Authentic Learning and Teaching in an Out-of-School Lab - First Steps Towards Empirical Investigation of a Theoretical Model

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Abstract: Out-of-school labs (OSLs) aim at fostering students' interest in natural or social sciences by engaging them in authentic learning. However, definitions of authentic learning and explanations of its effectiveness are diverse. Therefore, Betz, Flake, Mierwald, and Vanderbeke (2016) developed a theoretical model that captures various aspects of this heterogeneous construct. Our goal in this paper is to undertake first steps towards an empirical investigation of this model based on data from two pilot studies that were conducted in an OSL. In both studies, we investigated whether the intended authenticity level of the method that students used to solve a given task had an impact on students' perceived authenticity and situational interest. Our studies show mixed findings that are contrary to the assumptions underlying the model of Betz et al. (2016). Hence, suggestions for an advancement of that model as well as implications for future research on authentic learning are discussed.

Introduction

The goal of science education is not only to foster students' knowledge of science (i.e., content knowledge of scientific concepts), but also their knowledge about science (i.e., knowledge of scientific practices) (OECD, 2007). Out-of-school labs (OSLs), also known as reach-out labs or non-formal student labs, seem to have potential to offer deeper insights into the practices of scientists and to promote students' knowledge of and interest in scientific ways of thinking and working (Haupt & Hempelmann, 2015). To foster students' literacy and interest in natural or social sciences, OSLs try to engage students in authentic experiential learning activities (e.g., Pauly, 2012). However, authentic learning approaches subsumed under OSLs are very diverse, and the same holds for definitions of the term authentic learning as well as for explanations of its effectiveness. A recent model of authenticity (see Figure 1) was developed by Betz, Flake, Mierwald, and Vanderbeke (2016).

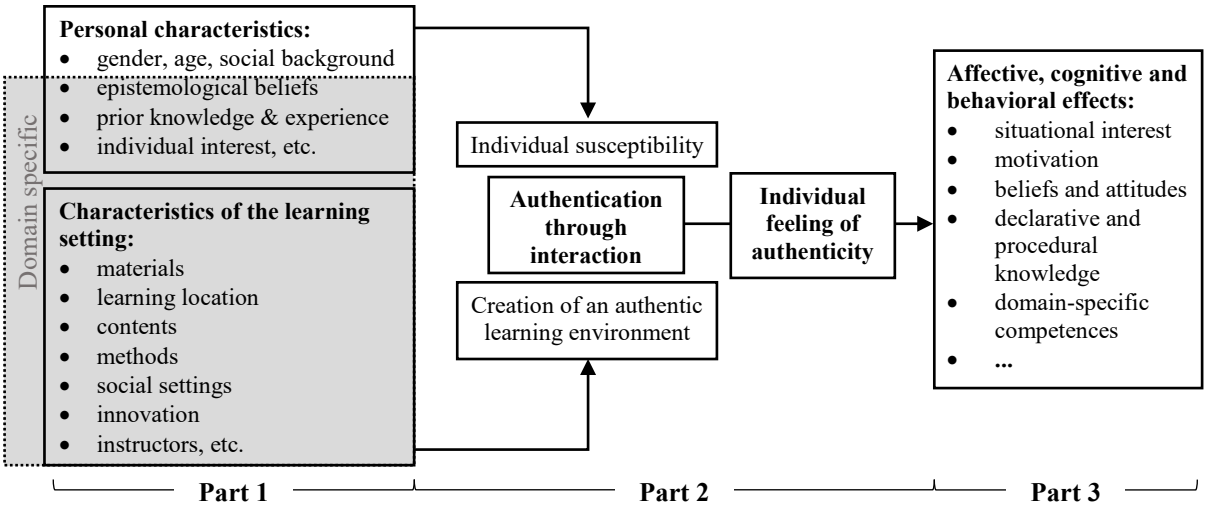

Figure 1. Model of authenticity in teaching and learning contexts (grey box: adaption, see discussion).

The theoretical model is divided into three successive parts. Part 1 can be characterized as the input-component of the model, as it highlights the characteristics of the learners and the features of the learning setting that may affect the authenticity of the learning context. Part 2 outlines the interaction of these two components in the process of authentication, which results in the individual perception of authenticity. Part 3 of the model includes outcomes that may be influenced by the perceived authenticity, such as the situational interest of students. Hence, this framework contains the assumption that the characteristics of learners and the features of the learning setting affect outcomes such as the situational interest of students, but that this impact is mediated by students' perceived authenticity. Previous research on authentic learning in OSLs demonstrated a

positive association between students' perceived authenticity and their situational interest (e.g., Pawek, 2009). Furthermore, findings from Betz (2017) showed that the location of the learning setting had an impact on those outcomes, as her results illustrated that students who studied in an OSL perceived higher authenticity and situational interest than students who studied in school. However, the question arises whether the variation of the authenticity level of characteristics of the learning setting other than the location, affects students' perceived authenticity and interests as well. In this paper we present data from two pilot studies focusing on whether a variation of the intended authenticity level of the scientific method that learners use to solve a given task or problem in two OSL-projects impacts students' perceived authenticity and students' situational interest. To investigate this question, we conducted two quasi-experimental pilot studies. Both investigations took place in an OSL at a large German university. Pilot study A was conducted in a lab for educational sciences and pilot study B in a lab for linguistics. Both pilot studies comprised two experimental conditions: an authentic method (A+) where students had to solve a problem by applying a scientific procedure, and a less authentic method (A-) where students had to solve the same task by using a practice that does not simulate the typical habits of scientists. Within the lab for educational sciences of study A, students in the A+ condition had to solve a complex problem without guidance prior to instruction. This approach is called Productive Failure (PF: Kapur, 2008) and is characterized as a highly authentic problem-solving method, as it simulates the professional practice of scientists (Cho, Caleon, & Kapur, 2015). Students in the A- condition received Direct Instruction (DI) before they applied the previously explained method to solve a problem. By receiving direct instruction, students were not asked to independently solve a complex and novel problem as scientists do. Therefore, the problem-solving phase of DI can be described as scientifically less authentic. Within the lab for linguistics of study B, students in the A+ condition had to judge the grammaticality of a linguistic phenomenon by using the thermometer method (Featherston, 2008) which is an objective and authentic linguistic method. Students in the A- condition had to judge the same data by using a less authentic linguistic method of introspective judgements that builds upon highly subjective feelings for language.

In light of the assumptions within the authenticity model described above and previous research on the effectiveness of OSLs, we hypothesized that students' perceived authenticity would correlate positively with their situational interest (H1). Moreover, we assumed that students of the A+ conditions would report higher perceived authenticity (H2) and higher situational interest (H3) than students from the A- conditions.

Method

Participants and design

In study A, 38 10th-graders (M_{age} = 16.38, SD = 0.55; 57.9% girls) from two classes of two secondary schools in Germany participated. The two classes were randomly assigned to the A+ condition (n = 19) and the A- condition (n = 19) as a whole. In both conditions, students experienced two successive 45 min. learning phases: a problem-solving phase and an instruction phase. To simulate the practice of scientists, A+ students started with the problem-solving phase that asked them to independently generate solution attempts for a complex and novel problem. Students from the A- condition started with the instruction phase before they had to apply the instructed method to solve the same problem. In study B, 49 8th-graders (M_{age} = 14.40, SD = 0.57; 63.3% girls) from two classes of two secondary schools in Germany participated. The two classes were randomly assigned to the A+ condition (n = 26) and the A- condition (n = 23) as a whole. At the day of the experiment, students in both conditions took part in the same introduction about the learning topic in the beginning as well as the same reflective discussion at the end of their lab visit. Only the main learning phase differed between both groups, in which students solved the same task while using different grammaticality-judgement methods.

Measures

In both studies, the same instruments were used to assess students' individual interest in the subject, their perceived authenticity, and their situational interest. The individual interest was measured with seven items at the beginning of the students' OSL visit (study A) or prior to their OSL visit (study B). An example item is "The subject of (in study A: educational sciences) is one of my favorite subjects". As in previous OSL-studies, the perceived authenticity (10 items) and the situational interest (12 items) were assessed at the end of the students' OSL-visit. An example item for perceived authenticity is "I think that the tasks in this project fit well with the work of real scientists", and for situational interest "The engagement with the contents of this project was exciting for me". Students replied on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*) to each item of the three instruments. The internal consistencies of all three measures were satisfactory (*Cronbach's α* = .78 - .93). Moreover, in both studies, students' grades in three different subject areas (German language, mathematics and in study A also educational sciences and in study B additionally English language) were assessed.

Results

For both pilot studies, MANOVAs revealed no significant differences between the A+ and the A- conditions in age, the reported grades in three subjects, nor the individual subject interest. To test our first hypothesis (H1), correlational analyses were conducted. For study A, the results showed a positive and significant correlation between students' perceived authenticity and their situational interest ($r = .45$, $p < .01$). For study B, the results confirmed this positive and significant association ($r = .42$, $p < .01$). Therefore, our H1 is supported. To assess differences in the effect of the experimental condition on participants' perceived authenticity (H2) and reported situational interest (H3), we calculated a MANOVA for pilot study A and a MANCOVA for pilot study B. In study B, students' individual subject interest significantly correlated with their situational interest ($r = .33$, $p = .02$) and was therefore included as a covariate. For study A, the MANOVA demonstrated a significant large-sized effect of the experimental condition on perceived authenticity ($F[1,36] = 11.15$, $p = .002$, $\eta_p^2 = .24$). In line with our H2, students of the A+ condition who worked with the authentic method reported higher perceived authenticity ($M = 3.58$, $SD = 0.43$) than students of the A- condition ($M = 3.02$, $SD = 0.59$). However, against our H3, the MANOVA revealed a non-significant small-sized effect on students' situational interest ($F[1,36] = 0.77$, $p = .39$, $\eta_p^2 = .02$). Hence, the results of study A support H2, but not H3. For study B, the MANCOVA revealed no effect of the condition on perceived authenticity ($F[1,46] = 0.06$, $p = .81$, $\eta_p^2 = .00$) which is against H2, but a significant large-sized effect on students' situational interest ($F[1,46] = 14.43$, $p < .01$, $\eta_p^2 = .24$). However, against H3, students of the A- condition who worked with the less authentic method reported higher situational interest ($M = 3.35$, $SD = 0.79$) than their counterparts of the A+ condition who worked with the more authentic method ($M = 2.55$, $SD = 0.66$). Therefore, the results of study B do not support H2, nor H3.

Discussion and conclusion

Our results suggest that contrary to our expectations, the intended authenticity of the method that students used to solve a task within two OSLs had different effects on students' perceived authenticity (H2) and their situational interest (H3) in an OSL for educational sciences (study A) compared to an OSL for linguistics (study B). While in study A students of the A+ condition reported significantly higher perceived authenticity than A- students, in study B, students' perceived authenticity did not differ between both conditions. With regard to students' situational interest, the intended authenticity of the method did not have a significant effect in study A, but a significant effect in study B (as although the direction of the effect was not as assumed). Although the recent pilot studies do not offer conclusive evidence, especially due to the small sample sizes, our findings do have interesting implications for future research, and several explanations can be offered for the findings.

One possible explanation regarding the mixed effects of the intended authenticity of the method on students' perceived authenticity (large effect in study A and no effect in study B) might be related to students' prior knowledge about scientific methods that are used in a certain domain. As Vanderbeke's (2017) qualitative analyses of student conversations during an OSL for molecular biology demonstrated, students' knowledge about scientific procedures is often non-existent or incorrect. The same could be assumed for students' knowledge of linguistic methods. Without this knowledge, it was probably not possible for participants of study B to evaluate the authenticity of the different methods, which in turn resulted in almost equal perceptions in both conditions. It must be noted that the assessment of students' perceived authenticity in our studies did not aim at investigating whether students' perceptions of the intended authenticity of the method were correct or not. Building upon the authenticity model of Betz and colleagues (2016), our goal was to investigate whether a variation of the authenticity level of the scientific method that learners use to solve a given task in two OSL-projects had an impact on their individual feeling of authenticity and in turn on their situational interest. However, one could assume that without any prior knowledge about scientific practices, students lack sensitivity to identify given problem-solving processes as scientific methods and afterwards to evaluate their authenticity. As study A revealed a different finding (large effect of authenticity of the method on perceived authenticity), it could be assumed that students' prior *knowledge about science* depends on the domain. Therefore, it seems necessary to adapt the model of Betz and colleagues (2016) to include the assumption that the preconditions of the learners such as their prior knowledge about science, which affect their individual feeling of authenticity, are domain-specific (see grey area in Figure 1).

Another explanation could be related to the authentic learning environment as a whole. Betz (2017) showed that the OSL as authentic learning location had a major effect on students' perceived authenticity. It is likely that the characteristics of the learning setting each have a different impact on the (perceived) authenticity of the environment. The OSL as authentic learning location might have had a higher impact on students' perceived authenticity in study B than the method they used. As the location was the same in both conditions, their perceptions probably did not differ. Hence, future research should focus on investigations that modify the authenticity level of characteristics of the learning setting other than the method. For instance, a current study

from Brauch, Mierwald, and Lehmann (2017) focuses on the material that is used in an OSL for history education and examines whether the variation of the intended authenticity level of the given material affects students' perceived authenticity. Building upon the argument developed before that students' prior knowledge about science differs depending on the domain, it is again likely that depending on the domain, some features of an authentic learning setting play a more important role for students' perceived authenticity than others. Hence, it seems appropriate to mark the characteristics of the learning setting within the authenticity model of Figure 1 as domain-specific. These assumptions should be investigated by future research with a larger sample size.

Our results regarding the association between students' perceived authenticity and their situational interest are interesting, as our analyses revealed mixed findings with respect to their relation. The correlational analyses confirmed a positive relation between students' perceived authenticity and their situational interest, but, in contrast to our H2 and H3, the variance analyses revealed that students' reported perceived authenticity differed from their reported situational interest (e.g., in study A, students' perceived authenticity significantly differed between both conditions, but students' situational interest did not). Therefore, future research should focus on examination of this association that is assumed based on theory.

In sum, our findings contribute to previous research on authentic learning in OSLs and to the further development of a theoretical model of authentic learning and teaching.

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