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Interest in Biology: Grade-dependent Differences and Benefits of Participating in Out-of-school Interventions

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Abstract

Many studies have shown a decrease in scientific interest with an increase in age. Since interest is linked to a high degree of deep-level learning, it is of great relevance to foster interest in science. This study investigates interest in biology from 7th, 9th, and 12th grade students in Germany (N=257). Results show a significantly lower interest in 9th grade in comparison to 7th grade, but a significantly higher level of interest in 12th grade compared to 9th grade. This increase could potentially be linked to the fact that students can chose to continue taking biology in upper secondary education, which leads them to be more interested in the subject. In order to increase interest in 9th grade students, a one-day intervention in an out-of-school student laboratory was developed. During the intervention, students conducted hands-on experiments to investigate the field of bionics. Students in 7th and 9th grade (N=121) participated in the intervention. An increase in interest in biology was observed in both grades. This highlights the potential of out-of-school laboratories to foster and develop interest. Future studies should investigate if the same effect is achieved using in-school interventions as well as looking at possible long-term effects.

Introduction

Interest is a prominent construct that has been heavily researched in educational science, as it undoubtedly has a positive influence on the learning process (Krapp, 1998). According to the Person-Object-Theory of Interest (Krapp, 1992), interest is linked to specific content, object or learning activity. Interest ~~"s~~parked" during an activity is called situational interest or interestedness (Müller, 2006, p. 52) and is linked to a particular ~~"o~~bject of interest". In the context of academic learning, this object is perceived as appealing to students either because of the content (e.g. genetics) or the context (e.g. conducting an experiment) (Geyer, 2008, p. 21f.; Krapp, 1998, p. 190). The combination of interestedness in an object with a high interestingness can lead to situational interest (see Figure 1). This form of interest is comparatively easy to evoke and can be seen as a starting point to develop individual and long-term interest (Krapp, 1998, p. 190f.). Although individual interest develops step-by-step over a longer time, exciting situational interest can lead to a higher degree of deep-level learning in the long-term (Krapp, 2002), which is desirable in an educational setting.

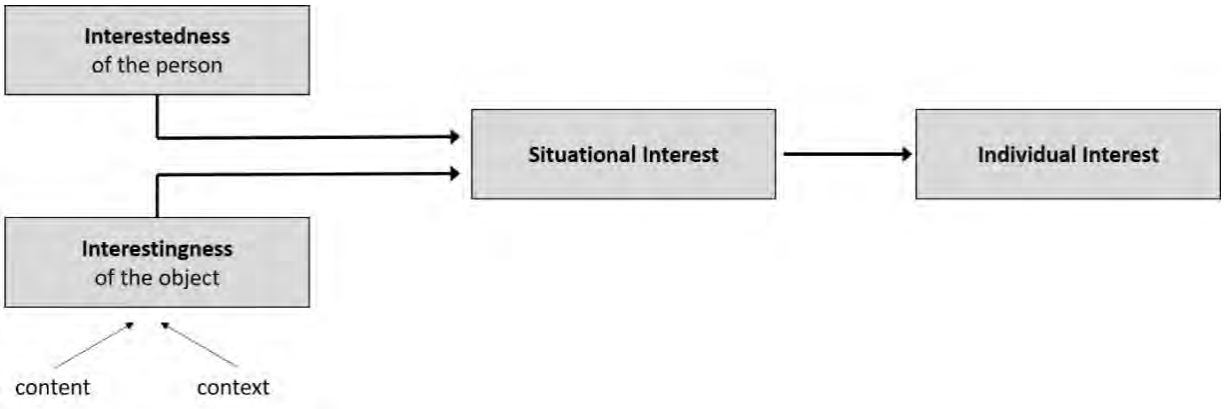

Figure 1. Interest Development (Krapp, 1998; Deci & Ryan, 1993; adapted by Elster, 2010)

Since interest is both subject- and topic- dependent, it is crucial to differ between interests in different scientific fields (Vlckova, Kubiatko & Usak, 2019). Although some studies look at a general scientific interest, it has been argued to look at interests in subdisciplines (such as biology or technology) and to focus on specific topics or contexts (Potvin & Hasni, 2014, p. 796). Fairbrother (2000) and Osborne (2003) have shown that students are generally more interested in biology than other scientific subjects, which could be explained by the fact that biology is strongly linked to everyday-life experiences and interactions with the human body, animals and plants (Gebhard, Höttecke & Rehm, 2017).

Gender and age influence scientific interest. Gender differences have been demonstrated ―with boys being on average more interested in physics and girls in biology" (Uitto, Juuti, Lavonen & Meisalo, 2006, p. 124; Direito, Connolly, Simon & Trevethan, 2017). However, Potvin and Hasni (2014) argue that gender differences are yet not fully understood and small in most reported studies (p. 789). In addition, age greatly influences general scientific interest, including in biology. Primary school students tend to have considerable interest in science, but this declines once they start secondary school (Gebhard et al., 2017; Osborne, 2003; Potvin & Hasni, 2014; Prokop, Prokop & Tunnicliff, 2007; Vlckova et al., 2019). In some studies, an increase in interest is reported after 10th grade, which may be a result because students are allowed to choose a subject themselves (Dietze, 2007). Interest in a subject has been shown to be a significant predictor for academic achievement and achievement-driven decisions for course election in secondary education (Bøe, 2012; Mujtaba & Reiss, 2013).

However, it is challenging to compare study results because curriculums can vary depending on what is offered for each grade, not only in different regions but entire countries, rendering it ambitious to measure interest in a specific topic for a certain grade. Moreover, studies concentrating on content do not always conclude the same results and might be biased within the same study. Meyer-Ahrens et al. (2014) ranked topics in the national biology curriculum with regard to interest; primary school students were asked using a questionnaire if they want to learn about different topics. Their results show that ―nutrition and digestion" is ranked 35 (of 39), whereas the context ―delicious and healthy" is in 4th place. A recent study by Jördens and Hammann (2019) highlighted that ―topics are the dominant dimension and moderate the general level of interest that students express in both topic-context and topic-activity combination". Therefore, the choice of context and activity might be less important than it was initially assumed to be. Instead, the topic itself determines the amount of interest.

In order to combat the decrease in scientific interest and to increase future achievements in PISA or TIMMS, more than 350 student laboratories have been established in Germany (Röllke, Maak, Wenzel & Grotjohann, 2020). These labs support the educational system by providing activities in an authentic environment. Furthermore, they give students the opportunity to conduct experiments that are often not possible to do in school, due to a lack of equipment and/or time. Out-of-school laboratories have a positive influence on multiple factors such as interest, motivation, and attitude towards science (Glowinski & Bayrhuber, 2011; Rodenhauser & Preisfeld, 2018), demonstrating the potential value it can add to the German educational system. Many schools implement a student laboratory visit in their school program; this allows us to evaluate workshops and investigate possible effects of the intervention.

Method

Study Design

This study was conducted in a student laboratory in 2019. The student laboratory ―Biology Up Close" was established in the biology didactic department at Bielefeld University in 2009 (Wegner & Strehlke, 2015) and consists of a series of workshops (see Table 1, Figure 2 and Figure 3). Workshops are supervised by faculty members or biology students that are intending to become teachers. All workshops focus on independent experimenting adhering to the scientific method and problem-solving in small groups. The workshops were conceptualized as an extra-curricular activity for students between 13-18 years old, where classes visit the university as part of a field trip.

The first section of the study investigates students in 7th, 9th, and 12th grade, and their general interest in biology. Our objective is to explore differences in 7th and 9th graders who take part in an out-of-school student laboratory ―bionic" workshop. This topic is not included in the national curriculum, but can be used as additional context to highlight curriculum topics (e.g. ―bionic" is a specific context for ―humans using plants and animals") or as an additional topic or field trip designed to foster interest in biology. Concerning the results from Prokop et al. (2007) and other studies, 7th and 9th grade students are especially interesting to examine, as there is a strong

decline of interest between these age groups. As biology is not offered in 8th grade in the state of North-Rhine-Westphalia, Germany, it was not possible to include all grades in our intervention. We aim to investigate if a general interest in biology is affected after taking part in the intervention. Additionally, we will explore age-differences observed by other studies.

Table 1. Brief Description of Workshop

Workshop	Description
Bionics – Using nature as a model	Climbing up walls like Spiderman? Many geckos find themselves in similar situations. Several of them are true trapeze artists and climb vertically up smooth surfaces. In this workshop basic principles will be covered, along with other exciting topics involving handling live animals, conducting experiments and exploring different models. (Figure. 2 and 3)

Figure 2. A Student Conducts an Experiment about the Lotus Effect

Figure 3. Students Take a Closer Look at the Skin of a Cat Shark (They discover the benefits of this physical adaption and discuss possible bionic-related inventions.)

Hypothesis

The aim of this study reflects current research about interest in biology. Since an interest in biology is dependent on the content and therefore possibly country-specific due to different curricula, we plan to investigate student interest in biology in three different grades (7th, 9th, and 12th). Since students can choose between different scientific fields and do not have to continue studying in biology after 9th grade, we formed the following hypotheses in regard to age and interest:

H1a: Biological interest decreases from 7th to 9th grade, independent of gender.
H1b: Biological interest increases from 9th to 12th grade, independent of gender.

Furthermore, we propose that a 5-hour bionic intervention workshop can increase interest in biology for students in 7th and 9th grade. We assume that an increase in interest is independent from age.

H2a: Students from 7th grade increase their interest in biology after taking part in the bionic intervention.
H2b: Students from 9th grade increase their interest in biology after taking part in the bionic intervention.

Participants and Data Analysis

A total of N=257 students from 7th (two classes, n = 58, 43.3% female, mean age = 12.32 years, SD: 0.57), 9th (three classes, n = 63, 57.1% female, mean age = 14.6 years, SD: 0.71) and 12th grade (seven classes, n = 127, 60.6% female, mean age = 17.5 years, SD: 0.95) participated in our study. Local schools can apply to participate in one of our workshops, particularly if it can be linked to a current topic that the students are learning. All classes from 7th grade, two classes from 9th grade and 3 classes from 12th grade are from the ―Gymnasium" (highest level of high school, where passing the final exam allows the student to later attend university), whereas the other classes (one from 9th grade and four from 12th grade) are from a ―Gesamtschule" (similar to an US-American high school, covering all learning levels).

Questionnaires were handed out to students before and after the respective workshops. The pre-test focuses on prior experiences with biology in school, specifically with interest in the subject. The post-test evaluates the completed workshop and focuses on the situational interest evoked by the intervention. Since the 12th grade students completed a different workshop (e.g. about photosynthesis or enzymatic reactions), only their pre-test results about interest in school biology is used for this study, whereas, post-test results about their situational interest evoked by the intervention is not displayed in this study. The presented results are part of a larger research project within the out-of-school student laboratory investigating multiple aspects, but the relevant questionnaire items used in this study deal with interest in school as well as interest in the specific workshop. Each item was rated on a six-point Likert scale (ranging from *strongly disagree* to *strongly agree).* Additionally, personal and demographic data such as grade, type of school, and prior knowledge were included. Cronbach's α values indicate that this is an acceptable test instrument (see Table 3). ANOVAs were calculated to determine the effect of grade and gender on interest in biology, as well as applying a repeated measures ANOVA to investigate the effect of the bionics workshop on interest in biology for 7th and 9th graders (analyzed using SPSS v. 24.0).

Table 3. Overview of Scale Interest with Number of Items and Respective Cronbach's α Values

Scale (reference)	Number of items	Cronbach's α (WS)	N
Interest – school biology (Wegner 2009)	4	.747	242
Interest – bionics intervention (Wegner 2009)	4	.702	120

Results and Discussion

Tukey post-hoc analyses revealed a significant difference between the different grades. The mean level of interest in biology was lower in 9th grade students than in 7th grade students (0.52, 95%-CI[0.14, 0.90] with p = .005) but higher in 12th grade students than in 9th grade students (-0.60, 95%-CI[-0.93, -0.27] with p < .001) (see Figure 4).

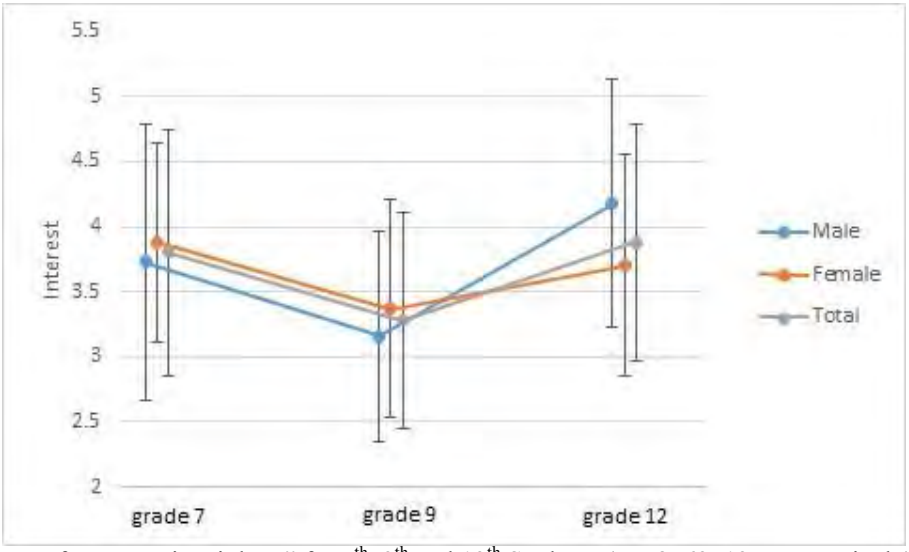

Figure 4. Mean of „Interest in Biology" for 7th, 9th and 12th Students (n=58, 63, 127, respectively) as a Group and Separated by Gender

No significant differences were found when comparing interest in biology in 7th and 12th grade students. The difference in interest from 7th to 9th grade is in line with results from previous studies that have shown a decrease in interest with increasing age (Gebhard et al., 2017; Osborne, 2003, p. 1060; Potvin & Hasni, 2014, p. 785; Vlckova et al., 2019). Furthermore, findings from Prokop, Prokop and Tunnicliff (2007) highlight that „6th grade students (ages 11-12) scored highest and 8th grade (ages 13-14) students lowest regarding interest in biology" (p. 38), which is supported by our data with 7th and 9th grade students. However, an increase in interest in biology in 12th grade students is paramount. Potvin and Hasni (2014) conducted a review to look at a decrease in scientific interest and show that only few studies research interest in students from age 16 onwards; moreover, results are contradicting (p. 786). Cheung (2007) and Gottfried et al. (2009) find a further decrease in scientific interest,

whereas Dietze (2007), Hassan (2008) and Reid and Skyrabina (2002) detect an increase in interest in older students.

An important factor to consider with our results is that one needs to keep in mind that students can elect specific subjects after 9th grade. Therefore, it is assumed that only students interested in biology will continue to study it, which may display an increase in interest in 12th grade (Dietze, 2007). However, since every student has to take at least one science class (biology, chemistry or physics), biology is often chosen by "uninterested" students as well because it is depicted as an "easy or soft science" in comparison to "difficult or hard sciences" such as chemistry and physics (Jansen, 2015, p. 13). Further studies need to be conducted to understand the individual development of interest in biology, especially with regard to electoral reasons in higher grades. It is of interest to perform a longitudinal study to investigate whether students who continue studying biology after 9th grade did already have a high interest in biology beforehand or if the factor of choosing influences the perceived interest. Our current cross-sectional data does not display actual longitudinal changes; however, the measured differences highlight the importance of investigating personal long-term interest developments.

When looking at the possible influence of gender, a statistically significant interaction between grade and gender was found, suggesting that the changes from 7th to 9th grade and then to 12th grade are independent from gender ($F(2, 240) = 4.140$, $p = .017$, partial $\eta^2 = .003$). Male students have a lower interest in biology in 7th and 9th grade, whereas their interest is higher than females in 12th grade. Gender differences in scientific interest have been displayed with boys being on average more interested in physics, girls in biology and no significant difference in chemistry (Direito, Connolly, Simon & Trevethan, 2017). This could result in different electoral behavior when it comes to choosing subjects in the higher grades. However, there was no significant main effect of gender, meaning that both genders do not differ within their grades ($F(2, 240) = 0.088$, $p = .916$, partial $\eta^2 = .001$). This underlines the conclusion that "boy-girl differences are rather small" (Potvin & Hasni, 2014, p. 796). In conclusion, both H1a and H1b can be verified by our data.

Students in 7th and 9th grade participated in an out-of-school bionics workshop, with the goal to investigate its influence on scientific interest. We found no statistically significant interaction between time and group, however there was a significant main effect for time and group, suggesting that intervention groups differed between both points of measurement ($F(1, 119) = 0.064$, $p = .801$, partial $\eta^2 = .001$; $F(1, 119) = 14.258$, $p < .001$, partial $\eta^2 = .107$l; $F(1, 119) = 18.372$, $p < .001$, partial $\eta^2 = .134$, respectively). This indicates that the bionics workshop increased interest in biology in both group, independent from grade. Therefore, both 7th and 9th grade students benefit from the intervention since it increases interest, however, mean differences in 7th and 9th grade do not change significantly (see Figure 5). This increase in interest may be explained by the workshop, confirming previous studies that show positive effects of external laboratories (Brandt, 2005; Guderian & Priemer, 2008).

Future studies should investigate whether the same workshop as part of an in-school intervention could result in the same effects. Wüst-Ackermann et al. (2018) investigated the effectiveness of an out-of-school intervention in comparison to an equivalent in-school intervention; their results indicate that both interventions had a positive effect compared to the control group that did not participate in neither of the workshops. However, the out-of-school intervention was superior. Future research should investigate if this effect can be applied to different topics and subjects. Moreover, a follow-up testing should look for long-term effects. In conclusion, both H2a and H2b can be verified by our data.

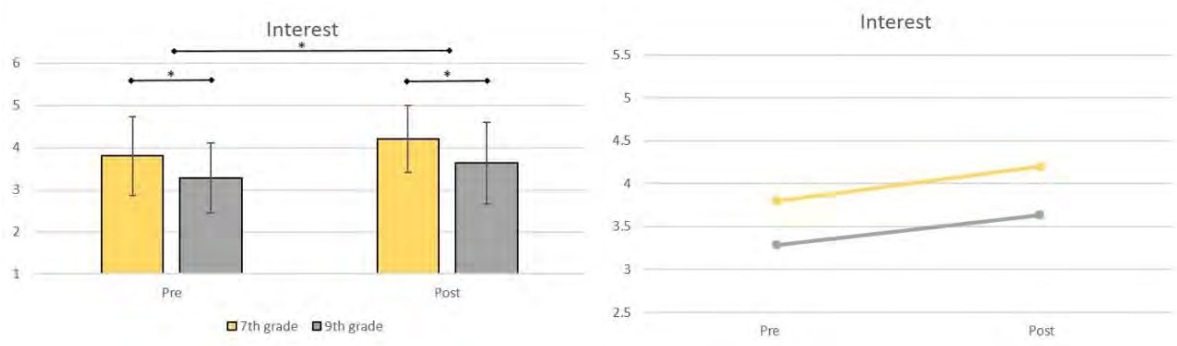

Figure 5. Mean of "Interest in Biology" for Students from 7th and 9th Grade (n=58, 63, respectively) in Relation to their Regular Biology Lessons (pre) and the Bionics Intervention (post)

Conclusion

The study demonstrates the well-known trend of a decrease in interest in biology from 7th to 9th grade. However, we highlighted a positive effect in observing a high interest in biology in 12th grade. As this age group has been neglected in previous studies, it might be of interest to investigate the development of interest on a larger scale. In the context of our study, it is assumed that the factor of choosing biology as an elective after 9th grade might increase subject interest. Hodapp and Mißler (1996) and Köller, Daniels, Schnabel and Baumert (2000) have shown that self-concept and interest determine subject choice in the last few years of high school. However, since every student has to take at least one scientific subject, many students choose biology since it is assumed to be the „easiest option". This trend has not changed in the last 20 years; Roeder and Gruehn (1996) investigated the number of students across the spectrum of all subjects and concluded that 75% of students continue with biology in upper secondary education (Roeder & Gruehn, 1996, p. 505). This has also been shown in Merzyn (2010), as 69% of his sample chose biology (Merzyn, 2010, p. 2). He concludes that biology has more everyday life-related content and does not appear to be too demanding in terms of academic requirements, which makes it appealing to the majority of students.

Nonetheless, a low level of interest in biology is seen in 9th grade. In order to tackle this nadir, we developed a hands-on bionics intervention for students between 7th and 9th grade. Our results show that situational interest increases in both groups of students after taking part in the intervention. More data is required to explore whether the interest decreases afterwards or if students benefit long-term. Since the workshop is only a one-day intervention, we assume a decline in interest in biology after a short amount of time; however, the intervention demonstrates that it is possible to increase interest for 9th grade students by providing hands-on experiments or out-of-school learning environments. Our data does not reveal all factors that influence interest, therefore further studies with in-school investigations should be conducted in the future. To investigate this, the test instrument should be modified to show differences in interest and investigate the achievement of the learning goals. Itzek-Greulich et al. (2015) conclude that learning goals can be achieved in both in-school and out-of-school interventions, as long as practical lab work is provided.

Taking all our results into consideration, we conclude that there is a decrease in interest in biology. However, if given the choice to voluntarily continue biology, an interest in the subject increases. To cope with the decline in interest in 9th grade, a hands-on intervention at an out-of-school student laboratory has shown to be suitable for a short-term increase in interest. The extent to which long-term effects can be achieved must be investigated in future studies; nevertheless, it is possible to „spark" interest in biology. Investigating interest in biology in our student laboratory has benefits that will be used for further studies. Since the project is well-established in the region, many local schools visit the student laboratory on a regular basis. Therefore, it is possible to gather data for long-term developments when students come for different workshops throughout their school career. By applying the same personal code in every study, we are able to track down personal interest development profiles that help us to support our hypothesis that we see a fluctuating development throughout secondary education. Furthermore, it is possible to detect which subject students continue with after 9th grade. Although the current data basis is limited, it presents possibilities for future studies. We hope that by having multiple interventions with a high level of situational interest (e.g. by different one-day workshops in the student laboratory) over the entire school career, one might see long-term effects concerning the individual interest in biology.

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