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AN INSTRUMENT TO MEASURE STUDENTS' PERCEPTION OF THE AUTHENTICITY OF AN OUT-OF-SCHOOL LEARNING PLACE

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STRUCTURED ABSTRACT

Background: One of the big opportunities offered by out-of-school learning places at research institutions is their authenticity, as they can provide insight into authentic research and work of scientists.

Purpose: To what extent the students perceive this "authenticity of place" may however be individually different. In order to measure whether students indeed perceive a given out-of-school learning offer as an authentic learning place from their individual perspective an instrument is needed.

Sample/setting: The Paul Scherrer Institute (PSI) is a genuine research environment for natural and engineering sciences and can therefore be considered as an authentic out-of-school learning place. Students from 3 different cantons in Switzerland participated in a field trip to the PSI, including a guided tour to one of its research facilities (on renewable energies) and a hands-on workshop in its science outreach lab (iLab) related to that topic. Data about test characteristics were collected in a pilot and in a main study (n = 80, March 2018 and n = 94, May to September 2018).
All the classes were taught by the same teacher to learn about the basics of the research being done in that particular field of research at PSI. The guided tour was done by the same scientist from PSI for all classes.

Design and methods: The questionnaire consists of a 6 point Likert scale with 9 items. An item analysis was carried out, as well as a factor analysis testing for the dimensionality of the questionnaire.

Results: In terms of content the items for authenticity of place can be divided into one group with a cognitive focus and another group with an emotional focus. The item analysis of the total instrument yields good to very good characteristics (Cronbach's Alpha as estimate of internal consistency $\alpha_C = .91$, average item-test-correlation $r_{it} = .71$), similarly for the sub-tests with cognitive and emotional focus ($\alpha_C = .80$, $r_{it} = .63$ and $\alpha_C = .89$, $r_{it} = .77$)
A performed confirmatory factor analysis proved compatible with a two-factor and a one-factor model (CFI = 0.98 and 0.97, respectively). The fact that the correlation between the two factors "cognitive" and "emotional" is very high (.94) argues in favour of the one factor model (McDonald's omega as estimate of internal consistency adapted to factor analysis: $\omega = 0.92$).

Conclusions/Implications for practice and future research: The instrument presented here can be used as a one factor scale with good to very good test characteristics, if an overall measure of perceived authenticity of place is needed. The two subscales with cognitive and emotional focus could also be used separately, as their test characteristics are also satisfactory to good. Due to its short format and administration time (around 2 minutes) the instrument can be well integrated in the evaluation of out-of-school learning places.
The scale was developed specifically for a research institute and has to be adapted for other out-of-school learning places such as museums, science centres or field trips. For future research it will be interesting to include other dimensions of perceived authenticity (such as authenticity of a person, e.g. the scientist at a research institute) and to study their combined effects on educational outcomes. Work along these lines within the framework of a larger research project on out-of-school science learning is in progress.

Keywords*: authenticity, out-of-school science learning, place-based learning, context-based science education*

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1 INTRODUCTION

Teachers are faced with a fundamental transformation of the spaces and opportunities for experiencing, learning and teaching scientific knowledge and practices. The meaningful use of learning spaces outside the school, in museums, science centres, industry and nature is resulting in a change in their teaching practices (Braund & Reiss, 2006; National Research Council, 2009). Research in science education highlights the positive effects of such a contextualized teaching, whether in terms of an increase of students' self-efficacy (Martin, Durksen, Williamson, Kiss & Ginns, 2016; Muthersbaugh, Kern & Charvoz, 2014; Pawek, 2009), strengthening interest in science and technology (Henriksen, Jensen & Sjaastad, 2015; Hulleman & Harackiewicz, 2009), or a better understanding of science and technology and a positive impact on attitudes (National Research Council, 2009; Place-based Education Collaborative, 2010; Rennie & Johnston, 2007; Rennie & Norman G. Lederman, 2014; Tal, 2012).

A central aspect of out-of-school learning and teaching is the sought-after authenticity of the activities, of the settings and of the social context. For example, with regard to place-based outdoor learning, authentic science opportunities are valued by teachers who report positive experience with students on the motivational, emotional and social levels (Glackin, 2016; James & Williams, 2017; Lloyd, Truong & Gray, 2018). Similar results were found within the framework of the Place-based Education Evaluation Collaborative (2010). On the basis of more than 1250 interviews and more than 2600 surveys it shows clearly that place-based education improves students' achievements and their "environmental, social and economic vitality" (Place-based Education Collaborative, 2010, p. 2). According to Rickinson et al. (2004, p. 5) affective and cognitive impacts influence each other and their reinforcement can "provide a bridge to higher order learning". However, there are indications that impacts on attitudes are stronger than the cognitive and behavioural ones (Knapp & Poff, 2001).

In the case of an out-of-school learning experience at a research institute, a genuine research environment and other aspects of authenticity can be experienced which are not (or less) possible by other offers (Braund & Reiss, 2006; National Research Council et al., 2009; Stocklmayer, Rennie & Gilbert, 2010). In the present work, we investigate effects of lower secondary visits to the Paul Scherrer Institute (PSI). It is the largest research institute for natural and engineering sciences in Switzerland, covering a wide range of well-renowned research activities („The Paul Scherrer Institute in brief", 2019) and can be considered a very authentic place to experience scientific research. On behalf of the Swiss federal 'energy strategy 2050' the PSI is currently doing research on possible solutions to store renewable energy. This is a highly relevant topic in the Swiss science curriculum (D-EDK, 2017). As several authors argue, authenticity has to emerge within the individual (Hutchison, 2008; Petraglia, 1998). In the case of PSI the potential for an authentic experience is given, but we cannot expect every student to perceive this authenticity in the way we intended.

Some authors claim that only an expert (e.g. the scientist working at the institute or the curator of a museum) can evaluate the authenticity of a place (Hede, Garma, Josiassen & Thyne, 2014). We have a different approach by taking into consideration both perspectives, the one from the expert and the one from the student (De Bruyckere & Kirschner, 2016; Schriebl, Robin & Müller, o. J.; Weiss & Müller, 2015). How will students evaluate the authenticity of a learning place – in our case PSI? To evaluate the students' perspective and to find out to which degree students rate the research institute an authentic place, an instrument is needed, which is the focus of the present study.

Below, we present the setting of the study and the development and properties of the newly developed instrument for authenticity of place.

2 METHODS

2.1 Setting

Five school classes of secondary level one visited the PSI for one day with the goal to learn about the research done on the ESI (Energy System Integration) platform. In the morning they attended a program held at the science outreach lab iLab of the PSI. The iLab is located in the environment of the PSI but not within the fenced area, where scientists are working on their research.

To be able to understand what research is done on the ESI platform of the PSI the students discussed energy issues with a special focus on the storage of renewable energy ("power-to-gas"), performed experiments (e.g. electrolysis of water) and learned about methanization of hydrogen, a key step in the power-to-gas process (Götz et al., 2016; Rubner, Grofe & Oetken, 2019). These basics were taught in the iLab before visiting the actual research site. After the teaching unit held at the iLab all the students were given a batch with which they entered the fenced area for the guided tour. The scientist being in charge for the iLab – a physicist who used to work in research and is now responsible for the iLab – led them to the research area of the ESI – platform.

2.2 Sample and Data Collection

A pilot study took place in March 2018 (n = 80). On the basis of its outcomes, the instrument has been adapted (selection and wording of items). The main study was carried out from May to September 2018 with n = 94 secondary level one students (48 female, 45 male, 1NA). Quantitative data were collected with pre- and post-questionnaires for authenticity of place. In the larger framework of studies on out-of-school learning offers, this has to be compatible with testing for several other variables (interest, attitudes, knowledge, curiosity, self-concept and more). Thus, a short questionnaire for authenticity of place is needed, as only strongly limited testing time is available.

2.3 Item development

Items emphasize on various aspects of the personal perception of authenticity and are systematically based on conceptualisations of authenticity of place discussed in the literature. A few items could be taken verbatim from published instruments. However, to our knowledge, there is no specific instrument for authenticity of place available in literature yet. Other items are inspired by other instruments or specific aspects of authenticity of place discusses by various authors (e.g. understanding the benefit of science institutions for society; see Tab. 1 for an overview.)

The items were developed and tested in German (see Tab. 1 for an English translation). Scale format is a 6 level Likert scale (1 = don’t agree at all ...6 = completely agree).

2.4 Statistical methods

To determine which items should be used for the instrument, we conducted an item analysis with the following statistics: Cronbach’s Alpha of the scale, Cronbach’s Alpha if the item is eliminated, the item-test correlation r_{it} (as a measure of the reliability of individual items) and the mean and standard deviation (Bortz & Schuster, 2010; Field, Miles & Field, 2012).

In a second step we ran a confirmatory factor analysis (CFA, Bollen & Curran, 2005; Ellis & Mayer, 2019) to establish whether the construct of authenticity of place consists of one or two factors. As the measurement model of CFA is different from that of classical test theory (congeneric instead of tau equivalent), a congeneric (or “composite”) reliability measure such as McDonald’s Omega has to be used[1] (McDonald , 1970; McDonald, 1999). It provides a better estimate for reliability than Cronbach’s Alpha and has to be used instead (Raykov, 2001).

All analyses were carried out using R Studio (RStudio Team, 2019) .

[1]We thank one of the reviewers for this methodological advice.

Tab. 1. Items of the authenticity of place questionnaire

	Item number (one/ two factor solution)	**Item wording**	**Item source**
Cognitive aspects	AutPl02 AutPlc01	Der Besuch am PSI hat mir Einblick in Hightech-Forschung gegeben. (The visit at PSI has given me an insight into high-tech research.)	"big science" and high tech institutions (Braund & Reiss, 2006)**
	AutPl04 AutPlc02	Der Besuch am PSI hat mir einen Eindruck davon gegeben, was die Gesellschaft von einem Grossforschungsinstitut hat. (The visit at PSI has given me an impression of how society benefits from a major research institute.)	benefit for society (Rennie, 1994; PLACES, 2012)***
	AutPl06 AutPlc03	Die Führung zur ESI-Plattform hat mir geholfen zu verstehen, was Power to Gas ist. (The tour to the ESI platform helped me understand what Power to Gas is.)	as AutPl09, but for a specific research unit (Rennie, 1994)***
	AutPl09 AutPlc04	Ich habe einen Eindruck erhalten, was am PSI gemacht wird. (I got an impression of what is done at PSI.)	(Rennie, 1994)***
Emotional aspects	AutPl01 AutPle01	Das PSI hat mir besser gefallen als alle anderen ausserschulischen Lernorte, die ich bisher besucht habe. (I liked PSI better than any other out-of-school learning place I have visited so far.)	(Schreiner & Sjøberg, 2007)***
	AutPl03 AutPle02	Ich würde mich gerne weiter über das PSI informieren (im Internet, Büchern etc.) (I would like to get more information about PSI (from the internet, books etc.))	wish to know more, related to research institution (Kuhn, 2010; Kuhn & Müller, 2014) ***
	AutPl05 AutPle03	Ich fand die Atmosphäre am PSI faszinierend. (The atmosphere at PSI was fascinating.)	fascination related to research institution atmosphere (Litman & Spielberger, 2003)***
	AutPl07 AutPle04	Ich fand es beeindruckend, den Arbeitsort von Wissenschaftlern sehen zu können. (It was impressive to see the workplace of scientists.)	authenticity of workplace: (Swinbank & Lunn, 2004)**
	AutPl08 AutPle05	Das PSI ist ein spannender Arbeitsort. (PSI is an exciting workplace.)	

* *item identical or close to an item in the given reference*
** *item based on an aspect of authenticity discussed in the given reference*
*** *item based on an item in the given reference*

3 RESULTS

3.1 Item analysis

Item analysis showed satisfactory to good indices (n = 85, see Tab. 1): Cronbach's alpha = .91, for the overall scale, 0.80 and 0.89 for the cognitive and emotional part, respectively. The item discrimination r_{it} of AutPl09 shows the lowest and only satisfactory value of .46 and could be dropped. Yet, the content of the item provides information about an important aspect about authenticity of place (Rennie, 1994) and therefore, it was decided to keep it in the scale.

Tab. 1. Item analysis AutPl

Item	Cronbach's α if item eliminated	r_{it}	Mean (SD)
AutPl01	.91	.60	3.37 (1.50)
AutPl02	.90	.73	4.23 (1.06)
AutPl03	.90	.70	3.08 (1.23)
AutPl04	.90	.77	4.20 (1.21)
AutPl05	.89	.85	3.88 (1.18)
AutPl06	.91	.66	4.22 (1.11)
AutPl07	.90	.78	4.28 (1.39)
AutPl08	.90	.82	4.19 (1.25)
AutPl09	.92	.46	4.70 (0.86)

3.2 One factor solution

First, we used authenticity of place as a single factor scale with all nine items (McDonald's Omega = .92). Confirmatory factor analysis for this model showed the following standardised values (Bollen & Curran, 2005; Ellis & Mayer, 2019; RStudio Team, 2019): ML Chi-Square = 42 (df = 27, p = .031), Comparative Fit Index (CFI) = 0.97 , Tucker-Lewis Index (TLI) = 0.96 , Root Mean Square Error of Approximation (RMSEA) = 0.08 (90% confidence interval), Sample-size adjusted Bayesian (BIC) = 1991.47, Akaike (AIC) = 2004.29.

The factor loadings for most items are satisfactory or good with exception of item AutPl09.

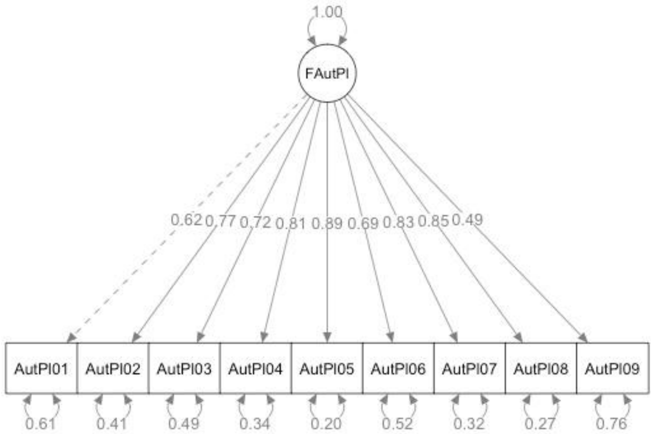

Fig. 1. Factor loadings for the one factor model

3.3 Two factor solution

Looking deeper into the content of the items, there are two different groups we can distinguish: The first focuses on whether students get insight into what is happening at the research institute and how it can help the student or society to understand the purpose of the institute and its research. These items only ask students to state whether they got an idea about these issues, but it is not asked whether or not this is a fascinating or interesting insight for the learner. So even though some students may not particularly like the place – maybe because they are not interested very much in science – they can still experience this aspect of authenticity of place. We summarize the focus of these items as "cognitive aspects" of the authenticity of place. This item group consists of four items. For the two factor solution, we renamed these items with the abbreviation "AutPlc" (with "c" for "cognitive", see Tab. 1).

The second group of items inquires about the emotional impact which an authentic place may have on a student. They can like the place, be impressed, fascinated etc. The item group AutPle (with "e" for "emotional") measures the emotional aspects of the authenticity of place. There are five items in this group.

Confirmatory factor analysis seems to confirm the considerations based of the content of the items. Fit indices (standardised values) are slightly better than for the one factor model: ML Chi- Square = 37 (df = 26, p = .066), Comparative Fit Index (CFI) = 0.98, Tucker-Lewis Index (TLI) = 0.97, Root Mean Square Error of Approximation (RMSEA) = 0.07 (90% confidence interval), Sample-size adjusted Bayesian (BIC) = 1988.12, Akaike (AIC) = 2001.65. The reliability shows a good but slightly lower value than the one factor model: McDonald's Omega = .83.

The correlation between the two factors was found to be very high (r = 0.94). The comparison of the two models with the Likelihood Ratio - Test (Werner, 2012) shows that the one factor model fits better with the data than the two factor model (Chi-Square-Difference = 4.64, p = .031).

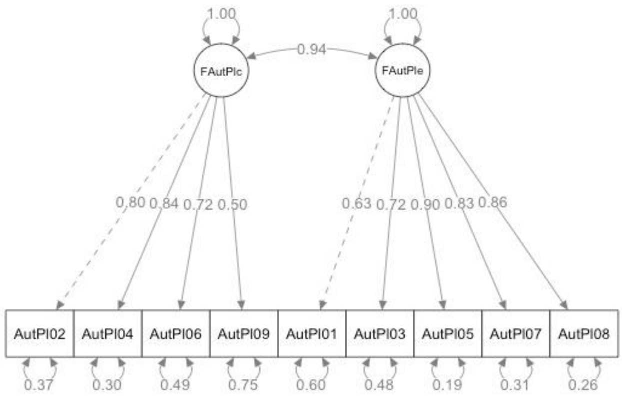

Fig. 2. Factor loadings for the two factor model

4 DISCUSSION

Allen et al. (2008) provide a list of impact categories for informal science education projects consistent with the ones found here. Their category "awareness, knowledge or understanding" can be related to the cognitive aspects of authenticity of place, whereas their category "engagement and interest" or "attitudes" can be related to the emotional aspects of authenticity of place.

Similarly, Rickinson et al. (2004) point out that there are cognitive and affective impacts of fieldwork or visits. They review several studies which looked into cognitive and affective impacts and their influence towards each other. Even though the cognitive impact often refers to knowledge or conceptual understanding in general, the same categories ("cognitive" and "affective") can also be applied to the experience of authenticity. The cognitive aspect of authenticity at an out-of-school learning place can be understood as part of a conceptual understanding which includes that students get a deeper insight of what is done at a research institute.

Our scale with the two factors is consistent with these findings and concepts from previous research. As the correlation of the two factors is very high (.94), the instrument as presented in this article should rather be used in the form of the one factor solution. However, the two subscales with cognitive and emotional focus could also be used separately, as their test characteristics are also satisfactory to good; we thus think that this information might be useful for potential users of the test.

As for limitations, on the individual item level, AutPl09 has a smaller factor loading than the other items of this dimension. One reason for this is probably the fact that students could not get a full idea of what is done at PSI, they only saw one single research project and solely visited a small part of the whole area. So due to the setting they merely got a glimpse of what is done at PSI. However, the content of the item is important for the scale (Rennie, 1994) and it was kept as part of the factor for that reason. For AutPl01, the item discrimination r_{it} has a satisfactory value of .60, yet we would drop it in hindsight. In the case of students who have never visited an out-of-school learning place before, their answer might be distorted by the way the item is worded.

On a more general level, impact categories of authenticity discussed in the literature (Allen et al., 2008; Hede et al., 2014) are much broader than authenticity of a place, which can be seen as only one individual aspect of a broader set of students' attitudes or students' understanding towards an out-of-school learning place. For future research it will be interesting to include other dimensions of perceived authenticity (such as authenticity of a person, e.g. the scientist at a research institute) and to study their combined effects on educational outcomes. Work along these lines is within the framework of a larger research project on out-of-school science learning.

Further analysis might also be needed regarding the distinction and relation between the concepts of "interest" in general (Hulleman & Harackiewicz, 2009; Krapp & Prenzel, 2011; Potvin & Hasni, 2014) and authenticity of place (emotional aspects).

Affective constructs and terms are often quite ambiguous and overlapping; an example are \`interest´ and \`curiosity´ (Pekrun, 2019). This holds in particular for the term \`authenticity´, which became a kind of educational "buzzword [...], applied loosely and inconsistently to a wide range of theoretical and practical work (Shaffer & Resnick, 1999). However, a quite widespread and useful understanding of \`authenticity´ in science education (closely related to the etymological origin: gr. authentikós "true"; lat. authenticus "reliable") is that learning should be related to actual, real(istic), genuine contexts and experiences for learners. This point of view is also essential to and strongly advocated in the framework of scientific literacy (Fensham, 2009; OECD, 2006). We believe that an out-of-school learning opportunity is a special kind of such a context, where authenticity means a place-based experience of and insight into real research and science, its relevance, and positive emotions (interest, fascination) related to and triggered by this experience. While different motivational aspects come into play here, they are intrinsically connected to the \`authenticity of place´, which is therefore used as a kind of overarching term.

5 CONCLUSION

The scale for authenticity of place can be a useful tool for researchers to measure authenticity of place as experienced by students with satisfactory to good psychometric properties.

The short format and administration time allow for integration in the evaluation of out-of-school learning places, where authenticity of place is only one among other variables of interest. Further items might be developed to improve the instrument if authenticity of place is the main target variable.

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APPENDIX

Questionnaire

		Stimme gar nicht zu	Stimme nicht zu	Stimme eher nicht zu	Stimme teilweise zu	Stimme zu	Stimme vollumfänglich zu
1.	Ich fand es beeindruckend, den Arbeitsort von Wissenschaftlern sehen zu können.						
2.	Ich habe einen Eindruck erhalten, was am PSI gemacht wird.						
3.	Ich fand die Atmosphäre am PSI faszinierend.						
4.	Ich würde mich gerne weiter über das PSI informieren (im Internet, Büchern etc.).						
5.	Der Besuch am PSI hat mir einen Eindruck davon gegeben, was die Gesellschaft von einem Grossforschungsinstitut hat.						
6.	Der Besuch am PSI hat mir Einblick in Hightech-Forschung gegeben.						
7.	Das PSI ist ein spannender Arbeitsort.						
8.	Die Führung zur ESI-Plattform hat mir geholfen zu verstehen, was Power-to-Gas ist.						
9.	Das PSI hat mir besser gefallen als alle anderen ausserschulischen Lernorte, die ich bisher besucht habe.						