**Out-of-school STEM learning in Germany: Can we catch *and* hold students' interest?**

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*Abstract*
Visits to informal learning facilities such as museums, science labs, zoos etc. are popular in school practice in Germany. With regard to students' interest in science positive effects are ascribed to theses learning settings. However, is there empirical evidence that supports this view? This talk summarizes ten years of research done in Germany that investigated students' situational interest in science in the context of informal learning. Most of the eight studies included in the review were published in German only and hence escaped international attention. Nevertheless, the results are not specific to Germany but of international relevance. It is our aim to present theses results and discuss them in an international science education context.

*Introduction*
In the last 15 years over 300 so-called *out of school laboratories* have opened their doors in universities, research institutes, science centres, museums and commercial companies all over Germany in order to give students the opportunity *do* science. The main goal of all laboratories is to catch and hold students interest in science. This is important since interest is one of the most important predictors for students' motivation and achievement in school. "[T]here appears to be a cause and effect relationship between the affective and cognitive: an increase in the affective responses of a student toward or in a given learning experience leads to higher levels of motivation which, in turn, should result in improved learning" (Kern & Carpenter 1986). So far, eight Germany-based studies looked at the effects of how informal learning facilities raise students' interest in science. Unfortunately, most of these studies were published in German only despite their international relevance. This is why we bring them into international attention. In the following we will give an overview of the gained results of these studies and put them into an international context. In order to do this, we will look briefly into the concept of interest, specify our review focus, and present and discuss the results.

*Theoretical background*
School classes in Germany regularly visit *science labs for school students*. In these institutions the students get the opportunity to deal with specific scientific questions and to conduct experiments in one-day projects on an informal basis. Almost all of these labs follow the aim to raise students' interest in science.
The following gives a short summary of the underlying concept of interest in order to familiarise the reader with what is exactly meant by this term. This is necessary due to a very different und imprecise use of phrases like "raising students' interest" in literature. The theoretical background of most of the studies was provided by the psychological definition of interest as proposed by Krapp et al. (1999, 2002). By this definition interest emerges from an interaction of pre-conceived structures of an individual (*individual interest*) and the *situational interest* caused by the interestingness of a subject for instance. Interest can be subdivided into three components: the *emotional component*

describes the amount of positive feelings assigned to certain activities, the *value-related component* considers whether the activities have a special importance to the individual, and the *epistemic component* finally mirrors the desire to learn more about the content. Generally, situational interest triggered by external factors is only a short-term effect. The question remains how to turn this momentary interest into dispositional interest. Mitchell (1993) proposed a multifaceted approach to situational interest, consisting of so-called *catch-* and *hold-facets* to describe this transition. The genesis of dispositional interest is preceded by two steps: The first step being the arousal of situational interest achieved by catch-facets (e.g. initiate cognitive conflicts, group work, puzzles etc.) which is only effective on a short-term basis. Hold-facets however stabilise the interest for a longer period (step 2). This is accomplished by a. making the content of learning meaningful for students and b. involving the students in *active* work. Not until this is achieved, the individual performs self-initiated activities concerning the subject matter further on, which means that the person has now fully developed a dispositional interest. (For a different stage model of interest see Hidi and Renninger 2006.)

Table 1. Studies included in the review and their basic characteristics.

| **Author/s, subject/s** | **Variables** | **Participants** | **Design** | **Additional information** |
|---|---|---|---|---|
| Engeln (2004), physics | Characteristics of the science labs: authenticity, openness of the experiments, cooperation of students<br>Personal attributes: situational interest, dispositional interest, self-concept, gender | Age: 15-16 years<br>n=334 (1st. survey)<br>n=265 (2nd. survey) | Intervention with post-test and follow-up-test 12 weeks later | Five different science labs |
| Brandt (2005), chemistry | Self-concept, gender stereotypes, dispositional interest, intrinsic and extrinsic motivation | Age: 13-14 years<br>n=494 | Pre- and post-test, follow-up-test four months later | Design with control-groups |
| Scharfen-berg (2005), biology | Acceptance of the science labs, knowledge acquisition, interest | Age: 18 years<br>n=314 | Pre- and post-test, follow-up-test six weeks later | Design with control-groups |
| Guderian (2007), physics | Situational interest, dispositional interest, curricular integration | Age: 11 and 16 years<br>n=93 | Pre- and post-test | Multiple vists to one science lab, curricular integration |
| Priemer et al. (2007), different subjects | Epistemic component of the situational interest | Age: 12-18 years<br>n=709 | Intervention with post-test | Different science projects in one science lab |
| Glowinski (2007), biology | Dispositional interest, situational interest | Age: 16-18 years<br>n=458 (1st. survey)<br>n=378 (2nd. survey) | Intervention with post-test and follow-up-test 10-12 weeks later | Five different science labs |
| Pawek (2009, 2012), physics | See Engeln (2004) | Age: 15-19 years<br>n=734 (1st. study, 2009)<br>Age: 17<br>n=83 (2nd. study, 2012) | 1st. study: pre-, post-, and follow-up test design<br>2nd. study: second follow-up-test after one year | Four different science labs |
| Zehren (2009), chemistry | Inquiry experiment, curricular integration, motivation, interest, knowledge acquisition | Age: 14 years<br>n=287 (1st. study)<br>Age: 15 years<br>n=131 (2nd. study)<br>Age: 16 years<br>n=100 (3rd. study)<br>Age: 19 years<br>n=92 (4th. study) | 1st. study: post-test after five visits<br>2nd. study: second post-test after 1-5 additional visits<br>3rd. study: third post-test after 1 additional visit<br>4th. study: fourth post-test after up to 25 visits in total | Four different projects in one science lab, design with control-groups |

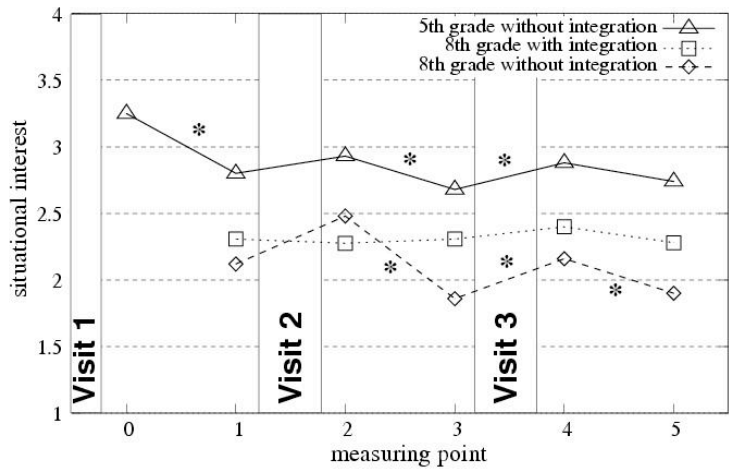


*Figure 1. The epistemic component of situational interest. Stars depict significant differences (p<.05). The y-axis consists of the full scale of the epistemic component with 1 being low interest and 4 being high interest (see Guderian 2006).*

*Research questions*

How do one-day visits to science labs for school students influence students' situational interest in science? What summarizing results can be stated when all relevant studies in German speaking countries are analyzed?

*Method*

We included in our review all studies that were a. conducted in German speaking countries, b. carried out in science labs for school students, c. focused on interest as a main research aim, and d. based on empirical data.

*Results*

Altogether eight studies fulfilled these criteria. They are characterized in brief in table 1 stating the authors, the science subjects addressed, variables investigated, participants, design of the study, and additional information.

Despite the heterogeneity of the studies and the evaluated science labs for school students some general results emerge. For example the science topic addressed, the age of the participants, and the characteristics of the laboratory influence students' interest. Due to the limited space here this proposal illustrates only one aspect in detail. We will address more results in the talk.

There is empirical evidence that visits to informal learning facilities raise students' interest in science significantly. The science projects catch interest! However, the results are divergent when looking at the long-term effects. While Guderian (2006) states that there is a drop in students' interest in the time after the visit, Pawek (2009, 2012) finds lasting effects. Since we think that it is important to know if out-of-school learning does not only provide catch- but as well hold-facets we take a closer look at both studies.

<u>The Guderian-study.</u> Figure 1 shows the epistemic component of the situational interest of three different groups of participants (one with an integration of the visit to the school curriculum) for six different times. It can be seen that both groups without integration showed mostly a significant increase of interest directly after each visit and a succeeding decline in the weeks following. All significant differences (as measured by t-tests) show

medium to high effect sizes. Obviously, the wish to learn more about the contents presented in the units of the science lab was significantly higher after the visit compared to the point of time before the next one. It is interesting to note that the values of the 5th-grade students exceeded those of the older age group significantly (as measured by analysis of variances), but the variation of the values with time is comparable to the 8th-grade class without curricular integration. It is apparent that only the group with integration showed constant development of interest. Although no increase immediately after a visit is palpable a subsequent decline in the weeks following is missing too.

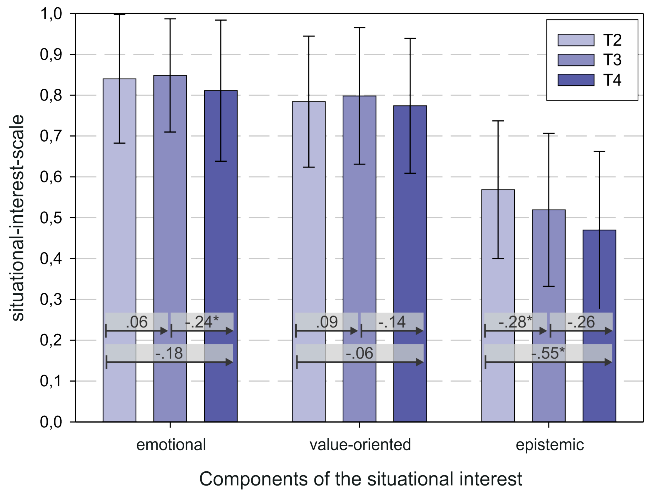


*Figure 2. Three components of situational interest (mean and std. deviation) directly after the visit (T2), six to eight weeks later (T3) and one year later (T4). Stars behind stated effect sizes depict significant differences (p<.05). The y-axis consists of the full scale with 0 being low interest and 1 being high interest (see Pawek 2012).*

<u>The Pawek-study.</u> Almost all school students agreed – six to eight weeks after a visit – that the science projects were fun (emotional component). They rated the experience as personally very important (value oriented component). Half of the participants stated that they would like to continue working on the topics addressed (epistemic component). The slightly declining mean values between the second and third survey indicate to a long-term drop of situational interest. Indeed, the emotional and the epistemic component decreases significantly (Wilcoxon and paired t-test), but the corresponding effect sizes are small. The change in the value-related component is not significant. One year after the visit, a subsample of 83 students were surveyed a fourth time (Pawek 2012). There are no significant changes between the surveys directly after the visit (T2) and one year later (T4) (see figure 2). Only the epistemic component decreases significantly with a medium effect size. However, the resulting mean value is still nearby the center of the scale. In summary, the generated situational interest seems stable.

It is obvious that both studies come to different conclusions regarding long-term effects. This may be due to different test instruments, samples, topics, characteristics of the labs involved, and preparation of the students before visiting the labs. At the moment we cannot give a final answer to this question.

*Discussion*

”If learners consider their experiences during the visit to be rewarding and enjoyable, then it is likely they will be receptive to subsequent related instruction. [...] In other words, an enjoyable and successful visit experience is an important outcome because it can predispose the learner to engage in further cognitive learning" (Rennie 1994). The cited paper is 20 years old but the message is still true. This is why informal learning is increasingly important to teach science. Science labs for school students provide interesting learning settings with a special focus on experiments. They catch students' interest. We assume that this is due to the stimulating learning setting with experiments (see for example Palmer 2007) and the authenticity and novelty of the place (see for example Dohn 2010, Orion 1993, Falk 1983). They can offer topics, material, and expertise schools usually do not have. However, in order to gain most of the investment the informal learning facilities make, the projects should be linked to school learning. This can be done by pre- and post instruction, by multiple visits, and by integrating the visit to the school curriculum. The results reveal the necessity to incorporate visits to extracurricular learning facilities into the current curriculum to attain effects exceeding the short-term nature of stand-alone visits as shown also by Jarvis and Pell (2005) in a museum context. This has to be done carefully since the interestingness of the learning situation may decrease when it resembles "usual" school learning. However, if learning in out-of-school context does *empower* (see Mitchell 1993) students to do science their interest may not only be caught but also held.

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