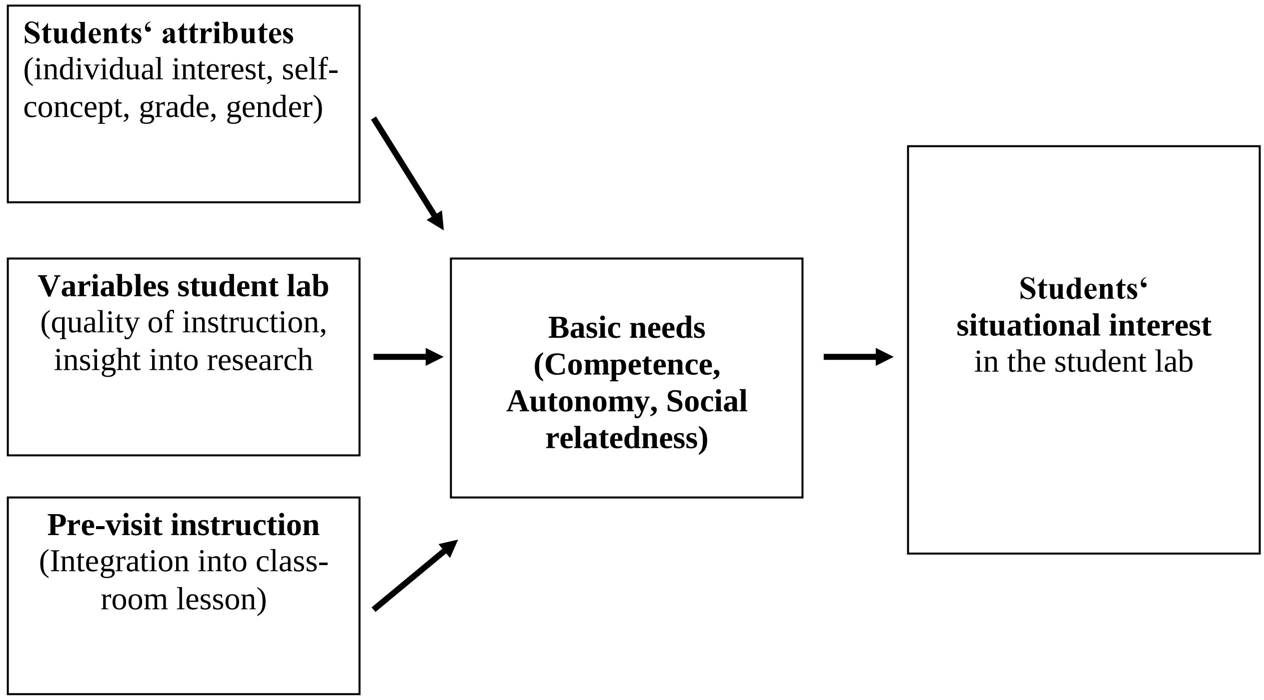

Figure 1. *Analytical framework of the study with the exogenous variables on the left side and the basic needs and students’ situational interest as endogenous variables*

The first factor (*Interest in experiments*) indicated students’ interest in experiments and practical work. The second factor (*Interest in research and application contexts*) included items with a connection to science research and application contexts and, in the third factor (*Interest in authentic learning environment*), items concerning the student lab as an out-of-school setting showed a high factor loading. Only two items regarding epistemic interest showed a high factor-loading on the fourth factor having an eigenvalue >1. They were excluded from the further analyses. When presenting factor loadings > .40, the factor analysis resulted in a loading on two factors for only one item. Together with Cronbach’s alpha, which has been shown to be satisfactory for the three scales, students’ interest in the student lab can be proved as being multi-component - with comprising students’ interest in doing practical work, the interest in research and application contexts and the interest in staying in a student lab as an authentic learning environment. It appears clearly that in the four-factor result with eigenvalue >1 the first three factors indeed correspond to the areas of interest based on the characteristics of the student lab that we introduced at the beginning of this report. Mean-values of M = 3.2 (*SD* .51) for *Interest in experiments*, M = 2.8 (*SD* .58) for *Interest in research and application contexts*, and M = 3.0 (*SD* .54) for *Interest in authentic learning environment* are considerably higher than the mid-range of the scale (2.5).

Correlation of Interest Scales. We concluded the analyses of the scales concerning students' situational interest by examining the correlations between the three different constructs. The Spearman correlation coefficients between each of the three (having controlled for students' individual interest as a variable with potential influence) resulted in Spearman's coefficients between $r_s = .46$ and $r_s = .58$ and indicate that the scales are relatively independent.

Analyses of Interrelationships. The following analyses investigated the reciprocal effects of the three scales which characterise students' situational interest in the student lab with the assessed students' attributes, the two scales which represent the quality of instruction and the perception of authentic research, and the degree of pre-visit instruction in school.

Regarding the interest theory which describes situational interest as always resulting from an interaction between individual and situational factors, the investigation of the interrelation between the two interest dimensions has been a fundamental analysis in this study.

There were only minor, but significant correlations between individual interest and the situational interest in experiments ($r = .44$, $p<.001$), situational interest in research and application contexts ($r = .38$; $p<.001$) and situational interest in authentic learning environments ($r= .30$; $p= .001$). However, there were significant differences concerning the three scales when looking at the results for students with high vs. students with low individual interest

Splitting the sample by the median split in students with high vs. a low individual interest, the Mann-Whitney-U-Test for testing significant differences showed all three scales to be on a high significant level ($p < .001$). Referring to these results, students with differences in their degree of individual interest (high vs. low) were analysed more in detail.

Results of Structural Equation Analyses

To investigate the effects of the exogenous and mediating variables on students' situational interest, the data were analysed using structural equation analyses. First, we examined the direct effects of the exogenous variables on the outcomes of students' situational interest in experiments, authentic learning environment and application contexts. Second, we tested whether the basic needs mediated the direct effects of the independent variables on the outcomes.

A model was specified to analyse relevant predictors for students' situational interest. Neither gender nor grade in biology show any significant interrelationship with students' situational interest. These variables were not included in the analyses.

Our analytic approach included students' individual interest as grouping variable aiming to investigate differences in causal relationships between students with a high vs. a low degree of individual interest in science which can be assumed in accordance to interest theory. In the Figures 2, 3, and 4, path coefficients are shown for two subpopulations, the one that represents students with a high and the one that represents students with a low individual interest. Path models are shown for each of the three outcome variables (three components of situational interest), including the satisfying model parameters. In order to give a better overview, only significant paths (for at least one subpopulation) are depicted and path coefficients are shown for students with low (LO) and high (HI) prior individual interest.

The model for situational interest in experiments (Figure 2) accounts for a significant amount of variance ($R^2 = .38$, $p < .001$ for students with low prior individual interest, $R^2 = .26$, $p< .001$ for students with a high prior individual interest)

Differences concerning the predictive effect of the exogenous and mediating variables indicate that students' situational interest in conducting experiments is promoted in different causal ways dependent on their prior individual interest. Students' competence feeling and social relatedness had a strong impact for already interested participants. For students with a low individual interest, however, the quality of instruction became the best predictor for their situational interest in experiments. This predictor showed no statistical significance for high interested participants.

Table 3. Exploratory factor analysis results (varimax) for students' situational interest in the student lab

	Component		
Interest statement	1 (Experiments)	2 (Research and Appli-cation contexts)	3 (Authentic learning environment)
I had fun while handling with the laboratory instruments.	,795		
Conducting the experiments increased my interest in the topic.	,704		
It was exciting to work with laboratory equipment not being available in school	,643		
To be familiar with the laboratory equipment is important for me.	,603	,417	
Doing experiments helped me to understand the topic better.	,575		
Often the experiments took too long	,479		
I would like to learn about current research in school lessons.		,782	
About research topics, which were presented us, I would gladly like to inform further.		,702	
I can learn subject knowledge better, if I have a chance to acquire in addition knowledge about application contexts.		,529	
Visits of student labs are not any more than a nice school trip			,734
I found it exciting having the chance to learn outside of the school everyday life			,692
I found it exciting that a scientist reported us personally on his research work.			,417
Current research can be presented with media just as excitingly as by the personal contact with scientists.			,405
Cronbach‘s alpha	α = .759	α = .688	α = .662

This points out that students with high individual interest may not need the same type of support; correspondingly that students with low individual interest develop situational interest in experiments when supported adequately while doing practical work.

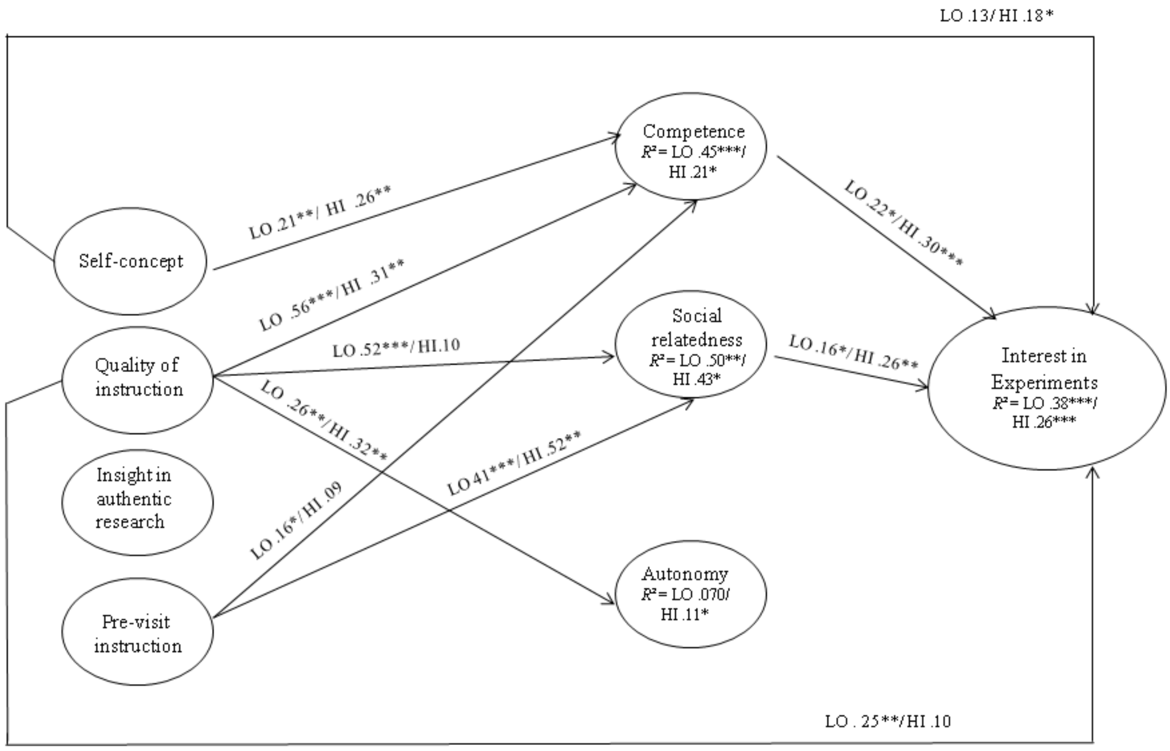

Figure 2. *Path model predicting situational Interest in Experiments. Grouping variable: Individual interest (median split); significant coefficients (std.) shown for students with low /high individual interest LO/HI.*

χ^2 = 174.1; *df = 138 p*(χ^2) = .0202; CFI = .94; TLI = .92; RMSEA = .044; *N* = 255.
**p* < .05, ***p* < .01, ****p* < .001

A further path model accounted for a significant amount of variance in situational interest in research and application contexts (R^2 = .51; $p < .01$ (low individual interest); $R^2 = .36$; $p < .01$ (high individual interest) (Figure 3). Whereas interest in research and application contexts primarily was predicted by feeling competent and the insight in authentic research for the subpopulation of high interested students, for low interested students the feeling of social relatedness came to the fore, attended by the insight in authentic research.

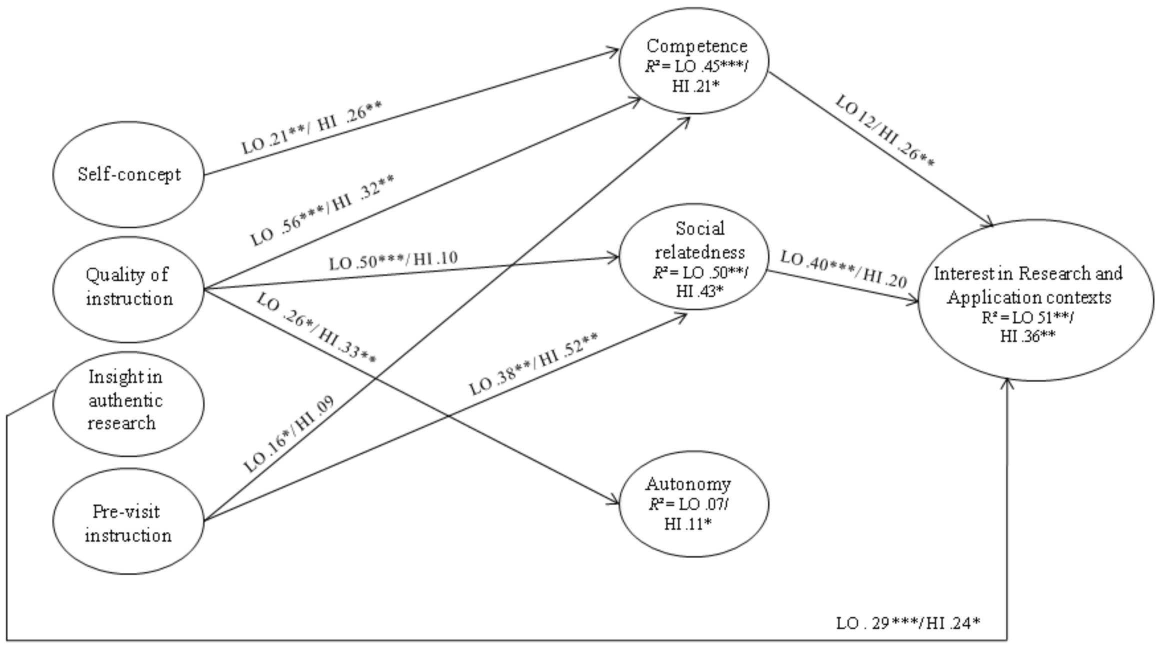

Figure 3. *Path model predicting situational Interest in Research and Application contexts. Grouping variable: Individual interest (median split); significant coefficients (std.) shown for students with low /high individual interest LO/HI.*

χ^2 = 184.1; *df = 138* $p(\chi^2)$ = .0053; CFI = .93; TLI = .89; RMSEA = .050; *N* = 255.
$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

Competence feeling did not not play a significant role in this subpopulation and could be a hint, that for these students interest in research and application contexts was rather not related to their ability to understand the research subject but to their experience to get involved in authentic research contexts together with their peers.

The path model for situational interest in the authentic learning environment also shows significant differences for students with high vs. low individual interest (Figure 4). Insight in authentic research, pre-visit instruction, and competence were the strongest predictors for participants with high interest. The most prominent predictor for participants with a low individual interest was the insight into authentic research, followed by quality of instruction and social relatedness.

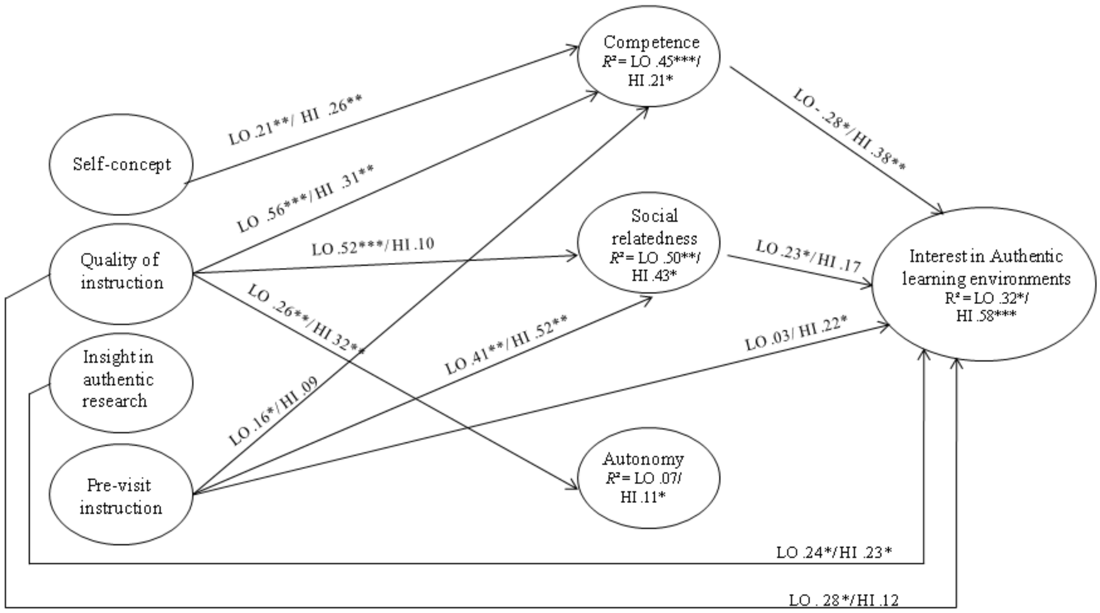

Figure 4. *Path model predicting situational Interest in Authentic learning environments. Grouping variable: Individual interest (median split); significant coefficients (std.) shown for students with low /high individual interest LO/HI.*

χ^2 = 180.9; *df = 138 p*(χ^2) = .0082; CFI = .93; TLI = .90; RMSEA = .048; *N* = 255.
$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

All this considered, this suggests that participants with a low individual interest felt curious in the exciting new learning environment without connecting the stay in the student lab with their pre-visit instruction. They rather developed a situational interest in the authentic learning environment feeling a high amount of social relatedness with their peers and affirmatively the path coefficient for competence feeling is negative. For high interested students, competence feeling, insight in authentic research and pre-visit instruction became significant predictors. Those participants seemed to link the stay in a student lab together with a scientist to their pre-visit instruction and their feeling to be competent to understand the authentic research provided to them might have enhanced their interest in the authentic learning environment on the university campus.

Basic needs (competence, autonomy, social relatedness) as mediator variables promoting interest

Concerning the design of the study, basic needs can be seen as mediator variables with regard to the independent variables and the variables concerning students' situational interest. Feeling of competence (M = 3.33, SD = .54) and social relatedness (M = 3.07, SD = .52) were scored by the students on a high level, while the mean for the autonomy scale (M = 2.46, SD = .82) is close to the mid-range of the scale (range 1-4). Correlations between the situational interest scales and the basic needs became significant for interest in experiments (Table 4) and point out the relevance of the basic needs even for activity-based aspects of the learning environment.

The correlations between the feeling of autonomy and the scales representing students' situational interest were not as high as expected, whereas the correlations with social relatedness appeared as significant.

Structural equation analyses to identify variables as predictors for the basic needs (competence, autonomy, social relatedness) once more provided different results for students with high vs. low individual interest (Figures 2,3,4). Participants with low interest profit from support and quality of instruction as well as from their self-concept and the degree of pre-visit instruction, while for students with high individual interest, self-concept and quality of instruction became the most prominent significant predictors for feeling competent in the student lab.

Table 4. Partial correlations (Spearman) between basic needs and dimensions of students' situational interest, controlled for individual interest

	Interest in Research and Application contexts	Interest in Authentic learning environment	Interest in Experiments
Competence	.21**	.11	.39***
Autonomy	.20*	.09	.20*
Social relatedness	.39***	.30**	.33***

Note. *p < .05. **p < .01. ***p < .001.

Pre-visit instruction (Integration into classroom lessons)

Many research studies indicate that the integration of out-of-school learning activities into classroom lessons (pre-visit instruction) is crucial for the intended outcomes. In our study, analysing students who experienced a high vs. a low degree of pre-visit instruction (divided by a median-split), significant differences for all three scales concerning students' situational interest could be shown (Mann-Whitney-U Test; $p < .001$). The conducted path analyses identified mediator-effects accountable for this. This means that the degree of pre-visit instruction had an impact on competence feeling and, therefore, did not become significant as a predictor variable on its own. Following Baron and Kenny (1986), three conditions must be fulfilled in order to establish mediator-effects: First, the independent variable (pre-visit instruction) must affect the potential mediator (competence). Second, the independent variable must affect the dependent variable (interest in experiments). Third, the potential mediator must affect the dependent variable even when the effect of the independent variable is controlled for. The indirect effect of pre-visit instruction on students' interest in experiments via competence was significant ($z = 4.13$, $p < .001$).

In addition, competence could be shown as mediator variable analysing the predictor effect of the variable quality of instruction and social relatedness became significant as a mediator between quality of instruction, pre-visit instruction and students' situational interest (Figure 2,3,4). This reveals the relevance of the social relatedness in the process of interest development, a relationship we had not expected having this relevance.

Discussion

Although many of the student labs have evoked a high degree of acceptance, there is a lack of studies investigating whether the potential of student labs to promote students' interest can be related to the described characteristic aspects of the out-of-school environment. The first aim of the study was to describe an instrument investigating students' interest in student labs as a new type of out-of-school settings based on theories of interest and interest development. Based on this instrument, further analyses aimed to investigate which factors are crucial to support students' interest, with a special regard to clear up differences between students showing different levels in their prior individual interest in science.

First, the factor analysis and reliability analysis resulted in a clear factor structure and led to the underlying structure of the three main components of students' situational interest in a student lab. The factors representing (1) Interest in experiments, (2) Interest in research and application contexts, and (3) Interest in authentic learning environment were statistically identified as separate factors describing students' situational interest in the student lab. Analyses of interrelationships with several independent variables confirmed students‘ situational interest in the student lab as being multi-dimensional. As expected, prior individual interest in the sciences shows the highest correlation with students' interest in experiments. However, being interested in research contexts and out-of-school learning environments does not seem to be strongly related to students' prior individual interest but rather to the interestingness of the situational factors like insight into authentic research and the quality of instruction. As the interest theory assumes situational interest to always be composed of one's long-lasting individual interest with the interestingness of the learning environment, a major research interest of the study was to examine, whether student labs have the potential to promote students' interest even if the students have little prior individual interest. Structural equation modeling provided further explanations for student labs' potential for promoting participants' interest. The results show that a lack of students' individual interest can be counteracted by well-defined support during the visit to the student lab or a high degree pre-visit instruction. In addition, predicting low interested learners' situational interest in student labs in our research agrees in several aspects with research on triggered situational interest in early phases (Hidi & Renninger, 2006), with the priority of experience rather than specific information or skills. A first insight in authentic research, presented by a scientist while staying in a professional laboratory and handling unknown lab equipment fulfills the criteria 'arousal' and 'curiosity', described as two factors promoting situational interest (Mitchell, 1993) , and not presupposing any appreciable individual interest. These exciting aspects of the learning environment can result in student's predisposition to reengage in the subject matter again and reach the next level of developing a long lasting individual interest (Hidi & Renninger, 2006). However, it has to be discussed, why these aspects come to the forefront notably for students with low individual interest in science. It could be assumed, that low interested learners do not make use of different sources of information about science outside school and the novelty effect in the student lab therefore stands in the foreground. Insight in authentic research presented in the new lab environment seems to play a crucial role for those students' situational interest. High interested students seem to develop situational interest when feeling competent and for this subpopulation, the link to pre-visit instruction is a significant predictor for situational interest in authentic learning environment. These students might appreciate the chance to aquire knowledge beyond classroom lesson presented by scientists. Taken together, the results indicate that student labs have the potential to enhance most participants' interest. This occurs differently, depending on different stages of interest development (Hidi & Renninger, 2006) and with some differences in the student lab aspects that are perceived as interesting by the students. Our results clearly indicate that gender has no relevance on students' interest in student labs as shown before in several studies (Hofstein et al., 1976).

Basic needs. As not a lot is known about the conditions that can support interest to shift from one phase to another (Hidi & Renninger, 2006), the results of this study point out the strong relevance of the three basic needs, especially for hands-on and activity-centred learning environments. The basic needs were analysed as mediator variables with regard to the theory of interest development. Students' competence experience could be shown to be a relevant factor in predicting students' interest and indicates the relevance of prior knowledge while doing practical work. Competence experience can be assumed to be critical to students' interest development, especially in activity-based learning environments with a high proportion of hands-on activities. Autonomy experience, in contrast, did not reach statistical significance as a predictor for any dependent interest variable. This corresponds with many research studies that assumed the open-endedness of experiments, which in some aspects is in line with autonomy experience, as being relevant for students' interest in practical work, but failed to prove it (Basey, Sackett, & Robinson, 2008). Social relatedness became obvious as a significant predictor for students' interest in the student lab. Results corroborate the thesis that cooperation and communication have an influence on interest development (Hofstein, 2004; Hofstein & Lunetta, 2004; Mitchell, 1993; Renninger & Hidi, 2002). The relevance of group work has been discussed for out-of-school environments by Falk & Dierking (2000) and for practical work in the laboratory by Fraser et al. (1993) and could be shown in this study as having a strong and prominent impact.

Pre-visit instruction. As described before, the pre-visit instruction was assumed to have a high influence on students' situational interest. Fraser et al. (1993) showed that of the five scales of the instrument (SLEI), integration had the best positive correlation with students' affective and cognitive learning outcomes. Results from this study confirm this assumption by showing significant differences between the situational interest of students with a high vs. those with a low degree of integration. However, pre-visit instruction failed to appear as a prominent predictor for interest in the regression analyses. Primarily, mediator effects could be shown to be accountable for this, because pre-visit instruction predicts the significant interest predictor variables 'competence experience' and 'social relatedness' and, therefore, becomes less important as a significant variable on its own in the regression model. With regard to the student lab's programme, a further explanation could also be discussed. In the definition of Domin (1999), the instruction style to be followed in the laboratory can be characterised as 'expository style' with defined procedures, directed actions of the students, and predetermined outcomes. It can be presumed that a more inquiry-type laboratory style would strengthen the correlation with integration because more prior knowledge would be required to master the lab programme and perceive the visit to the student lab as interesting and not overwhelming.

Conclusions

The strength of this study in the assessment of the potential of student labs to promote interest lies in the fact that it considered many variables as possible predictors. Paying close attention to the interest theory and theories of interest development, an evaluation design was developed and realised that turned out to be very suitable.

From a theoretical perspective, we wanted to understand how the several characteristics of student labs contributed to the development of situational interest. With the basic needs shown as mediator variables, this approach seems applicable - especially for hands-on and activity-based learning environments. Considering the basic needs in instruments for assessing students' interest can lead to a broader understanding of the process of interest development. However, this model has to be proved in other contexts to confirm the function of the basic needs in the process of interest development.

There are limitations to our study. Because interest development is a long-lasting process, we will have to investigate long-term effects of these out-of school learning environments. Further research will have to clarify the unexpected effects of social relatedness. Video-analyses could be helpful to clarify the effects of collaborative work and students' communicative processes while doing practical work and being in the role of a scientist.

The study provides evidence about to answer the question of how the scaffolding of participation in a student lab might be optimally provided for participants in different phases of interest development. Students with a low prior individual interest seem to be impressed by the professional environment itself and need instructional support to develop situational interest. These experiences have to be integrated into school science, to effectively blend out-of-school and school learning in order to significantly enhance students' interest and the learning of science. Students with a high individual interest might be scaffolded to focus on additional aspects of the out-of-school experience. For these participants the question is what conditions support them to shift from exploring science content to posing questions that characterize science literacy and authentic science tasks. Maybe there should be special programmes for high interested learners to make real-world science accessible to them and to give the chance to get a deeper insight in authentic research by a real scientist.

Lee & Songer (2003) point out the difficulties and challenges with regard to implementing authentic science in science education. The practical work observed in the student lab was effective in enabling the majority of students to do what the scientist intended. It is not clear if the practical tasks observed are effective in helping students to see the task from a scientific perspective and to develop substantive and procedural understanding. Further studies having an experimental approach might help to design student lab programmes that both emulates inquiry in science disciplines and is accessible to students.

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