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Modelling of interest in out-of-school science learning environments: a systematic literature review

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ABSTRACT

Out-of-school science learning environments enrich classroom education in many countries around the world. Numerous studies have been conducted on the effects of such learning environments, particularly their ability to promote interest. As different theories of interest were used in these studies, so far, no overview of this field of research exists. Therefore, based on a comprehensive and systematic international literature review, this article presents a detailed analysis of the theories of interest used to study out-of-school learning environments. In addition, inferences regarding situational and individual interest promotion in out-of-school science learning environments are derived, clearly showing that situational interest is promoted through these learning environments. Considering the influencing factors given in the different theories of interest, a model of student interest for these learning environments is then presented. This model can be used to guide the development and further improvement of out-of-school learning environments.

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Out-of-school laboratory; interest theory; outreach programmes

Introduction

The natural and engineering sciences provide solutions to many important societal problems. For the continued advancement of society, it is necessary to prepare the next generation through education in these fields. Out-of-school learning environments (OLEs) are valuable for fostering students' interest in science, technology, engineering, and mathematics (STEM), which, in turn, leads to students' discovery of technical and scientific fields of activity and suitable career paths (Gumaelius et al., 2016). To define and differentiate the various components of the core concept of 'interest', it is first important to understand the basic terminology. Interest usually 'emerges from an individual's interaction with his or her environment' (Krapp et al., 1992, p. 5). As a motivational variable, it includes both affect and cognition (Hidi & Renninger, 2006) and is characterised by a state of (re-)engagement with particular topics, objects, or events. Past studies have

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distinguished between the psychological state of interest experience and the dispositional personality factor of interest (Hidi & Renninger, 2006; Krapp & Prenzel, 2011). Interest as a disposition is often called individual interest (inI) or personal interest (Krapp et al., 1992). It includes a person's subjective orientation and tendency to re-engage with certain topics (Krapp et al., 1992). In contrast, the interest experience is a current psychological state characterised by feelings of, for example, enjoyment and concentration. An interested person can become completely absorbed in the pursuit of a topic; this is called flow (Csikszentmihalyi, 1975). The interest experience includes situational interest (SI) and actualised inI (Krapp et al., 1992), these forms of interest differ in their cause. The attractiveness of a learning object or learning environment leads to SI (Hidi & Renninger, 2006; Mitchell, 1993), while actualised (individual) interest is caused by inI already present in a person (Krapp, 2002a). An interest experience often lasts only for a short duration (Hidi & Renninger, 2006; Krapp, 1998; Mitchell, 1993; Schiefele, 1991). As it is difficult to determine the cause of interest, the term interest experience is used to describe all momentary occurrences of interest (Sansone & Thoman, 2005; Tsai et al., 2008). As an alternative, the terms 'current interest' or 'actual interest' are also used for the psychological state of interest especially for SI (Budke et al., 2019; Hausamann, 2012). In addition to the distinction between interest experience and inI, Häußler and Hoffmann (1995) distinguished between object and subject interest. Object interest refers to the general interest in a concrete object, for example, in physical matter. Subject interest refers to interest in a school subject, such as physics (Hoffmann, 2002). General interest is one form of inI whereas subject interest involves a combination of inI and SI (Hoffmann, 2002).

Numerous studies prove the importance of interest for learning. For a challenging reading task, it was shown that higher topic interest can mitigate some negative influences in learning, provide longer lasting enjoyment and more persistence in working on tasks (Fulmer & Frijters, 2011). Furthermore, studies on text learning show that there is a positive relationship between interest in the subject matter and success in undirected learning (Ryan et al., 1990). For an out-of-school learning programme interest also facilitates an increase in knowledge (Salmi & Thuneberg, 2019). Thus, student interest is a key characteristic for evaluating out-of-school learning opportunities in STEM fields. While numerous studies have been conducted on the subject to date, different theories of interest have been used, if any. Fortus (2014) noted that many articles on interest lack a clear definition of the term. Furthermore, an overview of the theories used in relation to interest in OLEs does not yet exist. Therefore, we conducted a systematic review of the existing literature and focused on the following research questions: (RQ1) What theories are used to explore interest in STEM-related, practical OLEs? (RQ2) What are the effects of STEM-related, practical OLEs on the interest components of interest theories, and how are these interest components related?

Theoretical background and state of research

To characterise theories that are used to explore interest in STEM-related, practical OLEs and their effects on the interest components of interest theories, an illustration of their most important aspects is given:

Hidi and Renninger (2006) presented a *four-phase model* (4PM) of interest development. In the first phase, SI is triggered by elements of the learning environment ('catch') – for example, group work, puzzles, or computer use (Mitchell, 1993) and does not entail inI. In the second phase, aspects of the content or the learning conditions like meaningfulness and personal involvement can lead to SI being maintained via a 'hold' effect, which is important for long-lasting interest (Harackiewicz et al., 2000; Mitchell, 1993). Nevertheless, SI tends to diminish with time and may disappear by the end of a learning situation (Krapp, 1998). In the third phase, SI stabilises and causes inI to emerge, influencing the personality of the learner. This takes place when the individual experiences (personally) significance and positive emotions, leading to a desire to engage further with the object of interest and learn more about it (Hidi & Renninger, 2006). Successful internalisation of interest leads to the fourth phase, namely inI. The basic psychological needs outlined in the self-determination theory (SDT) (Deci & Ryan, 1985, 1991) and various aspects, but not all, of the person-object theory of interest (POI, see below) (Krapp, 1998, 2002b) are also important to the 4PM, but these are not the only factors influencing interest development in the 4PM (Hidi & Renninger, 2006).

The *person-object theory of interest* (POI) is aimed at describing and classifying interest (Krapp, 1998). It states that interest emerges in the relationship between a person and an object. This object can be a real object or an abstract topic or idea (Krapp, 2002b). Any area of a person's knowledge can theoretically become such an object of SI or inI (Krapp, 2002b). A person presumably does not possess individual independent interests but an individual pattern of interests that is characterised, for example, by the content and activities of a school subject (Krapp, 2002b). SI and inI each contain feeling-related, value-related, and epistemic components. The feeling-related component describes the emotions an object of interest triggers, whereas the value-related component describes the emotionally independent meaning of the object for a person (Schiefele, 1990, 1991). The epistemic component is characterised by a person's desire to increase knowledge (Krapp & Prenzel, 2011).

Another theory related to interest is Deci and Ryan's (1985, 1991) *self-determination theory* (SDT), which focuses on motivation. According to the SDT, motivation for an action can be distinguished as intrinsic or extrinsic, and it always depends on the extent to which the three basic psychological needs – competence, autonomy, and relatedness – are met. Similar to POI, SDT defines interest 'in terms of the interaction between a person and an activity' (Deci, 1992, p. 49). These activities are in an ideal relation to the own wishes and preferences and are characterised by an optimal challenge and novelty (Deci, 1992). SDT is relevant for defining interest, as SI can be understood as an aspect of intrinsic motivation (Hidi & Harackiewicz, 2000). In addition, SDT can help explain the emergence and dynamics of interest and is thus significant when planning activities to promote interest (Krapp, 1992).

Next is the *(situated) expectancy – value theory* ((S)EVT), according to which expectations and values both influence performance (Wigfield et al., 2020; Wigfield & Eccles, 1992). Subjective task values can be divided into 'interest or intrinsic value, attainment value, utility value, and relative cost' (Wigfield et al., 2020, p. 664). Intrinsic value refers to the individual subjective interest and is similar to the construct of intrinsic motivation in the SDT (Wigfield & Eccles, 1992). Consistent with the model of interest development given by Hidi and Renninger (2006), this theory states that children may develop a hierarchy of (rather stable) subjective task values (Wigfield et al., 2020). Presumably, dimensional comparisons of different activities are important in developing patterns of interest (Wigfield et al., 2020). The influence of each component of the task values differs depending on the person, time, and task, because of which their interactions have been intentionally left unspecified (Wigfield et al., 2020). Nevertheless, studies have investigated the correlation between these components (e.g. Itzek-Greulich et al., 2017). Based on this research and with its focus on interest-dependent choices and performance, the EVT can contribute to interest research.

Overall, the different theories of interest often distinguish different forms of interest or refer only to certain forms. For example, in the 4PM there are triggered SI, maintained SI, emerging inI and well-developed inI, and in POI there are feeling-related, value-related, and epistemic interest components. In this article, these different forms and components of interest are referred to under the term 'interest component'. Furthermore, there are different variables that can affect forms of interest. Some of these variables can be assigned to a particular interest theory, for example, the interestingness of the learning environment in POI or autonomy, competence, and relatedness in SDT. Others are more general such as age and gender of a person. In this article, the term 'influencing factor' refers to such factors that affect interest components in a theory-independent manner. For OLEs several of these factors have been identified (Neher-Asylbekov & Wagner, 2022). These are on the one hand external factors such as the pedagogical structure of the OLE with a positive effect of hands-on activities (Dohn, 2011, 2013), active participation/practical work (Itzek-Greulich & Vollmer, 2017; Stavrova & Urhahne, 2010), and creative forms of instruction (Affeldt et al., 2015). On the other hand, there are personal factors such as gender and age (e.g. Ozogul et al., 2019; Wegner & Schmiedebach, 2020), and emotions such as joy, achievement, attainment value, competence beliefs, utility value, cost, anger and boredom (e.g. Itzek-Greulich et al., 2017).

The theories mentioned above have different emphasis on interest. The POI aims at structuring concepts of interest to help improving educational practice (Krapp, 2002a). It has been applied to text-based interest in educational research (Hidi, 1990). The emotional characteristic of interest in POI includes the basic needs of SDT (Krapp, 2002a). In contrast, the 4PM focusses on the dynamic process of interest development and includes many aspects of POI, but not the thesis that interest contains value-related and feeling-related valences (Hidi & Renninger, 2006). EVT and SDT are motivational theories that also consider learning (Deci, 1992; Wigfield et al., 2020). They have in common that certain feelings are the result or the goal of an acting person (Deci & Ryan, 2000; Hidi & Renninger, 2006; Wigfield & Eccles, 1992). In SDT, it is the fulfilment of basic psychological needs (Deci & Ryan, 2000). In EVT, motivation is a result of certain expectations and values (Wigfield & Eccles, 1992). As all these theories have been used to evaluate interest in former studies on OLEs, they are all important for this article. In particular, the distinction between the forms of interest in SI and inI, as made in POI and 4PM, and the development of interest in 4PM is of great importance. The EVT as well as the SDT are especially significant because of the factors influencing the interest (development).

The theories presented have a very high importance in the research of OLEs. OLEs are particular learning environments and various types of OLEs exist (Neher-Asylbekov &

Wagner, 2022). To keep a clear focus among this diversity, OLEs that offer clearly defined, maximum one-day activities for groups of K-12 students are considered in this article, as the time frame may influence certain components of interest (Dillon et al., 2016). An advantage of one-time events, compared to regular school instruction, is the greater ability to attribute the measured elements of interest development to the intervention. Such out-of-school events are often set up by institutions such as universities, science centres, and museums (Gumaelius et al., 2016) and often involve interest-promoting aspects (e.g. Duan et al., 2021). Usually, a specific topic from as a school subject or an engineering field is taught with the help of hands-on activities (Gumaelius et al., 2016). Many extracurricular learning environments focus on STEM topics, with the intention of increasing the number of students in these fields and attracting more women and minorities to engineering professions (Jeffers et al., 2004). Therefore, promoting interest in STEM-related subjects and careers among participating students is a major concern of these institutions (Guderian & Priemer, 2008).

To date, there has been little consistent research on the relationship between OLEs and student interest. Previous reviews focused on specific regions (e.g. Germany) (Guderian & Priemer, 2008; Rehfeldt et al., 2020) or lacked a focus on the school context (e.g. Schwan et al., 2014) or on interest (Suviniitty & Clavert, 2020). Lewalter et al. (2021) conducted a meta-analysis of interest in out-of-school time programmes and considered different approaches to interest research, but they did not elaborate on the various theories of interest used in past studies. Recently, Neher-Asylbekov and Wagner (2022) published a systematic literature review of research on OLEs, highlighting several factors that have an impact on interest. They criticised that a comparison of the interest theories used in such research is lacking and stated that the concept of interest needs to be further specified. Thus, a review summarising international research on OLEs, focusing on the theories of interest used in this context, is yet to be presented. Consequently, no article has examined the impact of these learning environments on student interest.

This paper intends to fill the identified research gap. The systematic review presented herein was conducted to understand the current state of research into theories used to explore interest in inquiry-based OLEs, the effects of these learning environments on student interest, and the relationship between the different components of interest.

Methods

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009). The procedure followed based on the PRISMA checklist is described below.

Eligibility criteria

To obtain a comprehensive understanding of the relevant literature and the state-of-the-art approaches used in research while ensuring a high degree of comparability of results, only scientifically sound articles could be included in the review. Accordingly, eligibility criteria first had to be defined. We included studies that used defined constructs of 'interest' in all its forms, as outlined in the introduction. For an in-depth focus on the relevant literature, other constructs (e.g. self-concept) were excluded. Studies of related constructs or theories, such as motivation or the SDT, were also excluded if they did not consider interest (e.g. Salmi et al., 2021; Thuneberg & Salmi, 2018). To ensure the necessary depth of analysis and comparability due to subject-specific teaching methods, only STEM-related studies were considered. Furthermore, to capture the diversity of OLEs in the STEM field, we included all student-related studies of OLEs with an experimental component, such as student laboratories, research centres, hands-on museums, or science centres, that held events lasting no more than one day for K-12 students in class or small groups. All form of scientific studies in the English language were considered to avoid publication bias, and the search was not restricted in terms of year of publication.

Search strategy

The literature search was performed on the Education Resources Information Centre (ERIC), Scopus, Google Scholar, Web of Science and EBSCOhost databases. These databases were chosen because they specialise in educational research and information or peer-reviewed literature or because they are particularly comprehensive. The search equation was determined based on the information presented in the introduction and the eligibility criteria described above. It consisted of various phrases related to 'out-of-school learning environment', 'school context', and 'interest' (see Table 1). The individual categories were linked with the 'AND' function, and the components within these categories were linked with the 'OR' function. The search equation was intentionally precise to exclude unsuitable entries. Due to a high number of hits in the search on Google Scholar, the terms 'FOOD' and 'MEDICINE' were additionally excluded for further precision in this database.

The literature search was conducted on 18 October 2021, and it resulted in 1657 articles. These were then filtered according to the PRISMA selection strategy (Moher et al., 2009; see Figure 1). After duplicates were removed, the titles and abstracts of the 1573 identified articles were independently reviewed twice for eligibility. To ensure the independence of the literature review, this was done by a qualified research assistant and a doctoral student. The inter-rater reliability was 95.5%; therefore, it can be assumed that the results are independent of the two reviewers. If the title and abstract did not allow for a clear decision or if the two reviewers did not agree, the entire document was read. Together with the texts classified as potentially relevant by both reviewers, a total of 135 contributions were read and checked for content suitability. Articles were excluded if they did not contain findings relevant to the aim of research, contained insufficient information about the concept of interest used or the studies described, did not target K-12 students, or evaluated multi-day events or offerings on non-STEM topics. One meta-analysis (Lewalter et al., 2021) was excluded due to a lack of comparability and partial duplication with the other articles found.

Table 1. Search equation.

Expressions for 'out-of-school learning environment'	HANDS-ON-LAB; HANDS-ON-LABORATORY; HANDS-ON-MUSEUM; OUT-OF-SCHOOL-INQUIRY; OUT-OF-SCHOOL-LAB; OUT-OF-SCHOOL-LABORATORY; OUT-OF-SCHOOL-PROGRAM; OUT-OF-SCHOOL-PROGRAMME; OUTREACH-LAB; OUTREACH-LABORATORY; OUTREACH-LEARNING; SCIENCE-CENTER; SCIENCE-CENTRE; SCIENCE-OUTREACH; STEM-OUTREACH; STUDENT-LAB; STUDENT-LABORATORY; STUDENT-RESEARCH-CENTER; STUDENT-RESEARCH-CENTRE
Expressions for 'school context'	PUPIL; SCHOOL; STUDENT
Expressions for 'interest'	INDIVIDUAL-INTEREST; PERSONAL-INTEREST; SITUATIONAL-INTEREST

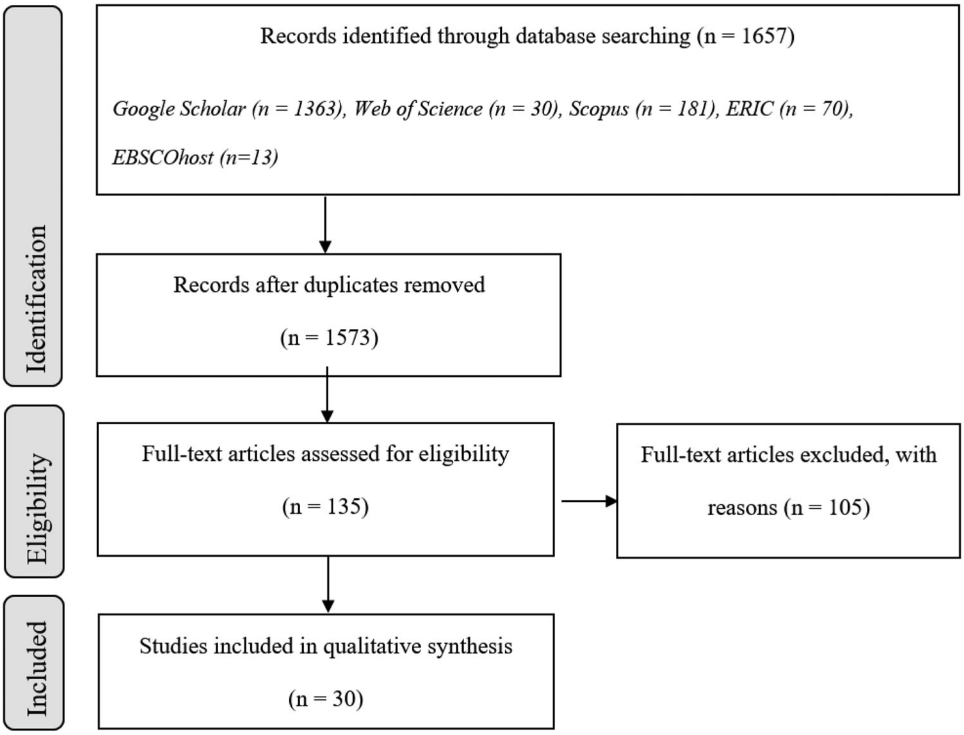

Figure 1. Flow of information through the different phases of the systematic review (Moher et al., 2009).

30 studies were finally included in this systematic review (see Table 2). The main characteristics of the studies were collected in a spreadsheet for further analysis and categorisation. In addition, all articles were analysed to determine the theories of interest used. The theories mentioned by name or those theories that the studies could be assigned to were noted.

Results

27 of the included 30 studies dealt with aspects of interest experience, with 15 studies focussing on SI and one each on actual interest and current interest. 16 studies dealt with areas of interest as a disposition, including five on inI. Table 2 provides an overview of the study parameters of the included literature.

The geographical locations of the included studies are shown in Figure 2 The clustering of studies in Germany can possibly be explained by the fact that certain extracurricular learning locations ('Schülerlabore') have been organised there for years in an association for the representation of interests (LernortLabor, 2023).

In the following sections, the theories of interest used in out-of-school learning settings (RQ1) are first discussed. Then, the results obtained are presented in relation to the interests of the participating students. Subsequently, the research results regarding the relationships between these interest components are presented (RQ2).

Table 2. Characteristics of included studies.

	Concepts of interest		Interest theories included							Participants	
Study, country	Interest experience (✓) incl. SI (◊)	Interest as disposition (✓) incl. inI (◊) incl. subject (#), object (+) & career (o) interest	4PM	POI	SDT	EVT	Other	Study design	Setting (Location, Subject, Duration)	Sample size (experimental group/control group)	(Mean) age in years
Affeldt et al. (2018) Germany	◊						SI	⓬ (pairs of students)	Non-formal learning environment 'Exploring and Improving the Quality of Water', chemistry, 3h	44 (22 interviews/-)	11–13
Affeldt et al. (2015) Germany	◊						Distinguish between personal interest and SI	e.g. questionnaires	4 student laboratories at 4 German universities, chemistry, 3h (additional activities possible)	141 (141/-)	Not specified
Bätz et al. (2010) Germany	✓				(x)		Interest=Intrinsic motivation in relation to the object.	① ②	Zoological garden, biology, 3 workstations with approx. 30min	223 (197/26)	10.45
Beranek-Knauer et al. (2020) Austria	◊		x	x	(x)	x	German translation of the questionnaire from Itzek-Greulich & Vollmer, 2017	① ② ③	Course at the Offenes Labour Graz (OLG), biology, one-day	282 (282/-)	17.7 ± 1.3
Budke et al. (2019) Germany	✓ (current interest)	✓ (general interest), #, +				x	Subject, object and current interest	① ② ③	Student laboratory GreenLab_OS/mobile lab at school, chemistry, one-day	340 (245 mobile lab, 95 university lab/-)	13.09, SD=.825
Dohn (2011) Denmark	◊		(x)	(x)				e.g.⓬, ❷	Aquarium, biology, one-day	16 (16/-)	17–19
Dohn (2013) Denmark	◊		(x)				Includes various articles about interest without mentioning a specific theory	e.g. ⓬, ❷	Zoo, biology, one school day	21 (21/-)	17–19
Fröhlich et al. (2013) Germany	◊						Distinguish between inI and SI	① ② retention test	Outreach farm/school, environmental education, 2x90min	176 (176/56)	11.5 (11–13)
Glowinski and Bayrhuber (2011) Germany	◊	◊	x	x	(x)			②	Student lab on a university campus, biology, 6h	378 (378/-)	18.3 SD=.76
Gutual (2019) USA	✓		x				Interest development with interest factors: Persevere, Independent Content Engagement, Personal Value,	① ②	Open enrolment K-12 engineering lab/school, biomedical engineering, 60-120min	55, (29 at engineering lab, 26 at school/-)	Not specified

						Independent Questioning, Content Knowledge, Self-Efficacy				
Hausamann (2012)[a] Germany	✓ (actual interest)	✓	x				① ② ③	DLR_School_Lab Oberpfaffenhofen, aeronautics and space, one-day	734 (734/-)	Not specified
Itzek-Greulich et al. (2017)[b] Germany	◊	✓	x		x		① ② ③	Interactive student research centre 'EXPERIMENTA'/ school, chemistry, 8 lessons of 45min	1854 (e.g. in pre-test: 1252/386)	15.3 SD=.7
Itzek-Greulich et al. (2017)[b] Germany	◊					Distinguish between inl and SI	① ②	Interactive student research centre 'EXPERIMENTA'/ school, chemistry, 8 lessons of 45min	1228 (44 classes/6 classes)	15.3 SD=.6
Lelliott (2007) South Africa	◊	◊				Distinguishes between personal interest and SI	e.g., ❶ ❷	Johannesburg Planetarium and Hartebeesthoek Radio Astronomy Observatory, astronomy, 2 - 4h	34 (34/-)	12–15
Markic et al. (2017) Germany	✓					Personal interest	②	Non-formal learning environment 'Exploring and Improving the Quality of Water', chemistry, 3h	244 (244/-)	11–13
Marth-Busch and Bogner (2020) Germany		✓	(x)	x		Interest in technology	① ② retention test, (③ n=183, 12 weeks & 1 year later)	Zoo, bionics, 5 school lessons	324 (324/-)	12.2
Ozogul et al. (2019) USA	✓				x		① ② ③	Arizona Science Lab (ASL) engineering workshop, electrical and mechanical engineering, one-day	3344 (3344/-)	9–14
Röllke et al. (2020) Germany	◊	◊	x			Triggered SI, maintained SI 'feeling' and maintained SI 'value' evaluated with SI Scale	Intermediate test ②	Laboratory teutolab biotechnologie at Bielefeld University/ school, biotechnology, 4h	287 (110 at university/177 at school)	15.6 SD=.8
Salmi and Thuneberg (2019) Finland	✓	✓		x		Interest evaluated with Semantic Differential method	① ②	Mobile science exhibition 'Science Circus', science education (physics,	256 (256/-)	12 years 6 months

(*Continued*)

Table 2. Continued.

	Concepts of interest		Interest theories included							Participants	
Study, country	Interest experience (✓) incl. SI (◊)	Interest as disposition (✓) incl. inI (◊) incl. subject (#), object (+) & career (o) interest	4PM	POI	SDT	EVT	Other	Study design	Setting (Location, Subject, Duration)	Sample size (experimental group/control group)	(Mean) age in years
									biology, chemistry), one-day		
Salmi et al. (2017) Finland	✓	✓	(x)		x		Interest evaluated with the Semantic Differential method	① ② delayed post-test	Dinosaur exhibition in science centre 'Heureka', biology, one-day	366 (249 with demonstration/-)	12–13
Salmi et al. (2017) Finland	✓	✓			x		Interest evaluated with the Semantic Differential method	① ②	AR Science Exhibition, physics/math (/chemistry), one-day	146 (146/-)	12.3
Salmi et al. (2020) Finland	✓	✓			x		Interest evaluated with Semantic Differential method	① ②	mobile exhibition 'Mars & Space', science/ mathematics, 115min	306 (306/-)	12.2 (11–13)
Seakins (2015) United Kingdom	✓	✓	x	x				❶/❷/delayed post-session interviews	Natural History Museum, London, one-day	38 (28 pre, 36 post, 32 delayed post/-)	16–18
Snetinová et al. (2018) Czech Republic	◊				x		Interest/enjoyment as a component of intrinsic motivation	②	Interactive Physics Laboratory (IPL)/physics demonstrations (DEMOS), physics, IPL:120min/ DEMOS:75min	1122 (303 IPL, 819 DEMOS/-)	15–19
Sripaoraya (2020) Thailand		✓	x	x	x			① ②	travelling science museum 'NSM Science Caravan', science/mathematics, one-day	1400 (1400 pre, 1084 post/-)	12–18
Stavrova and Urhahne (2010) Germany	◊						SI	① ②	German Museum in Munich, physics (energy topic), 2h	96 (54/42)	14.14 SD=.83
Streller (2015) Germany	◊	◊, #, o, Interest in Science and Experimentation	x	x	x			① ② ③ (6-8 weeks later)	Out-of-school laboratory at Helmholtz-Zentrum Dresden-Rossendorf research centre, physics, one-day	855 (570/285)	16.7 (16.7/ 16.8)
Vainikainen et al. (2015)	◊	◊	x				Distinguish between inI and SI, interest factor of the Semantic Differential method	① ②	Mobile interactive mathematics exhibition 'Discover the Art of Math',	793 (793/-)	12.39, SD=.99

Latvia & Sweden							math, 45min free exploring/45min workshop		
Wegner and Schmiedebach (2020) Germany		✓ (general interest), #	x			① ②	student laboratory 'Biology Up Close' at Bielefeld University, biology, 5h	121 (121/-)	12.32, SD=.57 (7th grade)/ 14.6, SD=.71 (9th grade)
Wünschmann et al. (2017) Germany	✓			x	Interest/enjoyment as component of intrinsic motivation	e.g. ②	Reptile and amphibian zoo/ school, biology, lesson at school and lesson at school or out-of-school	65 (school 18, Reptilium 23/24)	8–10

[a]The article by Hausamann (2012) summarises several studies; only the description of Pawek (2009) met the eligibility criteria for this review and was included.
[b]The studies by Itzek-Greulich et al. (2017) and Itzek-Greulich and Vollmer (2017) were partly based on the same dataset.
(x)=not mentioned by name, ①=pre-test, ②=post-test, ③=follow-up test, ❶=pre-interview, ⓬=interview during visit, ❷=post-interview

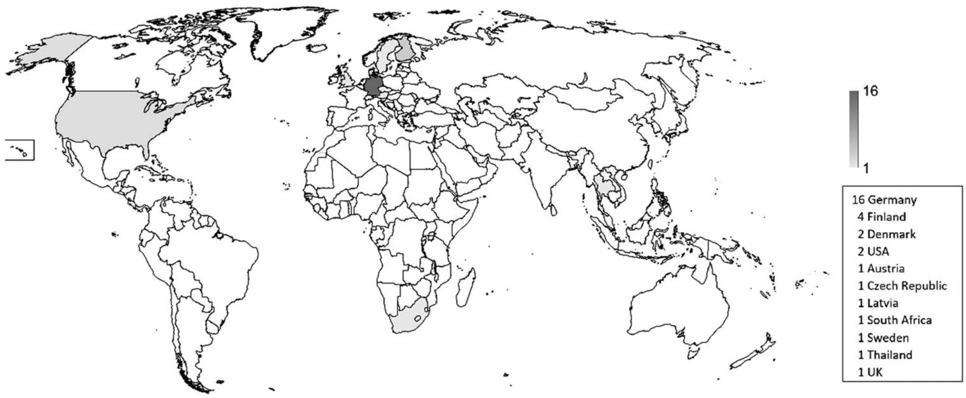

Figure 2. Geographic distribution of included studies.

Applied theories of interest

The theories described in the introduction of this article have been used by the studies in different ways.[1]

Nine (+ two) studies were found to refer directly (+ indirectly) to the POI, nine (+ three) studies to the SDT, four to the EVT, and seven (+ three) to the 4PM. Nine studies used multiple theories, with the POI, SDT, and 4PM being considered often. Seven studies didn't provide any definition of the interest theory applied. No patterns were found in the application of a particular theory of interest in a specific year or country.

When multiple theories were referenced in an article, they were found to be mentioned alongside each other but not deeply connected in terms of content (Itzek-Greulich et al., 2017; Salmi et al., 2017; Seakins, 2015). Often, only the common aspects of the theories were presented, such as the distinction between SI and inI (Dohn, 2011; Glowinski & Bayrhuber, 2011; Sripaoraya, 2020). Glowinski and Bayrhuber (2011), Streller (2015) and Beranek-Knauer et al. (2020) have mentioned the relevance of the basic psychological needs for interest development. None of the included articles synthesised all four theories of interest.

In response to RQ1, it can be said that all four theories of interest have been used to explore interest in OLEs.

Impact of out-of-school learning settings on student interest

Although all the included studies addressed interest, only some made general statements about interest levels or interest development in out-of-school learning settings. The following section is organised according to the theories of interest used: 4PM, POI, SDT, EVT, use of multiple theories, no mention of a specific theory.

Based on the 4PM, a qualitative study detected SI among the participating students due to the intervention conducted (Dohn, 2013). Quantitative studies using the 4PM also detected high levels of interest: Vainikainen et al. (2015) found that students reported a slightly higher level of SI than interest in school mathematics. In addition, Gutual (2019) found a significant ($p < .01$) shift in interest from pre to post test for the examined interest factors, namely 'persevere', 'content', 'value', 'questioning', 'knowledge', and 'self-efficacy', with medium effect sizes ($.418 \leq d \leq .745$).

Two studies used the POI and examined the level of interest at different measuring times before and after the visit to the OLE. Hausamann (2012) described a study in which participants were divided into three engagement groups. A comparison of the post – and follow-up tests showed no changes in the value-oriented component of actual interest, while the epistemic component (with an interim questionnaire redraft) decreased in all groups and the emotional component decreased in two of the three groups; Hausamann (2012) did not mention how significant the changes were. The author of the study concluded that there could be a positive effect on dispositional interest. Wegner and Schmiedebach (2020), on the other hand, compared interest in biology before and after the visit and found a significant change. Even though there was no significant interaction between time and group, a significant main effect was found for time and group ($F(1, 119) = .064$, $p = .801$, partial $\eta^2 = .001$; $F(1, 119) = 14.258$, $p < .001$, partial $\eta^2 = .1071$; $F(1, 119) = 18.372$, $p < .001$, partial $\eta^2 = .134$).

There is little data on interest based on the SDT alone. Only one study (Snetinová et al., 2018) mentioned the above-average values in the 'interest/enjoyment' category of the survey upon participation in laboratory or demonstration experiments (M(laboratory) = 5.54, SD = 1.52 / M(demonstration) = 5.67, SD = 1.17; theoretical mean of the seven-point Likert scale used = 4.0).

Budke et al. (2019) examined interest based on the EVT using a pre-, post-, and follow-up test design. A main effect was seen with factor time ($F(1.65, 555.88) = 345.08$, $p < .01$); there were no significant differences in subject interest between the pre – and post-test stages in the individual comparison, while subject interest decreased significantly between the pre-test and follow-up test. With respect to object interest, a global effect of factor time was seen ($F(1.93, 649.75) = 30.89$, $p < .01$), with a significant decrease in object interest between the pre – and post-test stages and no significant difference between the post-test and follow-up test. In contrast, a significant increase in current interest was measured in both experimental groups after the intervention. Two months after the intervention, however, the scale scores of both groups showed no significant differences from the baseline.

Several studies adopted multiple interest theories. Therefore, the results presented here are ordered according to study design. The qualitative studies without control groups detected SI among the students due to the intervention (Dohn, 2011; Seakins, 2015). Among the quantitative studies, one did not involve a control group: Glowinski and Bayrhuber (2011) found the mean-values for interest in experiments (M = 3.2, SD = .51), interest in research and application contexts (M = 2.8, SD = .58), and interest in authentic learning environment (M = 3.0, SD = .54) to be higher than the mid-range of the scale (2.5). In Itzek-Greulich et al.'s (2017) study, students were divided into four groups: three groups participated in interventions at school and/or a student research centre, and one group served as the control. Compared to the control group, students in the three intervention groups reported significantly ($p < .01$) high SI, with no significant differences between the three treatment groups. With regard to dispositional interest, no significant differences were found within or between the groups in the pre-test, post-test, and follow-up test.

Most studies using multiple theories measured interest at different times before and after their respective interventions. Using a pre-, post-, and follow-up test design, Streller (2015) analysed the role of an online portal in preparing and post enhancing the visit. A comparison of the post-test and the follow-up test revealed no significant differences in the feeling-related, value-related, and intrinsic components of SI in the control group without the online portal; for the treatment group, the feeling-related (t (226) = 5.19, $p < .001$, r = .33) and value-related (t(225) = 2.29, $p < .05$, r = .15) components of SI decreased significantly. In neither group were there significant changes over time for the three components of inI examined (interest in science/ experimentation/a career in physics). Marth-Busch and Bogner (2020) found a significant change in interest in technology before (M = 2.12 SD = 1.026), immediately after (M = 2.98 SD = .99) and six weeks after (M = 2.45 SD = 1.20) a bionics intervention. Interest in technology increased significantly between the pre – and post-test stages ($p < .001$) as well as between the pre-test and retention test ($p < .001$). However, the latter was only true for the experimental group as a whole and not for the subsample that was additionally surveyed. In this subsample, the same level of interest was found before the intervention, after six weeks ($p = .053$), after 12 weeks ($p = 1.00$) and after one year ($p = 1.00$). Beranek-Knauer et al. (2020) found a significant change in SI in their study. A medium increase was seen between the pre-test and post-test (effect size = .36) and a decrease from the post-test to the follow up about two months later. Sripaoraya (2020) found a significant increase in interest in science before and after the students' visit (M(pre) = 4.33, SD = .67; M(post) = 4.39, SD = .69, $t = 3.69$, $p < .001$). Among the studies that could not be clearly assigned to specific interest theories, those without control groups also reported high values for interest. In studies involving post-visit questionnaires, most students stated that they perceived the intervention topics as at least partly of personal interest to them (Affeldt et al., 2015: N = 141, over 95% agreement; Markic et al., 2017: N = 244, over 90% agreement). In their study of SI, Fröhlich et al. (2013) noted that students showed relatively high interest (M = 3.7, using a five-point Likert scale: 1 = not at all to 5 = very much). In a study by Itzek-Greulich and Vollmer (2017), students were divided into three experimental groups and one control group, with interventions conducted at school and/or a student research centre. Compared to the control group, a significantly high SI was found in the theoretical and practical parts of the intervention for the three groups – school only ($p < .001$), student research centre and school ($p < .01$), and student research centre only ($p < .001$) – with no significant differences between the groups.

Relationships between components of interest

Several studies examined the relationship between SI and inI among students visiting an extracurricular learning environment. Vainikainen et al. (2015) used the 4PM and found that inI could predict SI ($\beta = .28$, $p < .001$) in the OLE.

Röllke et al. (2020) conducted a study with the POI as the theoretical basis, in which students were divided into three groups according to their inI. Higher inI was found to be associated with significantly higher ($p = .00$) SI, triggered SI, values for the 'feeling' and 'value' components of maintained SI, and flow level, with medium to large effects ($.06 \leq \eta^2 \leq .15$).

These results are similar to those of SDT-based studies that found interest in the school learning context to predict interest in the science centre learning context (Salmi et al., 2020: β = .18, $p < .01$; Salmi & Thuneberg, 2019: β = .11, $p < .05$).

Studies that adopted the EVT analysed the correlation between the forms of interest. Ozogul et al. (2019) questioned students before, right after and two weeks after participating in an engineering workshop and found correlations between interest at the different test time points (Pearson inter-correlation coefficients pre/post: .59, $p < .01$; pre/delayed-post: .49, $p < .01$; post/delayed-post: .64, $p < .01$). Furthermore, Budke et al. (2019) reported that current interest correlated with subject interest (r = .576) and object interest (r = .656) in the pre-test stage.

Studies with multiple theoretical bases also reached similar conclusions. Glowinski and Bayrhuber (2011) found significant correlations between inI and SI in research and application contexts (r = .38; $p < .001$), authentic learning environments (r = .30; $p = .001$) and experiments (r = .44, $p < .001$). Salmi et al. (2017) found that interest in learning biology at school had a significant effect on interest in learning biology at the science centre (β = .19, $p < .001$).

Furthermore, Lelliott's (2007) work, that cannot be clearly attributed to a particular theory of interest, finds for an individual case that the SI promoted by an extracurricular learning experience was congruent with the visitor's inI.

Few studies are available on the composition of student interest in OLEs. Glowinski and Bayrhuber (2011) used factor analysis and reliability analysis to determine the composition of SI and found a multi-component structure. The three main components, namely 'interest in experiments', 'interest in research and application contexts', and 'interest in authentic learning environment', explained 44.3% of the variance (19.7%; 13.7%, and 10.9% respectively).

Discussion

Comparing results across different theories of interest

Data related to OLEs highlight the comparability of the results obtained with the different interest theories: Students showed high level of interest when visiting the OLEs considered. This is evident from the significantly high SI values reported in comparison to control groups (Itzek-Greulich et al., 2017; Itzek-Greulich & Vollmer, 2017) and the significantly higher SI in the post-test stage than in the pre-test stage (Budke et al., 2019; Gutual, 2019; Vainikainen et al., 2015). The above-average positive responses to interest-related questions (Affeldt et al., 2015; Fröhlich et al., 2013; Glowinski & Bayrhuber, 2011; Snetinová et al., 2018) also point in this direction.

The OLE did not appear to have lasting positive effects on interest as a disposition (Budke et al., 2019; Hausamann, 2012; Itzek-Greulich et al., 2017). This is not surprising, as interest development is a complex process (Hidi & Renninger, 2006; Krapp, 2002a), and a maximum one-day event cannot be expected to have a particularly large impact in this regard. Nevertheless, individual long-term effects are possible (Lelliott, 2007). To facilitate long-term effects on student interest, it may be useful to integrate out-of-school visits with classroom activities. In this way, the influencing factors named in the various interest theories, such as meaningfulness or competence, may be strengthened.

The results of several studies showed that higher inI is associated with higher SI in OLEs (e.g. Glowinski & Bayrhuber, 2011; Röllke et al., 2020; Vainikainen et al., 2015). This observation is consistent with the POI, according to which an interest that arises at a particular time can be caused by pre-existing dispositional interest (Krapp, 2002b). The emotional and value-based components of actual interest did not appear to depend on interest in specific disciplines when students visited the OLEs, but the epistemic component was significantly higher among students with an interest in mathematics, science, and technology than the other students (Hausamann, 2012). According to POI, this finding could indicate that only students with matching prior interests want to learn more about the topics covered in OLEs, but all students, regardless of their prior interests, tend to be equally emotionally engaged during these visits and recognise the personal relevance of the topics covered.

Since studies involving the POI (e.g. Glowinski & Bayrhuber, 2011; Hausamann, 2012; Seakins, 2015; Streller, 2015; Wegner & Schmiedebach, 2020), SDT (e.g. Marth-Busch & Bogner, 2020; Salmi et al., 2017; Salmi et al., 2020; Salmi & Thuneberg, 2019; Snetinová et al., 2018), EVT (e.g. Budke et al., 2019; Ozogul et al., 2019), and 4PM (e.g. Gutual, 2019; Seakins, 2015; Vainikainen et al., 2015) resulted in high values for interest experience as well as a similar pattern of interest thereafter and a similar relationship between individual and situational interest, the underlying interest theories seem to have played rather minor roles in the evaluation of interest.

Development of a comprehensive interest model (for out-of-school science learning environments)

Based on the results on interest in OLEs presented in this article we combined the initially illustrated interest theories to form an interest model for these learning environments. This step seems justified, since the studies involving the different theories yielded largely comparable results (see also Lewalter et al., 2021). The proposed model is given in Figure 3.

As elaborated in the chapter on the theoretical background, the different theories of interest vary in their emphases on interest. Nevertheless, the key construct of interest in the EVT is similar to the construct of intrinsic motivation in the SDT (Wigfield &

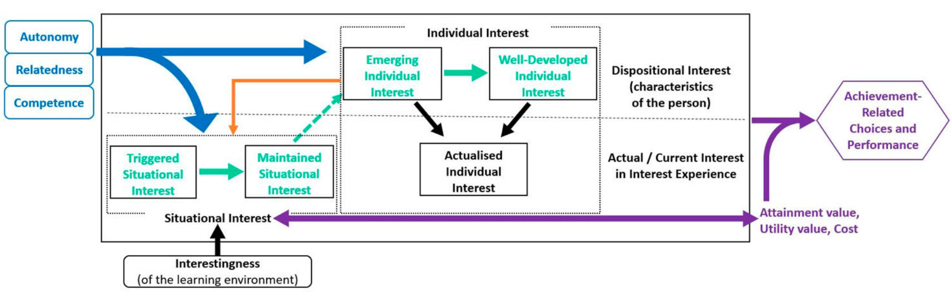

Figure 3. Interest-related components of the different theories used to evaluate interest in out-of-school learning environments: 4PM (green), POI (black), SDT (blue), and (S)EVT (purple).

Eccles, 1992), of which SI can be understood as one aspect (Hidi & Harackiewicz, 2000). In turn, SI is an important element in the POI and 4PM, both of which emphasise the relevance of three basic psychological needs for interest development (Hidi & Renninger, 2006; Krapp, 2002a). The theories differ, among other things, in the specifications and weighting of factors influencing interest, such as 'meaningfulness' and 'involvement' in the 4PM and 'competence', 'autonomy' and 'relatedness' in the SDT.

The 4PM can serve as a basis for describing interest development, while the other theories highlight important factors influencing this process. Numerous studies found a correlation between SI and inI. Effects of SI on inI through OLEs appear to be the exception, whereas the students' inI is associated with their SI during the visit. The effects of triggered SI on maintained SI as well as the effects of emerging inI on well-developed inI have not been (sufficiently) studied for OLEs so far. Therefore, the connection of these interest components shown in Figure 3 can only be assumed for OLEs on the basis of the 4PM, but not empirically proven.

Past studies have shown that autonomy, competence, and relatedness, which are important components of the SDT, correlate with the components of SI (e.g. Glowinski & Bayrhuber, 2011; Itzek-Greulich et al., 2017; Itzek-Greulich & Vollmer, 2017; Neher-Asylbekov & Wagner, 2022; Salmi et al., 2017); at least for competence beliefs a correlation with dispositional interest could also be demonstrated (Itzek-Greulich et al., 2017). EVT factors such as attainment value, utility value, and cost have also been shown to correlate with SI (Itzek-Greulich et al., 2017; Ozogul et al., 2019), even though the interaction of components was deliberately left open in the EVT itself (Wigfield et al., 2020). Factors related to the learning environment that have been highlighted in the POI, such as learning activities, were also found to influence SI (for hands-on activities, see Dohn, 2011, 2013; Lelliott, 2007; for active participation, see Stavrova & Urhahne, 2010). In addition, the POI enables a detailed view and finer structuring of interest by, for example, distinguishing between dispositional inI and actualised inI.

This theoretical model is based on the four interest theories mentioned above as well as the presented studies. It describes the process of interest development as well as factors influencing it in the context of OLEs. Thus, it can help provide a concise overview of important components and stages of interest development and how they are interrelated. For example, it enables researchers to create new research tools for the evaluation of interest. For practitioners, it highlights important connections and influencing factors that they should consider in their pedagogical work. For example, autonomy and relatedness are important for the development of interest, which in turn influences student performance.

As this model is based on the presented studies it is only applicable to OLEs. Other learning environments differ from it, nevertheless the model could also apply there, since it is in large parts a learning place-independent combination of the four presented theories. This is partly due to the fact that the theories of interest formed from studies on other learning contexts, are in many ways applicable to OLEs.

Limitations and suggestions for future research

This systematic literature review included 30 international studies focusing on interest in out-of-school STEM learning environments from the last 15 years. Since learning environments are highly diverse, the narrow search equation guaranteed the close proximity of the studies reviewed. Due to the limited number of thematically significant studies, we also included studies with methodological weaknesses. The 135 articles that were excluded due to their ineligibility attest to the complexity of this study. Since the included studies differed in their settings and subjects as well as the quality of study design and the selected journals, a direct comparison would have been difficult, so we decided against a meta-analysis.

The reviewed studies used the theories of interest in very different ways, and some used multiple theories, making it difficult to categorise the studies by theory. This was particularly the case with the studies of Itzek-Greulich et al. (2017) and Itzek-Greulich and Vollmer (2017): both (partly) involved the same dataset, but the former explicitly mentioned the EVT and POI, while the latter did not mention any theories.

Another obstacle in comparing the studies was that the construct of interest is complex, and the theories related to it continue to evolve. Many studies did not make a distinction between the different interest components and thus could not detect small differences in them. Furthermore, the evolution of said theories may have caused studies that were far apart in terms of year of publication to reach different conclusions. Therefore, there remains a great need for current, more detailed research on the interest components of OLEs, especially the influencing factors given in the SDT and (S)EVT, and on the relationship between triggered and maintained SI.

Conclusion

This article provided a structured overview of the state of research on student interest in OLEs by drawing from the 4PM, POI, SDT and EVT. All theories have been used in studies and variously combined (RQ1). Regardless of the theory used, these learning environments were found to promote SI, whereas long-term effects occurred only in individual cases, if at all (RQ2). The influencing factors postulated by the different theories correlated with the components of interest, which was illustrated through a combined model of the four interest theories specific to OLEs (RQ2). This model can be used by both providers of those educational settings and researchers to guide the development and further improvement of OLEs.

Note

1. As underlying theories are not always mentioned by name, we have mapped them to one or more of the above theories of interest whenever possible (see Table 2).

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Ethics statement

No ethical approval (by an external committee) was required for this study, as all data were publicly available and anonymous.

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