

## **WP 2 : MAP**

Deliverable 2.1

Conceptual Framework





Work Package	WP2 : MAP
Deliverable	D2.1 Conceptual Framework
Lead Partner	Science Gallery at Trinity College Dublin
Month Due	M5
Month Submitted	M9
Month Updated	M18
Deliverable Type	Report
Dissemination Level	Public
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## Revision History

Revision	Date	Author	Partner	Description
0.1	31/10/2018	Joseph Roche	SGD/TCD	Initial draft
0.2	23/11/2018	Evangelos Kapros	SGD/TCD	For review
0.3	29/11/2018	Eva Durall, Christian Voigt	Aalto, ZSI	Reviewers comments
0.4	09/01/2019	Evangelos Kapros	SGD/TCD	Comments addressed
1.0	09/01/2019	Kali Dunne	SGD/TCD	Final version
1.1	08/05/2019	Autumn Brown	SGD/TCD	Updated version
1.2	23/10/2019	Joseph Roche, Mairéad Hurley	SGD/TCD	Reviewers comments
2.0	25/10/2019	Kali Dunne	SGD/TCD	Final check & formatting



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# 1 Background

## 1.1 SySTEM 2020

People learn science<sup>1</sup> in a variety of settings throughout their lives. As societies worldwide have begun to transition away from industrial economies in favour of innovation and technology based systems, flexible, and adaptive learning opportunities have become a vital portal of possibility for learners seeking to contribute to and actively participate in the culture of science.

This paper is a part of a larger venture called SySTEM 2020. SySTEM 2020 is a multi-faceted project focused on evaluating the impact and delivery of science learning outside of the classroom. The intention of the project is to map current informal<sup>2</sup> learning organizations and activities across Europe, evaluate a number of existing programmes, and use this information to design a robust framework for informal science education. This framework is meant to be utilised by educators and learners alike. During the project, platforms for self-evaluation will be piloted to examine individual learning ecologies, document informal science learning experiences, and provide scope for credentialisation. The project will examine practices in 19 European countries, and learners between the ages of 9-20 years old in an array of contexts including those from geographically remote, socio-economically disadvantaged, minority, and migrant communities.

There are five main objectives for SySTEM 2020:

1. To thoroughly assess existing informal and non-formal science learning in Europe.
2. To establish challenges surrounding informal science education, and identify necessary factors that support fair inclusion and engagement in this field by learners. This will involve stakeholders and learners through a co-design format.
3. To design consolidated frameworks and tools for facilitating informal science education, including a technology platform that can be used by STEM learners, allowing them to gain credentialisation.
4. To reflect on and evaluate the impact of the above outlined pilot studies, and adapt the learning tools accordingly to improve their efficacy.
5. To disseminate the learnings of SySTEM 2020 via research papers, conferences and workshops, as well as engage and inform stakeholders, peers, and the general media to foster public awareness of this field.

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<sup>1</sup> 'Science' here is used for brevity. The scope of the project includes science, technology, engineering, and mathematics (STEM) and related areas, and STEAM, when the aforementioned includes the arts.

<sup>2</sup> As above, 'informal' here means 'outside of the classroom'. Definitions of informal, non-formal, and semi-formal education to follow.



## 1.2 Definitions and Rationale

There exists a stark lack of consensus in identifying those characteristics which define learning that takes place outside of the classroom (Rogers 2014; Sefton-Green 2004; 2013; Werquin 2010). The features which delineate a unique and separate pedagogy while often explored, (Hein, 1998; Hofstein and Rosenfeld, 1996; Jarman 2012) have remained polemical. Researchers in the early 90's favoured models which outlined sharp distinctions between formal classroom learning and that learning which took place outside of school (Wellington, 1990). These models however, did not allow for the nuanced and cooperative relationships which in school and out of school learning often share to be fully acknowledged and examined. Increasingly, researchers have sought to create more flexible conceptualisations, which sometimes place learning on a spectrum (Werquin, 2007) or favour broad descriptions which define modes of learning primarily through setting rather than any distinct pedagogical characteristics or processes.

A number of these expansive models have gained popularity in recent years, including the boundary defying free-choice learning (Falk & Dierking, 1998; Hall & Schaverien, 2001), and the panoptic life-long, life-wide, life-deep learning (Banks et al, 2007). Though broadly useful the growing trend of free-choice learning within formal education institutions, such as those primary and secondary schools now incorporating a Reggio Emilia approach, renders free-choice learning conceptually over-encompassing. Life-long, life-wide, and life-deep presents similar challenges.

Some experts have observed that school based learning, most often described as 'formal learning' and the learning which takes place outside of school are becoming so increasingly intertwined, particularly with the advent of online education, that to define boundaries may put researchers at risk of creating false distinctions (Eshach, 2007; Marsick, 2009). Rennie notes in her 1999 paper that, "the notion of distinguishing between informal and formal learning is unproductive, after all learning is learning" (Rennie, 1999).

The tripartite conceptualisation of informal, non-formal, and formal learning was proposed most famously by Coombs & Ahmed in 1974, likely in response to a call from UNESCO and the World Bank to move knowledge making towards notions of lifelong learning. This was during a time of rapid political, technological, and social change, leading some experts to suggest that formal education was not equipped to adapt at a reasonable speed, to the educational needs of society, (Bowles & Gintis, 1976; Field & Leicester, 2000). A new approach to education which valued personal motivations, learner-led decisions, flexible contexts, and speed, thus emerged.

As educators, policy makers, and other stakeholders have become increasingly interested in the value of such flexible and accessible learning, governmental bodies have stepped forward to provide their own definitions, with similarly dissimilar results (see Table 1 below).



Organisation	Formal	Informal	Other
European Commission (2000)	Formal Learning: in education and training institutions and leads to a qualification	Informal Learning: from everyday situation; <i>not necessarily intentional</i>	Non-Formal Learning: alongside mainstream system of education; does not lead to a qualification
EUROSTAT (2000/06)	Formal Education: in the initial education and training system, below age 20/25	Informal Learning: intentional, less organised, less structured than formal learning	Non-Formal Education: Organised and sustained; all ages; within and outside education institutions; education programmes for adults (literacy...)
European Centre for the Development of Vocational Training (2005)	Planned and intentional learning activities	Not planned and non-intentional learning activities	Planned and intentional activities, no learning objective
Organisation for Economic Co-operation and Development (2007a)	Formal Learning: in an educational institution, adult training centre or in the workplace	Informal Learning: from daily work, family or leisure activities. Not organised or structured. Unintentional	Non-Formal Learning: programmed but not assessed and does not lead to a qualification; intentional
European Centre for the Development of Vocational Training (2008/14)	Learning that occurs in an organised and structured environment (e.g. in an education or training institution or on the job)  Explicitly designated as learning (in terms of objectives, time or resources)  Intentional from the learner's point of view. It typically leads to validation and certification.	Learning resulting from daily activities related to work, family or leisure.  Not organised or structured in terms of objectives, time or learning support.  In most cases unintentional from the learner's perspective.	Learning embedded in planned activities not explicitly designated as learning (in terms of learning objectives, learning time or learning support).  Non-formal learning is intentional from the learner's point of view.
International Standard Classification of Education 2011	Formal Education: institutionalised, intentional, and planned through organisations and recognised private bodies and, in their totality, constitute the formal education system of a country.	Informal Learning: intentional, or deliberate but are not institutionalised. Consequently less organised and structured than either formal or non-formal education	Non-Formal Education: is institutionalised, intentional, and planned by an education provider. Defining characteristic is that it is an addition, alternative, and or complement to formal education, lifelong learning.
National Centre for Vocational Education Research (2013/17)	Learning that takes place through a structured program of instruction which is generally recognised by the attainment of a formal qualification or award (for example, a certificate, diploma or degree).	Learning resulting from daily activities related to work, family or leisure. It is not organised or structured (in terms of objectives, time or learning support). Informal learning in most cases is unintentional from the learner's perspective. It typically does not lead to certification.	Any organised and sustained educational activity that does not correspond exactly to the definition of formal education.  Non-formal education may therefore take place both within and outside educational institutions, and cater to persons of all ages.
United Nations Educational, Scientific, Cultural Organisation (2015)		Learning that results from daily activities	Structured learning that lies outside of the formal system

Table 1: Definition of Terms



While continuously refined and redefined, this three-pronged approach allows researchers to explore and operationalize the distinct circumstances in which science learning occurs, while acknowledging the porous boundaries and tensions between contexts (Coombs & Ahmed 1974).

The purpose of this paper is to conduct a systematic literature review of recent publications exploring and creating informal and non-formal science learning frameworks, to categorise these, identify gaps in the field, and to propose a consolidated framework which will provide the basis for future work. The paper will also consolidate the viewpoints of our analysed literature and create a consensus definition for formal, non-formal, and informal learning to be used as a reference for future work.

## 1.3 Research Questions

The research questions were developed to be practical, specific, and answerable, following the guidelines suggested by Jensen and Laurie (2016) along with best practices from the Campbell Collaboration, an international network which publishes systematic reviews of social and economic interventions since 2000 (Campbell Collaboration, 2015).

The research questions are:

1. How does the academic literature classify science learning activities which take place outside of the classroom?
2. What are the most common frameworks used to analyse science learning outside the classroom?

## 2 Methods

### 2.1 Systematic Literature Review

A systematic literature review was carried out to establish the breadth and depth of existing conceptual frameworks used to explore informal science learning. Sometimes these reviews can be basic narrative-style interpretations of the existing literature. The difference between a systematic literature review and these other type of basic reviews is that systematic literature reviews require a well-defined and rigorous approach when appraising literature in a specific area (Fink, 2005; Budgen & Brereton, 2006). Basic reviews may provide useful context, but are of little scientific value. In contrast, systematic literature reviews provide a definitive assessment of a field of work and can then guide future research within a particular area of research. Gough, Oliver, and Thomas (2017) point out that “reviews of research are themselves pieces of research and so need to be undertaken according to some sort of method” (p. 4). If research is undertaken in an area without the existence of a systematic literature review, that research runs the risk of being redundant





and misleading. Therefore, a systematic literature review is an ideal way to summarise the best current research into existing conceptual frameworks in informal science education.

Building on the established processes for systematic reviews (Khan, Kunz, Kleijnen, & Antes, 2003; Cronin, Ryan, & Coughlan, 2008; Denyer & Tranfield, 2009; Okoli & Schabram, 2010), this systematic literature review will:

- Identify relevant primary studies in the field
- Search through the available literature using clear, well-defined, and transparent search criteria
- Explicitly highlight and justify the inclusion and exclusion criteria to minimise bias and error
- Collate these studies with any other relevant research conducted in this area
- Systematically analyse gathered content
- Summarise the available evidence based on the review.

## 2.2 Inclusion & Exclusion Criteria

The inclusion criteria are the rules of selection, used to determine which studies or publications are to be included in the systematic review. The starting point for choosing the selection criteria are the research questions themselves, which are unpacked to establish the boundaries of the search process and how extensive it must be. For this review, the inclusion criteria extended to both theoretical and empirical peer-reviewed scholarly articles. Commissioned reports from reputable organisations - known as “grey literature” (McAuley, Tugwell, & Moher, 2000), and books were included if frequently referenced in the core texts. In order to cover fresh ground, publications preceding 2007 were excluded, as a thorough literature review, (Phipps, 2010) was conducted, covering publications from 1999 through 2007. Works which were not published in the English language were also excluded from this systematic literature review due to time constraints and limited resources.

Two Boolean searches were carried out for each listed database found in appendix 1. The terms for these searches are outlined in Table 2.

Boolean Search Terms		
1	Education	{Semi Formal OR Non-formal OR Informal OR outside the classroom OR out of school} AND {Learning OR Education} AND {Science}
2	Extra Curricular	{Extra curricular OR after school OR Maker} AND {Programmes OR Course OR Clubs OR Activities} AND {Science}

Table 2: Boolean search terms for publication databases



## 2.3 Database Searching

A number of databases were targeted to ensure a comprehensive search was undertaken in line with the recommendations of Papaioannou et al., (2010). These included a series of bibliographic databases outlined in Appendix 1. Once a paper or study was found that fit the search criteria, its reference list was searched as well as any publications that had subsequently cited the work. This is commonly referred to as the “pearl growing” method (Ramer, 2005). Pearl citations were then subjected to the same inclusion and exclusion criteria outlined above.

A comprehensive list of all included literature has been provided in Appendix 2. Once the studies had been collected, they were systematically evaluated. This process was carefully documented to ensure that the way in which the studies were collected and assessed was transparent and could be replicated. All of the studies were collected and assessed between July 2018 and September 2019. The first step in the evaluation process consisted of a review of the publication’s title and abstract. If, following this initial appraisal, the work was determined to have met the inclusion criteria, then the rest of the publication was examined in detail. Following this secondary appraisal, attributes such as the paper’s approach (theoretical, empirical, etc.) were documented, as was their framework.

This further examination qualified the work for analysis subject to a further set of inclusion/exclusion criteria. Exclusion criteria included publications whose pearl citations were predating 1998, and publications whereby a critique or point of view on a referenced framework was not delivered. Papers in which informal education evaluation frameworks were provided without adequate definition were also excluded.

Inclusion criteria included those works in which a critique, discussion, or definition of informal, non-formal or any alternative moniker, e.g. free-choice learning, or lifelong, life-wide, or life-deep learning were provided. Publications which had not been peer-reviewed but were repeatedly referenced throughout the literature were also considered for inclusion.

## 3 Results

### 3.1 Core Literature

The studies that met the inclusion criteria were appraised and indexed chronologically (as shown in Table 3) by: title of the study, the year of its publication or release, the country in which the work was conducted, whether it resulted in an empirical, or theoretical study, report or review, and the theoretical or conceptual framework used whenever it was stated by the authors, or identifiable.



Title	Year	Country	Journal	Approach	Reference (APA)	Frameworks (conceptual and/ or theoretical)
Evaluating Informal STEM Education: Issues and Challenges in Context	2019	USA	Evaluation in Informal STEM education	Report	Allen, Sue & Peterman, Karen (2019)	Learning ecologies
Guerilla Science: Mixing science with art, music, and play in unusual settings	2019	USA	Leonardo: MIT Press	Empirical	Rosin, Mark & Wong, Jen & O'Connell, Kari & Storksdieck, Martin & Keys, Brianna. (2019)	Theory of change
The Relationship between Formal Education and Non-Formal Education: A Descriptive and Analytical Review of the Publications about Astronomy Education in Journals and Events Related to Science Teaching in the Brazilian Context	2018	Brazil	Science Education International	Review	Menezes, Isadora Moutinho Carvalho A.; Ovigli, Daniel Fernando Bovolent; Colombo, Pedro Donizete, Jr. (2018)	Sociocultural
The formality of learning science in everyday life: A conceptual literature review.	2018	Denmark	Nordic Studies in Science Education	literature review	Dohn, Niels. (2018).	Compares free choice, lifelong, and hybrid learning resulting in original conceptual framework
Research trends and issues in informal science education	2018	Thailand	International conference for science educators and teachers (conference paper)	Review	Pinthong, Tanwarat & Faikhamta, Chatree. (2018).	Sociocultural and constructivist theories identified as most common
Science in the learning gardens a study of students' motivation, achievement, and science identity in low income middle schools	2018	USA	International Journal of STEM Education	Theoretical	Williams et al, (2018)	Motivational framework and self-determination theory
A Framework for Informal STEM Education Outreach at Field Stations	2018	USA	Bioscience	Theoretical	Struminger, R. et al. (2018)	Inquiry based learning followed by original conceptual framework (adapted from learning ecologies)



Integrating Academic and Everyday Learning Through Technology: Issues and Challenges for Researchers, Policy Makers and Practitioners	2018	Canada Netherlands New Zealand India UK USA	Technology Knowledge and Learning	Theoretical	Lewin, C., Lai, K. W., van Bergen, H., Charania, A., Ntebutse, J. G., Quinn, B. & Smith, D. (2018).	Learning environments framework
Students' perceptions of STEM learning after participating in a summer informal learning experience	2018	USA	International Journal of STEM Education	Empirical	Roberts, T., Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Cavalcanti, M., Cremeans, C. (2018).	Theory of situated learning
When Makerspaces Meet School: Negotiating Tensions Between Instruction and Construction	2018	Norway	Journal of Science Education and Technology	Empirical	Tan, Michael, (2018)	Constructivist
Eight-Legged Encounters--Arachnids, Volunteers, and Art help to Bridge the Gap between Informal and Formal Science Learning	2018	USA	Insects	Empirical	Hebets, E. A., Welch-Lazoritz, M., Tisdale, P., & Wonch Hill, T. (2018).	CML (Contextual Model learning)
"Some Explanation Here": A Case Study of Learning Opportunities and Tensions in an Informal Science Learning Environment	2017	USA	Instructional Science	Empirical	Stewart, O. G., & Jordan, M. E. (2017).	Socio-constructivist
Use of the concept of Bildung in the international science education literature, its potential, and implications for teaching and learning	2017	Germany	Studies in Science Education	Theoretical	Sjöström, Jesper; Frerichs, Nadja; Zuin, Vânia & Eilks, Ingo (2017)	Critical Bildung framework (metatheory) Transformative learning theory
Beyond the Classroom Walls: Technology Infusion Advancing Science Education	2016	USA	Delta Kappa Gamma Bulletin	Empirical	Ponners, P., & Asim, S. (2016).	Socio-constructivist
Enacting Informal Science Learning: Exploring the Battle for Informal Learning	2016	UK	British Journal of Educational Studies	Empirical	Clapham, A. (2016). Enacting informal science learning: exploring the battle for informal learning. British Journal of Educational Studies, 64(4), 485-501.	Grounded theory approach
STEM learning ecologies: Relevant, responsive, and connected.	2016	USA	Connected Science Learning	Theoretical	Bevan, Bronwyn. (2016).	Learning ecologies framework informed by Funds of knowledge



Social media and education: Reconceptualizing the boundaries of formal and informal learning	2016	USA, UK	Learning Media and Technology	Theoretical	Greenhow, Christine & Lewin, Cathy (2016)	Connectivism and social constructivism
The Organization of Informal Learning	2016	USA	Review of Research in Education	Theoretical	Rogoff, B., Callanan, M., Gutierrez, K. D., & Erickson, F. (2016).	Scribner and Cole, Greenfield and Lave, Followed by LOPI, (Learning by Observing and Pitching In)
An investigation of the role of learning conversations in youth's authoring of science identities during an informal science camp	2015	USA	International Journal of Science Education	Empirical	Kelly Riedinger & J. Randy McGinnis (2017)	Social practice theory and identity theory
Benefits of Informal Learning Environments: A Focused Examination of STEM-based Program Environments.	2015	USA	Journal of STEM Education	Empirical	Denson, C., Austin, C., Hailey, C., & Householder, D. (2015).	Grounded theory approach
A Non-Formal Student Laboratory as a Place for Innovation in Education for Sustainability for All Students	2015	Germany	Education Sciences	Empirical	Affeldt, F., Weitz, K., Siol, A., Markic, S., & Eilks, I. (2015).	Green chemistry, Model of differentiated learning environments
Informal science education: Life-long, life-wide, life-deep	2014	USA	PLOS Biology	Theoretical	Sacco, K., Falk, J. H., & Bell, J. (2014).	Life-long life-wide life-deep
Science Education through Informal Education	2014	Brazil	Cultural studies of science education	Theoretical	Kim, M., & Dopico, E. (2016).	Sociocultural, Collaborative framework
Equity in informal science education: developing an access and equity framework for science museums and science centres	2014	UK	Studies in Science Education	Theoretical	Dawson, Emily (2014)	Sociocultural-constructivist approach, adapted porter's access framework, a new 3 part equity framework
The role of informal science centers in science education: attitudes, skills, and self-efficacy	2014	Israel	Journal of Technology and Science Education	Empirical	Sasson, Irit. (2014)	Original framework to characterize learning environments: organizational, psychological, and pedagogical Not explicit but sociocultural



Reframing research on informal teaching and learning in science: Comments and commentary at the heart of a new vision for the field	2014	USA	Journal of Research in Science Teaching	Theoretical	Rahm, J. (2014).	CHAT, network theory, social practice theory
Summer science camp for middle school students: A Turkish experience	2013	Turkey	Journal of Turkish Science Education	Empirical	Sezen Vekli, G. (2013)	Constructivist though not explicitly stated
Where it gets interesting: Competing models of learning in after-school.	2013	USA	Afterschool Matters	Theoretical	Bevan, Bronwyn, and Michalchik, Vera. (2013)	Additive model of learning, CML(Contextual model of learning), and Learning Ecologies
School and out-of-school science: a model for bridging the gap	2013	UK	Studies in Science Education	Theoretical	Fallik, O., Rosenfeld, S., & Eylon, B. S. (2013).	Activity theory for organisations (expanding learning framework) and a design-based research (DBR) framework
STEM Clubs and Science Fair Competitions: Effects on Post-Secondary Matriculation	2013	USA	Journal of STEM Education	Empirical	Sahin, Alpaslan. (2013).	Facilitative learning social learning theory
Deepening Students' Scientific Inquiry Skills During a Science Museum Field Trip	2012	USA	Journal of Learning Science	Empirical	Gutwill, Joshua & Allen, Sue. (2012).	Framework based on zones of proximal development (socio-constructivist)
Science Learning through Scouting: An understudied context for informal science education	2012	Ireland	International Journal of Science Education	Empirical	Jarman, R. (2012).	sociocultural
Mapping the informal science education landscape: An exploratory study	2011	USA	Public Understanding of Science	Theoretical	Falk, J. H., Randol, S., & Dierking, L. D. (2012).	Community of practice
The roles of the formal and informal sectors in the provision of effective science education	2010	Australia, UK	Studies in Science Education	Theoretical	Stocklmayer, S. M., Rennie, L. J., & Gilbert, J. K. (2010).	CML( Contextual model of learning) though never explicitly stated
The 95 Percent Solution	2010	USA	American Scientist	Report	Falk, J. H., & Dierking, L. D. (2010).	None
Research Trends and Findings From a Decade (1997-2007) of Research on Informal Science Education and Free-Choice Science Learning	2010	USA	Visitor Studies	Literature Review	Phipps, Molly. (2010).	Describes Behaviourist, constructivist, CML, sociocultural, and experiential



Learning Science in Informal Environments. People, Places and Pursuits.	2009	USA	National Research Council	Report	National Research Council. (2009).	Behaviourist, cognitive and sociocultural are described
Framework for Evaluating Impacts of Informal Science Education Projects	2008	USA	National Research Council	Report	Allen & Campbell et al. (2008)	None
Research on Learning in Informal Contexts: Advancing the field?	2007	UK	International Journal of Science Education	Editorial	Osborne, Jonathan & Dillon, Justin (2007)	Sociocultural
Bridging in-school and out-of-school learning: Formal, non-formal, and informal education	2007	Israel	Journal of Science Education and Technology	Theoretical	Eshach, Haim. (2007).	Compares CML (Contextual model of learning) and three factor model
The Value of "Dialogue Events" as Sites of Learning: An exploration of research and evaluation frameworks	2007	UK	International Journal of Science Education	Theoretical	Lehr, Jane, L et al 2007.	Compares 3 new frameworks of dialogue events as sites of learning in non-formal PEST contexts
Learning in a personal context: Levels of choice in a free choice learning environment in science and natural history museums	2007	Israel	Science Education	Empirical	Bamberger, Yael., & Tal, Tali. (2007).	CML (Contextual model of learning)

Table 3: Studies that met the inclusion criteria

### 3.2 Limitations

Similar to the warnings of Booth, Sutton, and Papaioannou (2016), the greatest constraints on this systematic review, were those of time, resources, expertise, and data (p. 37-38). Moreover, the results that were returned from the queries represent recent practices in the field, and theoretical approaches based on these practices; however, no pure policy-based databases were searched for definitions and frameworks. The searches and analysis were also limited by language, having been conducted in and resulting exclusively English language results.

These limitations stem from the scope of SySTEM 2020 which is focused on mapping current practice and reflecting upon it, as opposed to conducting a review of the policy landscape. An additional limitation resulting from the above is that of the geographical distribution of empirical evidence. It was often found that some countries or regions had far more results in the queried searches than others. In addition, several of the results were focused on areas other than those outside of the scope of the SySTEM 2020 project, such as teacher training and curation practices. The project is primarily concerned with those frameworks which are inclusive and applicable to diverse learner groups and learning contexts.



## 4 Discussion

### 4.1 How does the literature categorise science learning outside the classroom?

The literature uses four primary means of categorisation for science learning outside of school; setting, learning process or pedagogical approach, qualifications, and intention. In this section we will examine each of these in more detail.

**Setting:** The literature continues to place a large emphasis on classifying learning by location (Eshach, 2007; Osborne & Dillon, 2010; Falk 2010; Gutwill, 2012). While this practice of categorisation by setting can be useful, it may also serve to oversimplify the distinctions between formal, non-formal and informal learning. Though setting is perhaps the most common feature used to distinguish between these modes of learning, it does not address the nuances, pedagogical perspectives, assessment tools, or research parameters found within each approach and is often used as a proxy for other more determinate features such as learner autonomy, degrees of structure, and time spent engaged in learning practice.

Setting has sometimes been linked directly to a learner's level of control over their learning environment including how freely they may move through a physical space (Bamberger, 2007). It has also been used to illustrate the degree of procedural structure, including to what degree a learner may interact with peers or an instructor if present, and to refer to the size of learner group (Hebets, 2018). Setting may also be a way to explore the temporal limits of a learning opportunity, distinguishing formal learning as something that occurs in repetitive and scheduled instances, where non-formal learning may be episodic, and informal learning is "...fluid and sporadic" (Stocklmayer, 2010).

When setting as a feature refers to location, the distinctions are usually institutional; does the activity or experience take place at a school, a museum, or in the home (Allen & Peterman, 2019; CAISE, 2019; Clapham, 2016; Romi, 2009). The primary complication with this approach is that while a learner may have certain psychological associations with a place (i.e. a school is where learning is meant to happen) those associations can be superseded by pedagogical approaches, and organizational objectives. In addition, it does not address the hybrid nature of events like field trips, or science fairs, where a cohort of students, organised in a formal setting, are presented with a semi-structured learning opportunity outside of the classroom (Gutwill & Allen, 2012; Sahin, 2013).

**Learning approach:** Though considered the default approach of classroom based instruction, didactic teaching methodologies are giving way to more inquiry based and dialogic techniques, leveraging the interests and unique identities of the learner (Voet & Wever, 2018). A didactic mode of teaching is to be understood as one which is lecture-based learning, or a teacher-centred pedagogical approach in which learning is derived from the instructor (Cope & Prosser, 2005).





Comparatively, non-formal science learning opportunities most often utilise a dialogic approach lead by a qualified facilitator who is trained to encourage critical thinking, exploration and, critically, reflection. (Affeldt et al, 2015; Sasson, 2014; Struminger, 2018). Dialogic learning is a pedagogical approach that involves students in the collaborative construction of meaning and is characterized by shared control over the key aspects of learning discourse (Gregory & Reznitskaya, 2013). A mixed method approaches to science education, those which allow for both dialogic and autonomous subject exploration are also commonly within non-formal learning opportunities (Eshach, 2007; Sezen, 2013).

This feature is also sometimes used to refer somewhat tangentially to the degree of autonomy that the learner is able to exercise over the learning experience. It has also been heavily shaped by Falk and Dierking's free-choice learning framework (Falk & Dierking, 1995). Free choice learning should be understood as a relative concept in which the crucial point is whether the learner feels that they have free choice and autonomy: "Ultimately... what one person sees as a 'free-choice' learning situation may be perceived by another person as 'compulsory': free-choice learning is a psychological construct and thus cannot be defined a-contextually" (Falk, 2005).

**Assessment and qualification:** Qualification, or the certification of a learning experience is one of the few features most researchers and practitioners can agree upon as a determining characteristic for whether a learning opportunity is formal, non-formal, or informal. Formal learning, which is understood to be mediated by a pre-set curriculum, is regularly assessed through standardised tests, meant to measure the vertical knowledge gains of the learner (Sacco, 2014). These assessments are also intended to provide feedback for both the learner and instructor, though primarily they are intended to document and certify the knowledge acquisition of the learner.

Alternatively, non-formal learning does not typically feature assessment. If an assessment is conducted, it is not used to evaluate the learner, but to provide insight on the ability of a workshop, exhibition or other activity of intervention to meet institutional objectives (Phipps, 2010). Evaluations may measure attitudes, values, enjoyment, inspiration, skills and knowledge. Some research has revealed that a lack of formal rubrics such as course grades may have a positive impact on knowledge retention and application in various real world settings. A recent meta-analysis suggests that intrinsic motivation predicts the quality of an individual's performance with higher validity than the presence of external incentives like formal marks. (Cerasoli, Nicklin, & Ford, 2014). Informal learning, by its serendipitous and incidental nature is understood to be un-assessed (Clapham, 2016; Eshach, 2006).

**Intention of the learner and organization or institution:** Many of the authors included in the core literature divide formal, non-formal, and informal learning by intentionality. The first level of distinction is between learning that is determined and initiated by the learner or is "learner-led" (usually classified as non-formal or informal), and learning that is designed to meet certain externally defined subject requirements or instructor-led (usually classified as formal). It is worth noting that the distinction relates mainly to the extent to which learning is the prime and deliberate focus of activity as opposed to enjoyment, inspiration or skill acquisition (Dohn, 2018).



The literature categorises most non-formal learning experiences as those which are self-directed (Clapham, 2016; Menezes et al, 2018; Tan, 2018), referring to those opportunities when the learner exercises a large degree of control over the learning situation. Broadly, this suggests that the learner not only has the power to decide what and how to learn, but that other decisions, such as when and how much to learn are also implicit (Dohn, 2018). The learner not only selects but may also reject learning topics and resources at will, and crucially, has the authority to determine the satisfaction of the outcomes (Affeldt et al, 2015; Lehr, 2007). Whereas Informal learning, is often seen as a by-product of another activity, like interpersonal interaction, experimentation, or even formal education and is unintentional (Dohn; 2018).

These values may be compared and contrasted with the intentions and formal objectives set by the organisation or institution which provides the learning opportunity throughout the literature. The two are sometimes set at odds with one another, in that the institution wishes the learner to gain knowledge that the learner feels is not relevant to them. Institutional intentions are generally planned and determined far in advance of the learning opportunity, and often reflect the policy consideration, institutional values or mandates, and at times funding concerns. The result is often a list of outcomes or objectives by which the “success” of the learning opportunity may be measured and determined (Allen & Peterman, 2019; Terrazas-Marin, 2018).

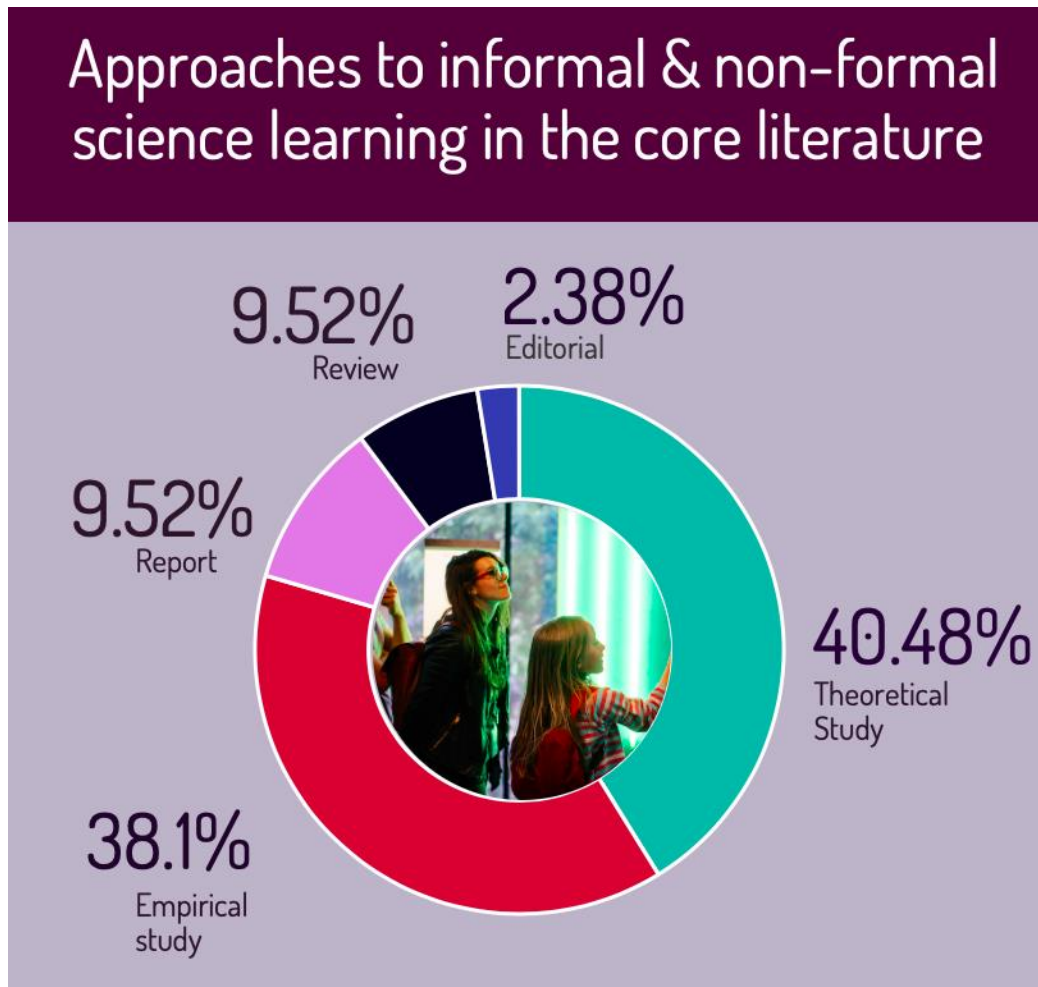


Figure 1: Approaches to informal & non-formal science learning in the literature

## 4.2 What are the most common frameworks used to analyse science learning outside of the classroom?

**Sociocultural** is a term which may be applied to a number of theories and frameworks, which have their origins in developmental psychology, first coming into prominence between 1920 and 1934 through the works of Lev Vygotsky. These identified the role that social interactions and cultural context play in the development of knowledge construction, language, and skill acquisition (Rogoff 1990). Studies which utilise this approach tend to focus on qualitative changes in behaviour over time in an attempt to explain unseen processes in development of thought. Often researchers taking a sociocultural approach to their work evaluate levels of participation (Jarmon, 2012; Menezes et al, 2018) collaboration, (Stewart, 2017), and degree of independent learning, (Gutwill, & Allen, Sue, 2012). Just over 14% of the publications included within the core literature utilise a sociocultural framework.



This approach is utilised in both empirical and theoretical works, and was consistently referenced and analysed in previous literature reviews.

Sociocultural theories have remained popular throughout the 2000s, and have been frequently employed to describe broad trends over time (Dawson, 2014; Menezes, 2018; Phipps, 2010) Studies that examined non-formal science learning from a sociocultural perspective typically investigated how learners use cognitive tools to mediate their thinking such as language (Osborne & Dillon, 2007). The literature shows a shift around 2013 towards adaptive sociocultural models, such as the learning ecologies perspective. We see these frameworks most often in papers which examine museums, science centres and other non-formal learning spaces.

**Constructivist** approaches are interested in tracking changes in learner's expectations and understanding of phenomena. This approach is focused on a learner's ability to apply previous knowledge in an unfamiliar situation, demonstrating understanding and creating new knowledge (Hendry, 1996). Reflection, following the experience of new or unfamiliar information is a key component of evaluating this reconing of new and previous knowledge. This approach assumes that learning is active, built and evaluated against previous knowledge (Greenhow & Lewin, 2016; Tan, 2018). Constructivist approaches comprise just under 10% of the core literature within this paper.

**Social/socio-constructivist** frameworks also make up around 10% of the approaches found in the core literature. Social constructivist approaches build on the idea of the learning process as one which is active and collaborative put forth by constructivists by emphasising the importance of cultural context (Vygotsky, 1978). It goes on to assume that learning is more than the process of acquiring new information, but is a way in which learners are able to engage with a larger knowledge community. Greenhow and Lewin may have put it best in their work with social media and informal education, stating that, "What is known resides not only in the individual, a position advanced by cognitive constructionists, but also in the collaboration and interaction among many", (Greenhow & Lewin, 2016). The majority of the works which employed this theoretical lens focused on the ways group interaction impacted an activity.

**CML (Contextual Model of Learning)** is not a theoretical framework, but a highly adaptive model of informal and non-formal learning. It was the most common model within our core literature and was employed across non-formal and informal contexts, though originally developed for application in non-formal contexts such as science centres and museums. It posits that three contexts; personal, sociocultural and physical work to shape a learner's experience (Falk & Storksdieck, 2005). In doing so, it neatly compartmentalizes several contexts that may impact the learning experience. However, the strength of this approach, may also be its weakness, in that some authors suggest that organising the contexts in such a way does not allow for the relationships between them to be adequately explored. Around 14.3% of the core texts used CML to frame and analyse their work.

**Learning ecologies** or an ecosystems perspective has become one of the most widely adopted modern approaches to understanding science learning. Nearly 10% of the publications included within the core literature employ a learning ecologies framework. All of these studies were conducted in a non-formal learning environment.



An ecological perspective on informal science learning environments builds on socio-cultural frameworks, and contextual model of learning. This approach is based on the assumption that learning takes place throughout a learner’s life, across many settings and that these learning moments are contextually and historically influenced. “A learning ecology is the physical, social, and cultural context in which learning takes place” (Bevan, 2016). One of the framework’s most unique features is its acknowledgement of history’s impact on a learning opportunity. This approach is informed in part by the Funds of knowledge theory which posits that, “cultural resources such as language, traditions, and other social practices, are the means by which we engage with the world (Molly & Greenburg, 1990).

Building on the knowledge, and applications of these frameworks, SySTEM 2020 proposes the following definitions for formal, non-formal, and informal science learning as presented by the National Centre for Vocational Education Research of Australia (NCVER 2013/17). The definitions have been chosen for their universality, and inclusiveness with regard to subjects, levels, and contexts. That is, these definitions are functional for a variety of ages, countries, activities, abilities, and STEM topics.

	<b>Formal</b>	<b>Informal</b>	<b>Non-Formal</b>
National Centre for Vocational Education Research (2013/17)	Learning that takes place through a structured program of instruction which is generally recognised by the attainment of a formal qualification or award (for example, a certificate, diploma or degree).	Learning resulting from daily activities related to work, family or leisure. It is not organised or structured (in terms of objectives, time or learning support). Informal learning in most cases is unintentional from the learner's perspective. It typically does not lead to certification.	Any organised and sustained educational activity that does not correspond exactly to the definition of formal education.  Non-formal education may therefore take place both within and outside educational institutions, and cater to persons of all ages.

Table 4: NCEVER (2013/17) Definitions

As the project is focused on learning outside the classroom, we are interested in the definitions of informal and non-formal learning in themselves as much as we are interested in their contrast with formal learning. The use of qualifiers such as “mostly”, or “generally”, result in a definition which allows for the porous reality of these fields. They are not completely distinct, but often share spaces and features. In addition, the inclusive language of NCVER referring to institutions, age groups, instruction and qualifications, corresponds with the breadth of our project, which strives to identify criteria for fair inclusion in science learning outside the classroom.



## 5 Conceptual Framework

Having reached a conclusion about the definitions of formal, informal, and non-formal education, we turn to their applications within SySTEM2020. The scope of this project encompasses STEM learning which takes place outside the classroom across 19 EU nations. A number of consistent **attributes** have been identified through the literature review, allowing for broad categorization of an initiative as more or less formal, non-formal or informal. These have then been placed on a spectrum which allows for a more nuanced understanding of the interrelated nature of these learning modalities.

The primary attributes, according to the literature review, are as follows:

### 1. Institutional Learning objectives

This dimension refers to the learning planning process from the point of view of the learning institution. The institution may have planned specific learning objectives for the learners, or identified broader, non-specific goals. Often a combination of processes is applied in practice.

- Formal learning **has** learning objectives
- Non-formal learning **has** specific learning objectives
- Informal learning **does not have** learning objectives

### 2. Learner Intention

This dimension discusses the intentionality to learn from the learner's point of view. The literature did identify that intention may be oriented towards a goal such as compliance, rather than learning itself.

- Formal learning **is** intentional from the learner's point of view
- Non-formal learning **is** intentional
- Informal learning **may or may not** be intentional (generally **not**)

### 3. Learning Approach

This dimension addresses the broad pedagogical approach of the learning opportunity whether didactic, or lecture based, dialogic, or autonomous and led primarily by the needs and interests of the learner.

- Formal learning **is** didactic
- Non-formal learning **is** dialogic or didactic
- Informal learning **is** autonomous





#### 4. Assessment and Qualification

The information gathering during the mapping tasks of the WP may reveal better what the practitioners perceive as such. It is also important to note that as a part of the SySTEM2020 project, researchers will be piloting tools which may necessitate a reassessment of this dimension’s role in categorizing formal, non-formal, and informal learning.

- Formal learning **usually** leads to a qualification
- Non-formal learning **does not** lead to a qualification
- Informal learning **does not** lead to a qualification

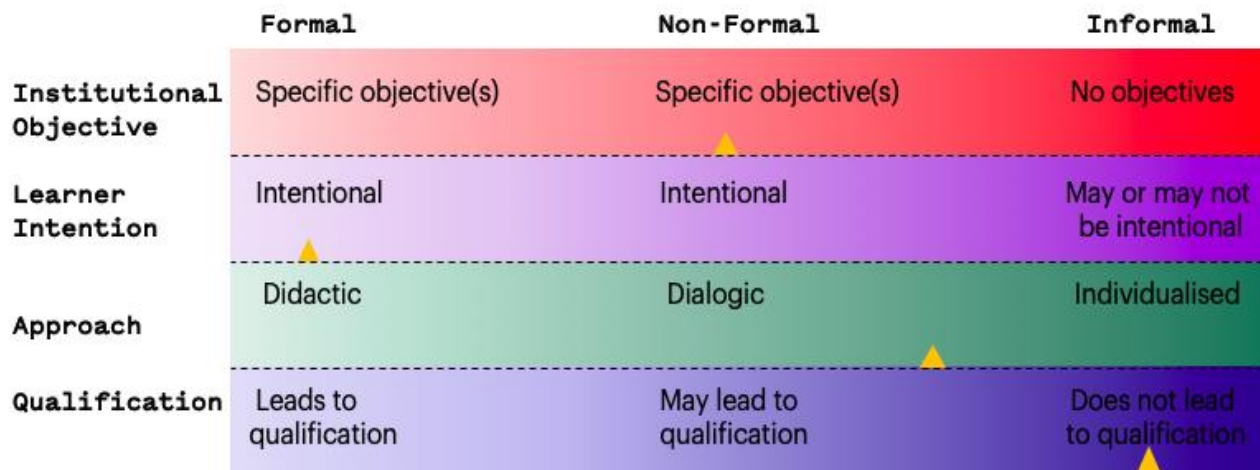


Figure 2: The spectrum of attributes and modes of learning

Figure 2 above reveals how a learning experience can be understood along a spectrum of educational modes through the examination of four core attributes. The modes and attributes of learning can be considered in a three by four spectrum matrix. Though the three modes of learning are represented as distinct and separate from one another, there are no firm divisions drawn between them. This allows practitioners, researchers, policy makers and other stakeholders the ability to place attributes in the interstitial spaces along the spectrum. For example, if a workshop includes approaches of both roundtable discussion and individual reflection, this attribute can be recorded between informal, and non-formal learning.

Along the vertical line are the core attributes identified in the literature as the most dependable in characterising educational modalities. Along the horizontal line is the spectrum of educational modalities.

This matrix connects the broad spectrum of learning which takes place outside of the classroom, identifying those attributes which are powerfully diagnostic of informal and non-formal learning. Over the course of the project the feedback and data from the map and learner profiles will be explored and interconnections evaluated and integrated into the conceptual framework.



## 6 Implications

This revised conceptual framework has a number of implications for the project, researchers, practitioners, and policy makers. Firstly, the framework itself is agnostic to defining non-formal or informal education. The framework acknowledges the porous and often shared and mixed processes which characterise the various modalities of learning.

The spectrum approach of the framework allows those science educators and other practitioners to choose additional or mixed-approach attributes. For example, activities which include both dialogic aspects like roundtable discussions and individual reflections may place their activity between informal and non-formal learning along the “approach” portion of the spectrum.

Similarly, qualifications and metrics may be understood in a way that is new and complements the common definition as derived from the literature. In literature ‘qualification’ was almost always understood as a combination of credentialing and accreditation, though there is potential for the two to be separated.

Overall, flexibility and inclusiveness are the primary working principles of this conceptual framework. This adaptability may create a ‘bottom-up’ fluidity as opposed to classifying initiatives ‘top-down’ in rigid categories, and will allow for a comprehensive and informative categorisation. This document will further benefit from the analysis of over 1000 informal and non-formal learning activities collected through the map portion of SySTEM202. These data points will help elucidate how the identified attributes from the literature review appear in practice and how they may be operationalised in a research context.

## 7 Gaps in the literature

A number of gaps were identified over the course of the literature review. Many of these gaps were related to the serendipitous and personal nature of informal learning. For example, personalised learning outcomes can be difficult to assess, and success should be determined largely by the learner and the goals they have set for themselves. Interfering with this process, while helpful to researchers, may be an unwelcome intrusion on the learner’s pursuit and enjoyment of science learning.

In addition, a number of empirical publications, while providing utilising a strong theoretical framework, do not define their objectives, or outcomes clearly. The field of informal science learning is at an exciting stage, where new theoretical traditions are emerging, and practitioners are sharing ground-breaking approaches to learning “in the wild”. However, taking care to elucidate the goals of a research project is essential. The parameter of what it means to be a learner though often referenced are also rarely defined. When does one become a learner? Under what circumstances? Many studies do not provide operational definitions.





Theoretical underpinnings are becoming increasingly common but are sometimes not explicitly stated or described in detail. Conceptual frameworks and models are often conflated as well. Models make predictions, whereas frameworks help us scaffold our expectations and bridge theory and practice. Finally, informal learning remains an understudied and under-theorised topic. All but one of the empirical studies listed here are non-formal in nature. Currently the most popular frameworks (CML, Sociocultural-6, Constructivist-4, Socio-Constructivist-4, and Learning ecologies/ Ecosystems-4) are sometimes used interchangeably. CML is the only model consistently used across learning outside of school and is informed by in part by sociocultural theory. It may be beneficial to further investigate the way these common theories have shaped or given rise to one another. This may mitigate their conflation across empirical and theoretical works.

## 8 Future Work

Several areas are marked as requiring future work during the remainder of the SySTEM 2020 project. As the scope of this document was to conduct a literature review and derive a conceptual framework concerning formal, informal, and non-formal education, it has not conducted an analysis of specific parameters of the papers such as specific demographics or pedagogical practices. This analysis will be useful for several work packages in SySTEM 2020. Additionally, outlining the areas of further work of the reviewed papers in order to identify future research directions will be interesting, as there was little consensus in the articles about areas to be explored further: a comparative analysis between this outline and our proposed approach can inform us about the project. In addition, the actual use of the defined attributes and the additional dimensions that comprise the framework as a practice in the SySTEM 2020 project will be defined, and refined in an iterative fashion throughout the lifecycle of the project.

Out of the five objectives set out at the beginning of this paper, the current deliverable fulfils the first three, while it leaves the last two as future work. That is, the deliverable conducted a literature review of the existing informal science education frameworks in Europe, it outlined the current frameworks of informal science education research and identified existing gaps and definitions mismatch, and it constructed a categorisation technique to employ on existing frameworks for informal science education programmes. Throughout the project, it will continue to identify current strengths and challenges faced by existing informal science education programmes.

The literature review has unearthed a number of interesting questions within the scope of the SySTEM2020 project. If informal learning is, by its nature, unassessed, how might its classification and characterisation change if project researchers seek to evaluate it? Similarly, if non-formal learning and informal learning are characterised in part by their lack of credentialisation, how might their classification be impacted by researcher's future efforts to accredit these learning efforts?



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Tan, Michael, (2018). *When Makerspaces Meet School: Negotiating Tensions Between Instruction and Construction*. *Journal of Science Education and Technology*. *Journal of Science Education and Technology* v28 n2 p75-89 Apr 2018.

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Werquin, Patrick. (2010). *Recognising non-formal and informal learning: Outcomes, policies and practices*. 10.1787/9789264063853-en.





# Appendix 1 - List of databases included in systematic review of literature

Academic Search Complete
Applied Social Sciences Index and Abstracts
Australian Education Index
British Education Index
Caise
Childlink (UK/IRL incl. Education issues)
ERIC (EBSCO)
ERIC (ProQuest)
HCPP
JSTOR
MyiLibrary
OECDiLibrary
Oxford Journals Online
ProQuest Dissertations & Theses: UK & Ireland
PsycINFO
RIAN(open resource to Irish university research)
Sage Journals Online
Scopus
SpringerLink
Taylor and Francis Journals
Web of Science
Wiley Online Libraryw
ZETOC (research alerting service)





## Appendix 2 - List of relevant publications from database search

Title	Database	URL
Benefits of Informal Learning Environments: A Focused Examination of STEM-based Program Environments.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=103267431&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=103267431&amp;site=ehost-live</a>
Creating Better Learners Through Learning Science: A Sample of Methods.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=129156991&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=129156991&amp;site=ehost-live</a>
Eight-Legged Encounters--Arachnids, Volunteers, and Art help to Bridge the Gap between Informal and Formal Science Learning.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=128684062&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=128684062&amp;site=ehost-live</a>
From Seeing to Observing: How Parents and Children Learn to See Science in a Botanical Garden.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=125480418&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=125480418&amp;site=ehost-live</a>
Learning in non-formal education: Is it 'youthful' for youth in action?	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=122421134&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=122421134&amp;site=ehost-live</a>
NDM-PHILOSOPHY OF EDUCATION IN THE 21ST CENTURY.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=122596237&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=122596237&amp;site=ehost-live</a>
Non-formal and Informal Science Learning: Teachers' Conceptions.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=100638957&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=100638957&amp;site=ehost-live</a>
Promoting children's learning and transfer across informal science, technology, engineering, and mathematics learning experiences.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=131071409&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=131071409&amp;site=ehost-live</a>
Research Trends and Issues in Informal Science Education.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=127173647&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=127173647&amp;site=ehost-live</a>
So You Want to Share Your Science .... Connecting to the World of Informal Science Learning.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=130915154&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=130915154&amp;site=ehost-live</a>
The Effects of School-Related and Home-Related Optional Science Experiences on Science Attitudes and Knowledge.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=131135357&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=131135357&amp;site=ehost-live</a>
Towards a pedagogical model for science education: bridging educational contexts through a blended learning approach.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=121044243&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=121044243&amp;site=ehost-live</a>
Conceptualising Lifelong Learning: a reflection on lifelong learning at Lund University (Sweden) and Middlesex University (UK)	ASSIA	<a href="https://search.proquest.com/docview/226949027?accountid=14404">https://search.proquest.com/docview/226949027?accountid=14404</a>



Informal in formal: The relationship of informal and formal learning in popular and jazz music master workshops in conservatoires	ASSIA	<a href="https://search.proquest.com/docview/1865907654?accountid=14404">https://search.proquest.com/docview/1865907654?accountid=14404</a>
Non-formal learning and tacit knowledge in professional work	ASSIA	<a href="https://search.proquest.com/docview/216972804?accountid=14404">https://search.proquest.com/docview/216972804?accountid=14404</a>
Recognising and accrediting informal and non-formal learning in higher education: An analysis of the issues emerging from a study of France and Scotland	ASSIA	<a href="https://search.proquest.com/docview/226947318?accountid=14404">https://search.proquest.com/docview/226947318?accountid=14404</a>
Reframing research on informal teaching and learning in science: Comments and commentary at the heart of a new vision for the field	ASSIA	<a href="https://search.proquest.com/docview/1520326850?accountid=14404">https://search.proquest.com/docview/1520326850?accountid=14404</a>
Research Trends and Findings From a Decade (1997-2007) of Research on Informal Science Education and Free-Choice Science Learning	ASSIA	<a href="https://search.proquest.com/docview/754139441?accountid=14404">https://search.proquest.com/docview/754139441?accountid=14404</a>
Social-Class Differences in Summer Learning Between Kindergarten and First Grade: Model Specification and Estimation	ASSIA	<a href="https://search.proquest.com/docview/216485380?accountid=14404">https://search.proquest.com/docview/216485380?accountid=14404</a>
A culture of learning in the informal museum setting?	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764187739?accountid=14404">https://dialog.proquest.com/professional/docview/764187739?accountid=14404</a>
After-School Spaces : Looking for Learning in All the Right Places	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1970665447?accountid=14404">https://dialog.proquest.com/professional/docview/1970665447?accountid=14404</a>
Blended learning : an approach to delivering science courses on-line	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764267334?accountid=14404">https://dialog.proquest.com/professional/docview/764267334?accountid=14404</a>
Cases on formal and informal e-learning environments : opportunities and practices.	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1365297217?accountid=14404">https://dialog.proquest.com/professional/docview/1365297217?accountid=14404</a>
Children learning science and technology in out-of-school settings as members of a community of learners : an action research project	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764194013?accountid=14404">https://dialog.proquest.com/professional/docview/764194013?accountid=14404</a>
Engaging diverse young people with science education : articulating a framework of practice	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1970258819?accountid=14404">https://dialog.proquest.com/professional/docview/1970258819?accountid=14404</a>
Enhancing students' learning experiences outside school (LEOS) using digital technologies	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1794133386?accountid=14404">https://dialog.proquest.com/professional/docview/1794133386?accountid=14404</a>
Formal and informal environments for the learning and teaching of computer programming	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764292251?accountid=14404">https://dialog.proquest.com/professional/docview/764292251?accountid=14404</a>
Informal learning : a vital component of lifelong learning	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1614431023?accountid=14404">https://dialog.proquest.com/professional/docview/1614431023?accountid=14404</a>



Informal science learning environments : assessment, determinants and effects	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764378754?accountid=14404">https://dialog.proquest.com/professional/docview/764378754?accountid=14404</a>
Measuring the impact of informal learning experiences : what variables should we choose?	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764308690?accountid=14404">https://dialog.proquest.com/professional/docview/764308690?accountid=14404</a>
On the determinants of employment-related organised education and informal learning	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1925332525?accountid=14404">https://dialog.proquest.com/professional/docview/1925332525?accountid=14404</a>
The Maker Movement : retinkering education	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1794134002?accountid=14404">https://dialog.proquest.com/professional/docview/1794134002?accountid=14404</a>
The recognition of non-formal and informal learning in Australia : country background report prepared for the OECD activity on Recognition of non-formal and informal learning.	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764327991?accountid=14404">https://dialog.proquest.com/professional/docview/764327991?accountid=14404</a>
Theoretical perspectives on learning in an informal setting	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764198337?accountid=14404">https://dialog.proquest.com/professional/docview/764198337?accountid=14404</a>
Toward an agenda for advancing research on science learning in out-of-school settings	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764198321?accountid=14404">https://dialog.proquest.com/professional/docview/764198321?accountid=14404</a>
Worlds still to discover : museums and other informal learning environments	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764195290?accountid=14404">https://dialog.proquest.com/professional/docview/764195290?accountid=14404</a>
Bridge21: teamwork, technology and learning. A pragmatic model for effective twenty-first-century team-based learning.	BEI	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=128460651&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=128460651&amp;site=ehost-live</a>
Equity in informal science education: developing an access and equity framework for science museums and science centres.	BEI	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=98423527&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=98423527&amp;site=ehost-live</a>
On the Relation Between Teachers' (In)formal Learning and Innovative Working Behavior: the Mediating Role of Employability.	BEI	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=132112955&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=132112955&amp;site=ehost-live</a>
School and out-of-school science: a model for bridging the gap	BEI	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=BEI.220959&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=BEI.220959&amp;site=ehost-live</a>
The influence of extracurricular activities on middle school students' science learning in China.	BEI	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=124481373&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=124481373&amp;site=ehost-live</a>
The promise and the promises of Making in science education.	BEI	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=121519777&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=121519777&amp;site=ehost-live</a>
The role of informal learning spaces in enhancing student engagement with mathematical sciences.	BEI	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=121746359&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=bri&amp;AN=121746359&amp;site=ehost-live</a>



Abstract Book EDUSREF (Education, Society, and Reform Research) 2018: "Improving Education as a Social System in the Face of Future Challenges" (Ankara, Turkey, April 6-7, 2018)	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=ED582065&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=ED582065&amp;site=ehost-live</a>
Boundary Interaction: Towards Developing a Mobile Technology-Enabled Science Curriculum to Integrate Learning in the Informal Spaces	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1175556&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1175556&amp;site=ehost-live</a>
Developing a Useful and Integrative STEM Disciplinary Language	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1168669&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1168669&amp;site=ehost-live</a>
Developing Non-Formal Education Competences as a Complement of Formal Education for STEM Lecturers	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1167607&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1167607&amp;site=ehost-live</a>
Examination of a Successful and Active Science Club: A Case Study	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1132085&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1132085&amp;site=ehost-live</a>
Informal Physics Learning from Video Games: A Case Study Using Gameplay Videos	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1162197&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1162197&amp;site=ehost-live</a>
Learning and Engagement through Natural History Museums	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1178499&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1178499&amp;site=ehost-live</a>
Out-of-School Learning in Hungarian Primary Education: Practice and Barriers	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1186860&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1186860&amp;site=ehost-live</a>
Participation in Informal Science Learning Experiences: The Rich Get Richer?	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1162751&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1162751&amp;site=ehost-live</a>
Renovating Our Science Learning Centers	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1184325&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1184325&amp;site=ehost-live</a>
Student Agency: An Analysis of Students' Networked Relations across the Informal and Formal Learning Domains	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1140409&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1140409&amp;site=ehost-live</a>
Student Teachers' Images of Science Instruction in Informal Settings: A Focus on Field Trip Pedagogy	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1186549&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1186549&amp;site=ehost-live</a>
Students' Plans for Lifelong Learning and Teaching	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=ED568659&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=ED568659&amp;site=ehost-live</a>
The Dimensions and Impact of Informal Science Learning Experiences on Middle Schoolers' Attitudes and Abilities in Science	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1126202&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1126202&amp;site=ehost-live</a>
The Relationship between Formal Education and Non-Formal Education: A Descriptive and Analytical Review of the Publications about Astronomy Education in Journals and Events Related to Science Teaching in the Brazilian Context	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1177841&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1177841&amp;site=ehost-live</a>



Using Blended Learning and Out-of-School Visits: Pedagogies for Effective Science Teaching in the Twenty-First Century	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1174644&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1174644&amp;site=ehost-live</a>
Approaching Multidimensional Forms of Knowledge through Personal Meaning Mapping in Science Integrating Teaching outside the Classroom	ERIC-ProQuest	<a href="https://search.proquest.com/docview/2009556144?accountid=14404">https://search.proquest.com/docview/2009556144?accountid=14404</a>
Design, Implementation and Evaluation of Innovative Science Teaching Strategies for Non-Formal Learning in a Natural History Museum	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1871585948?accountid=14404">https://search.proquest.com/docview/1871585948?accountid=14404</a>
Enacting Informal Science Learning: Exploring the Battle for Informal Learning	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1871585950?accountid=14404">https://search.proquest.com/docview/1871585950?accountid=14404</a>
Expanding Our View of Authentic Learning: Bridging in and Out-of-School Experiences	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651862998?accountid=14404">https://search.proquest.com/docview/1651862998?accountid=14404</a>
Informal and Non-Formal Education: An Outline of History of Science in Museums	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651866788?accountid=14404">https://search.proquest.com/docview/1651866788?accountid=14404</a>
Informal Learning in Science Museum: Development and Evaluation of a Mobile Exhibit Label System with iBeacon Technology	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1913345057?accountid=14404">https://search.proquest.com/docview/1913345057?accountid=14404</a>
Informal Learning in Science, Math, and Engineering Majors for African American Female Undergraduates	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1697498964?accountid=14404">https://search.proquest.com/docview/1697498964?accountid=14404</a>
Informal Science Learning through Inquiry: Effects on Preschool Students' Achievement in Early Science Learning	ERIC-ProQuest	<a href="https://search.proquest.com/docview/2101379067?accountid=14404">https://search.proquest.com/docview/2101379067?accountid=14404</a>
Informal Science: Family Education, Experiences, and Initial Interest in Science	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1895989017?accountid=14404">https://search.proquest.com/docview/1895989017?accountid=14404</a>
Nonformal and Informal Adult Learning in Museums: A Literature Review	ERIC-ProQuest	<a href="https://search.proquest.com/docview/61983444?accountid=14404">https://search.proquest.com/docview/61983444?accountid=14404</a>
Professional Learning outside the Classroom: Expedition Iceland	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1322240507?accountid=14404">https://search.proquest.com/docview/1322240507?accountid=14404</a>
Science Education through Informal Education	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1826537885?accountid=14404">https://search.proquest.com/docview/1826537885?accountid=14404</a>
Science of Learning Is Learning of Science: Why We Need a Dialectical Approach to Science Education Research	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1018479388?accountid=14404">https://search.proquest.com/docview/1018479388?accountid=14404</a>
Social Justice and Out-of-School Science Learning: Exploring Equity in Science Television, Science Clubs and Maker Spaces	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1913348828?accountid=14404">https://search.proquest.com/docview/1913348828?accountid=14404</a>
Tap Into Informal Science Learning	ERIC-ProQuest	<a href="https://search.proquest.com/docview/62329218?accountid=14404">https://search.proquest.com/docview/62329218?accountid=14404</a>
The Missing Link to Connect Education and Employment: Recognition of Non-Formal and Informal Learning Outcomes	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1031154538?accountid=14404">https://search.proquest.com/docview/1031154538?accountid=14404</a>





The Potential of the Non-Formal Educational Sector for Supporting Chemistry Learning and Sustainability Education for All Students--A Joint Perspective from Two Cases in Finland and Germany	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1895978936?accountid=14404">https://search.proquest.com/docview/1895978936?accountid=14404</a>
Towards a More Authentic Science Curriculum: The Contribution of Out-of-School Learning	ERIC-ProQuest	<a href="https://search.proquest.com/docview/62013988?accountid=14404">https://search.proquest.com/docview/62013988?accountid=14404</a>
The role of informal science centers in science education: attitudes, skills, and self-efficacy	ERIC-ProQuest	<a href="https://eric.ed.gov/?id=EJ1135264">https://eric.ed.gov/?id=EJ1135264</a>
Where it gets interesting: Competing models of learning in after-school	ERIC-ProQuest	<a href="https://eric.ed.gov/?id=EJ1003837">https://eric.ed.gov/?id=EJ1003837</a>
Framework for Evaluating Impacts of Informal Science Education Projects	NSF.GOV	<a href="https://www.nsf.gov/od/broadeningparticipation/framework-evaluating-impacts-broadening-participation-projects_1101.pdf">https://www.nsf.gov/od/broadeningparticipation/framework-evaluating-impacts-broadening-participation-projects_1101.pdf</a>
A Framework for Informal STEM Education Outreach at Field Stations	NSF.GOV	<a href="https://fieldstationoutreach.info">https://fieldstationoutreach.info</a>
“Some explanation here”: A case study of learning opportunities and tensions in an informal science learning environment.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-50203-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-50203-001&amp;site=ehost-live</a>
Attractor states in teaching and learning processes: A study of out-of-school science education.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-10139-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-10139-001&amp;site=ehost-live</a>
Explorations of the structure–agency dialectic as a tool for framing equity in science education.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-13038-002&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-13038-002&amp;site=ehost-live</a>
Formal and informal learning and first-year psychology students’ development of scientific thinking: A two-wave panel study.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-42026-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-42026-001&amp;site=ehost-live</a>
Informal science education: Lifelong, life-wide, life-deep.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-02165-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-02165-001&amp;site=ehost-live</a>
Informal science institutions and learning to teach: An examination of identity, agency, and affordances.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-39621-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-39621-001&amp;site=ehost-live</a>
Research–practice partnerships as a strategy for promoting equitable science teaching and learning through leveraging everyday science.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-26102-002&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-26102-002&amp;site=ehost-live</a>
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The role of emotion in informal science learning: Testing an exploratory model.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-20369-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-20369-001&amp;site=ehost-live</a>
The role of self-determination in informal and formal science learning contexts.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2018-12141-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2018-12141-001&amp;site=ehost-live</a>



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Distinctive Characteristics of Small Businesses as Sites for Informal Learning	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/1534484317704291">http://journals.sagepub.com/doi/full/10.1177/1534484317704291</a>
Ecological education and action research: A transformative blend for formal and nonformal educators	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/1476750313477156">http://journals.sagepub.com/doi/full/10.1177/1476750313477156</a>
Educational relationships in out-of-school-time activities: are children in poverty missing out again?	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/1746197910370728">http://journals.sagepub.com/doi/full/10.1177/1746197910370728</a>
Environmental Adult Learning and Transformation in Formal and Nonformal Settings	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/1541344611406736">http://journals.sagepub.com/doi/full/10.1177/1541344611406736</a>
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Gardening Activities, Education, and Self-Esteem: Learning Outside the Classroom	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/0042085907304909">http://journals.sagepub.com/doi/full/10.1177/0042085907304909</a>
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Informal Science Learning for Older Adults	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/1075547016655358">http://journals.sagepub.com/doi/full/10.1177/1075547016655358</a>
Instrument for Assessing Disposition for Contextual Learning of Science of Students in East Africa	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/2158244013494862">http://journals.sagepub.com/doi/full/10.1177/2158244013494862</a>
Integrative Literature Review on Informal Learning: Antecedents, Conceptualizations, and Future Directions	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/1534484318772242">http://journals.sagepub.com/doi/full/10.1177/1534484318772242</a>
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To boldly go where no learner has gone before: Independent inquiry, educational technology, and society in science fiction	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/2042753015571825">http://journals.sagepub.com/doi/full/10.1177/2042753015571825</a>
A four dimensional model of formal and informal learning	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84863011739&amp;partnerID=40&amp;md5=1f097312e7692637c5d83d18f406e36c">https://www.scopus.com/inward/record.uri?eid=2-s2.0-84863011739&amp;partnerID=40&amp;md5=1f097312e7692637c5d83d18f406e36c</a>
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Complementing formal learning with mobile technology outside the classroom	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84922823507&amp;doi=10.1109%2fIMCTL.2014.7011103&amp;partnerID=40&amp;md5=489ebd947799a871b8b273e342ebd244">https://www.scopus.com/inward/record.uri?eid=2-s2.0-84922823507&amp;doi=10.1109%2fIMCTL.2014.7011103&amp;partnerID=40&amp;md5=489ebd947799a871b8b273e342ebd244</a>
Constructing informal learning mode based on social software	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-80054021445&amp;doi=10.1109%2fICCS E.2011.6028853&amp;partnerID=40&amp;md">https://www.scopus.com/inward/record.uri?eid=2-s2.0-80054021445&amp;doi=10.1109%2fICCS E.2011.6028853&amp;partnerID=40&amp;md</a>





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Design framework for informal learning based on mobile technologies	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-0040924311&amp;doi=10.1080%2f09500690116959&amp;partnerID=40&amp;md5=9521ed148661bbb3c2e9d384a74bdc39">https://www.scopus.com/inward/record.uri?eid=2-s2.0-85049387071&amp;doi=10.1145%2f3202667.3202671&amp;partnerID=40&amp;md5=d4bcdcaf8d7afcc7b4ce2e80288027c3</a>
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Mobile computing to seamlessly integrate formal and informal learning	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84882761242&amp;doi=10.1080%2f03057640902904472&amp;partnerID=40&amp;md5=d5b3fc42c52460e4fd41cf468b31af7b">https://www.scopus.com/inward/record.uri?eid=2-s2.0-47649127587&amp;doi=10.1109%2fICALT_2007.190&amp;partnerID=40&amp;md5=197b12803cb7c999a3fa6943d16df3c4</a>
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Relationships among informal learning environments, teaching procedures and scientific reasoning ability	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-0013234956&amp;doi=10.1080%2f09500690116971&amp;partnerID=40&amp;md5=53">https://www.scopus.com/inward/record.uri?eid=2-s2.0-0013234956&amp;doi=10.1080%2f09500690116971&amp;partnerID=40&amp;md5=53</a>



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Teaching science outside the classroom	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84918922729&amp;doi=10.4324%2f9780203838266&amp;partnerID=40&amp;md5=ea8ffbf29cc5ae4b2090c3d20fb6db">https://www.scopus.com/inward/record.uri?eid=2-s2.0-84918922729&amp;doi=10.4324%2f9780203838266&amp;partnerID=40&amp;md5=ea8ffbf29cc5ae4b2090c3d20fb6db</a>
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"Science Isn't Just What We Learn in School": Interaction Rituals That Value Youth Voice in Out-of-School-Time Science	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1697504619?accountid=14404">https://search.proquest.com/docview/1697504619?accountid=14404</a>
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"We Could Think of Things That Could Be Science": Girls' Re-Figuring of Science in an Out-Of-School-Time Club	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651858750?accountid=14404">https://search.proquest.com/docview/1651858750?accountid=14404</a>
A call for change and pedagogy: A critical analysis of teacher education in Turkey	ASSIA	<a href="https://search.proquest.com/docview/226934573?accountid=14404">https://search.proquest.com/docview/226934573?accountid=14404</a>
A context-aware ubiquitous learning approach to conducting scientific inquiry activities in a science park	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1139432100?accountid=14404">https://dialog.proquest.com/professional/docview/1139432100?accountid=14404</a>
A longitudinal follow-up study of the alumnae of a middle-school science and literacy program : achieving and sustaining.	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764342802?accountid=14404">https://dialog.proquest.com/professional/docview/764342802?accountid=14404</a>
A practical approach to probability in the context of a science fair	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-70350004930&amp;partnerID=40&amp;md5=501cf5e41ffb24a14e1a21c9921728fc">https://www.scopus.com/inward/record.uri?eid=2-s2.0-70350004930&amp;partnerID=40&amp;md5=501cf5e41ffb24a14e1a21c9921728fc</a>



A radical constructivist approach to high school science teaching : investigating its potential to extend students' meaningful learning through the optimisation and possible extension of their cognitive abilities	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764199857?accountid=14404">https://dialog.proquest.com/professional/docview/764199857?accountid=14404</a>
A Review of Technology Education in Ireland; a Changing Technological Environment Promoting Design Activity	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651850716?accountid=14404">https://search.proquest.com/docview/1651850716?accountid=14404</a>
A school excursion to a museum can promote physical activity in children by integrating movement into curricular activities	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/1356336X17700660">http://journals.sagepub.com/doi/full/10.1177/1356336X17700660</a>
A study of changes in belief structures of preservice primary teachers involved in peer collaboration in science	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764197546?accountid=14404">https://dialog.proquest.com/professional/docview/764197546?accountid=14404</a>
Advocating for Equitable Science-Learning Opportunities for Girls in an Urban City Youth Club and the Roadblocks Faced by Women Science Educators	ERIC-ProQuest	<a href="https://search.proquest.com/docview/62277836?accountid=14404">https://search.proquest.com/docview/62277836?accountid=14404</a>
After-School and Informal STEM Projects: The Effect of Participant Self-Selection	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1175647&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1175647&amp;site=ehost-live</a>
After-School Elementary School Mathematics Club: Enhancing Achievement and Encouraging Future Teachers	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ964926&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ964926&amp;site=ehost-live</a>
An evaluation of an experiential learning and outdoor education school program on the life effectiveness skills of middle school boys	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764334418?accountid=14404">https://dialog.proquest.com/professional/docview/764334418?accountid=14404</a>
An Unexpected Outcome: Afterschool STEM Enrichment Empowers Facilitators, Too!	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1160890&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1160890&amp;site=ehost-live</a>
Are you saying I'm to blame?' Exploring the influence of a principal on elementary science delivery	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764231205?accountid=14404">https://dialog.proquest.com/professional/docview/764231205?accountid=14404</a>
Authentic Science Research in Elementary School After-School Science Clubs	ERIC-ProQuest	<a href="https://search.proquest.com/docview/964171670?accountid=14404">https://search.proquest.com/docview/964171670?accountid=14404</a>
Bridging the Arts and Computer Science: Engaging At-Risk Students through the Integration of Music	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1171661&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1171661&amp;site=ehost-live</a>
Bridging the gap between science and policy: an international survey of scientists and policy makers in China and Canada.	ASC	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=112855860&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=a9h&amp;AN=112855860&amp;site=ehost-live</a>
Building self-taught scientists: Students from a traditionally low academically performing region excel through self teaching mediums such as wikipedia and hands on learning	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84991585284&amp;partnerID=40&amp;md5=4cd98d9c73ef55713f4f480a81dcfe5e">https://www.scopus.com/inward/record.uri?eid=2-s2.0-84991585284&amp;partnerID=40&amp;md5=4cd98d9c73ef55713f4f480a81dcfe5e</a>



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Challenging science teachers' beliefs and practices through a video-case-based intervention in China's primary schools	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1312526826?accountid=14404">https://dialog.proquest.com/professional/docview/1312526826?accountid=14404</a>
Changes in science teaching self-efficacy among primary teacher education students	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1823923883?accountid=14404">https://dialog.proquest.com/professional/docview/1823923883?accountid=14404</a>
Climbing the Staircase: science education for the knowledge economy	ASSIA	<a href="https://search.proquest.com/docview/226936702?accountid=14404">https://search.proquest.com/docview/226936702?accountid=14404</a>
Cognitive development in a secondary science setting	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764160643?accountid=14404">https://dialog.proquest.com/professional/docview/764160643?accountid=14404</a>
Community and contribution: Factors motivating students to participate in an extra-curricular online activity and implications for learning	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/2042753015571828">http://journals.sagepub.com/doi/full/10.1177/2042753015571828</a>
Confronting Barriers to Teaching Elementary Science: After-School Science Teaching Experiences for Preservice Teachers	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651835939?accountid=14404">https://search.proquest.com/docview/1651835939?accountid=14404</a>
Connecting Urban Students with Engineering Design: Community-Focused, Student-Driven Projects	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1913355078?accountid=14404">https://search.proquest.com/docview/1913355078?accountid=14404</a>
Crosswalk between the "Framework for K-12 Science Education" and "Standards for the 21st-Century Learner": School Librarians as the Crucial Link	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1509082301?accountid=14404">https://search.proquest.com/docview/1509082301?accountid=14404</a>
Crumpled Molecules and Edible Plastic: Science Learning Activation in Out-of-School Time	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1913353517?accountid=14404">https://search.proquest.com/docview/1913353517?accountid=14404</a>
Curricular and extra-curricular activities to develop the environmental awareness of young students: A case from Turkey	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-70450285232&amp;partnerID=40&amp;md5=35cd09bc88b82c510e609fb592e7b30c">https://www.scopus.com/inward/record.uri?eid=2-s2.0-70450285232&amp;partnerID=40&amp;md5=35cd09bc88b82c510e609fb592e7b30c</a>
Development and implementation of a structured outreach program in IT for middle and high school students	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764298126?accountid=14404">https://dialog.proquest.com/professional/docview/764298126?accountid=14404</a>
Dragons, Ladybugs, and Softballs: Girls' STEM Engagement with Human-Centered Robotics	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1122237&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1122237&amp;site=ehost-live</a>
Effective STEM Programs for Adolescent Girls: Three Approaches and Many Lessons Learned	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1373090459?accountid=14404">https://search.proquest.com/docview/1373090459?accountid=14404</a>
Effects of a modified Thinking Science program for year 8 students of various abilities	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1970660662?accountid=14404">https://dialog.proquest.com/professional/docview/1970660662?accountid=14404</a>



Effects of an Afterschool Early Literacy Intervention on the Reading Skills of Children in Public Housing Communities	ASSIA	<a href="https://search.proquest.com/docview/1994556782?accountid=14404">https://search.proquest.com/docview/1994556782?accountid=14404</a>
Effects of an Expressive Art Intervention with Urban Youth in Low-Income Neighborhoods	ASSIA	<a href="https://search.proquest.com/docview/1814063896?accountid=14404">https://search.proquest.com/docview/1814063896?accountid=14404</a>
Effects of Youth Participation in Extra-Curricular Sport Programs on Perceived Self-Efficacy: A Multilevel Analysis	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/0031512517697069">http://journals.sagepub.com/doi/full/10.1177/0031512517697069</a>
Elementary School Garden Programs Enhance Science Education for All Learners	SAGE	<a href="http://journals.sagepub.com/doi/full/10.1177/004005991204400606">http://journals.sagepub.com/doi/full/10.1177/004005991204400606</a>
Eliminating shyness through co-curricular activities towards enhancing the career development of engineering students	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-85051382837&amp;doi=10.1088%2f1742-6596%2f1049%2f1%2f012057&amp;partnerID=40&amp;md5=38061851453b34db641b28fadca6df0a">https://www.scopus.com/inward/record.uri?eid=2-s2.0-85051382837&amp;doi=10.1088%2f1742-6596%2f1049%2f1%2f012057&amp;partnerID=40&amp;md5=38061851453b34db641b28fadca6df0a</a>
Emotional and motivational outcomes of lab work in the secondary intermediate track: The contribution of a science center outreach lab.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-59236-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-59236-001&amp;site=ehost-live</a>
Engagement and Knowledge Building in an Afterschool STEM Club: Analyzing Youth and Facilitator Posting Behavior on a Social Networking Site	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1153201&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1153201&amp;site=ehost-live</a>
Enhancing student learning through science related excursions	AUSEI	<a href="https://dialog.proquest.com/professional/docview/2023694082?accountid=14404">https://dialog.proquest.com/professional/docview/2023694082?accountid=14404</a>
Environmental clubs as vehicles for promoting education for environmental sustainability in Mauritian secondary schools	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84874766674&amp;partnerID=40&amp;md5=9d46365631a1728d8dd014f60c7506e3">https://www.scopus.com/inward/record.uri?eid=2-s2.0-84874766674&amp;partnerID=40&amp;md5=9d46365631a1728d8dd014f60c7506e3</a>
Evaluation of the In2science peer mentoring program : final report	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1970662707?accountid=14404">https://dialog.proquest.com/professional/docview/1970662707?accountid=14404</a>
Examination of the Effect of the GEMS Program on Problem Solving and Science Process Skills of 6-Year-Old Children	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1185639&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1185639&amp;site=ehost-live</a>
Examining Fidelity of Program Implementation in a STEM-Oriented Out-of-School Setting	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651850803?accountid=14404">https://search.proquest.com/docview/1651850803?accountid=14404</a>
Expanding high school STEM literacy through extra-curricular activities	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84942741158&amp;doi=10.1109%2fIASECon.2015.7119940&amp;partnerID=40&amp;md5=a612a36bc49b1b62fb5b11a9b431e5b">https://www.scopus.com/inward/record.uri?eid=2-s2.0-84942741158&amp;doi=10.1109%2fIASECon.2015.7119940&amp;partnerID=40&amp;md5=a612a36bc49b1b62fb5b11a9b431e5b</a>



Exploring Curriculum for Science Education: Lessons from a Mexican Biosphere Reserve	SAGE	- <a href="http://journals.sagepub.com/doi/full/10.1177/0973408218763443">http://journals.sagepub.com/doi/full/10.1177/0973408218763443</a>
Extra curricular photonics education in Romanian high schools	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-36248979208&amp;doi=10.1117%2f12.756798&amp;partnerID=40&amp;md5=d27344d49dd545f9b0fcee03b894c96">https://www.scopus.com/inward/record.uri?eid=2-s2.0-36248979208&amp;doi=10.1117%2f12.756798&amp;partnerID=40&amp;md5=d27344d49dd545f9b0fcee03b894c96</a>
Flexner 3.0â€”Democratization of Medical Knowledge for the 21st Century:Teaching Medical Science Using K-12 General Pathology as a Gateway Course	SAGE	- <a href="http://journals.sagepub.com/doi/full/10.1177/2374289516636132">http://journals.sagepub.com/doi/full/10.1177/2374289516636132</a>
Fueling Interest in Science: An After-School Program Model that Works	ERIC-ProQuest	<a href="https://search.proquest.com/docview/61893882?accountid=14404">https://search.proquest.com/docview/61893882?accountid=14404</a>
How much can little data reveal?: The effect of science club participation on final exam outcomes	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-84957890751&amp;partnerID=40&amp;md5=eebc41487517b4c93eab24f87912483e">https://www.scopus.com/inward/record.uri?eid=2-s2.0-84957890751&amp;partnerID=40&amp;md5=eebc41487517b4c93eab24f87912483e</a>
How to shape attitudes toward STEM careers: The search for the most impactful extracurricular clubs (RTP)	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-85030566534&amp;partnerID=40&amp;md5=5b73b59ff6e52f136a533afc29d6fb64">https://www.scopus.com/inward/record.uri?eid=2-s2.0-85030566534&amp;partnerID=40&amp;md5=5b73b59ff6e52f136a533afc29d6fb64</a>
Impacting students' interest in stem fields: An electronic communication course for K-12 underrepresented students	Scopus	<a href="https://www.scopus.com/inward/record.uri?eid=2-s2.0-85029113164&amp;partnerID=40&amp;md5=1f02b93dd750b5bdb5153eb4bc75dc7e">https://www.scopus.com/inward/record.uri?eid=2-s2.0-85029113164&amp;partnerID=40&amp;md5=1f02b93dd750b5bdb5153eb4bc75dc7e</a>
Implementing STEAM in maker-centered learning.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-41156-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-41156-001&amp;site=ehost-live</a>
Influence of a Science-Focused After-School Program on Underrepresented High-School Students' Science Attitudes and Trajectory: A Survey Validation Study	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1895975796?accountid=14404">https://search.proquest.com/docview/1895975796?accountid=14404</a>
Informal science education for girls : careers in science and effective program elements.	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764337771?accountid=14404">https://dialog.proquest.com/professional/docview/764337771?accountid=14404</a>
Kids Code in a rural village in Norway: Could code clubs be a new arena for increasing girls' digital interest and competence?	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-50142-007&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2015-50142-007&amp;site=ehost-live</a>
Learning from Science: Case Studies of Science Offerings in Afterschool Programs	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651827898?accountid=14404">https://search.proquest.com/docview/1651827898?accountid=14404</a>
Learning to be a science teacher : reflections and lessons from video-based instruction	AUSEI	<a href="https://dialog.proquest.com/professional/docview/885360677?accountid=14404">https://dialog.proquest.com/professional/docview/885360677?accountid=14404</a>





Leveraging cultural values and 'ways of knowing' to increase diversity in maker activities.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-01271-003&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-01271-003&amp;site=ehost-live</a>
Long-Term Participants: A Museum Program Enhances Girls' STEM Interest, Motivation, and Persistence	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1651862330?accountid=14404">https://search.proquest.com/docview/1651862330?accountid=14404</a>
Making the Science Literacy Connection: After-School Science Clubs	ERIC-ProQuest	<a href="https://search.proquest.com/docview/62117849?accountid=14404">https://search.proquest.com/docview/62117849?accountid=14404</a>
New Faces, New Places: A 4-H Science Learning Program in Urban Out-of-School Settings	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1068348&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1068348&amp;site=ehost-live</a>
Newcomer programs: An educational alternative for secondary immigrant students	ASSIA	<a href="https://search.proquest.com/docview/202706402?accountid=14404">https://search.proquest.com/docview/202706402?accountid=14404</a>
Out-of-School Time Science Activities and Their Association with Career Interest in STEM	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1136298&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1136298&amp;site=ehost-live</a>
Outreach Programmes Using the Triple Helix Model to Encourage Interest in Science and Technology among Underrepresented Youth	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1171582&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1171582&amp;site=ehost-live</a>
Perceived effects of embedding a learning strategy course in a Year 8 science program	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764252551?accountid=14404">https://dialog.proquest.com/professional/docview/764252551?accountid=14404</a>
Personal Inquiry: Orchestrating Science Investigations within and beyond the Classroom	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1060708&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1060708&amp;site=ehost-live</a>
Physical Computing for STEAM Education: Maker-Educators' Experiences in an Online Graduate Course	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1170375&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1170375&amp;site=ehost-live</a>
Pre-service chemistry teachers' expectations and experiences in the school experience course	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1139429583?accountid=14404">https://dialog.proquest.com/professional/docview/1139429583?accountid=14404</a>
Productive Communication in an Afterschool Engineering Club with Girls Who Are English Language Learners	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1161071&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1161071&amp;site=ehost-live</a>
Professional Development for Technology-Enhanced Inquiry Science	SAGE	<a href="http://journals.sagepub.com/doi/full/10.3102/0034654311415121">http://journals.sagepub.com/doi/full/10.3102/0034654311415121</a>
Professional development in primary science : teacher mentoring	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764242952?accountid=14404">https://dialog.proquest.com/professional/docview/764242952?accountid=14404</a>
Reflections on STEM, Standards, and Disciplinary Focus	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1174484&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1174484&amp;site=ehost-live</a>
School Maker Faires	ERIC-ProQuest	<a href="https://search.proquest.com/docview/2034280483?accountid=14404">https://search.proquest.com/docview/2034280483?accountid=14404</a>



Science after School: Way Cool! A Course-Based Approach to Teaching Science Outreach	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1129831&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1129831&amp;site=ehost-live</a>
Science Club--A Concept	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1107796&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1107796&amp;site=ehost-live</a>
Sooner Elementary Engineering and Science--A Model for After-School Science Clubs Based on University and K-5 Partnership	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1720060086?accountid=14404">https://search.proquest.com/docview/1720060086?accountid=14404</a>
STEM Clubs and Science Fair Competitions: Effects on Post-Secondary Matriculation	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1413417592?accountid=14404">https://search.proquest.com/docview/1413417592?accountid=14404</a>
STEM High School Administrator's, Teacher's, and Student's Perceptions of Curricular and Instructional Strategies and Practices	SAGE	- <a href="http://journals.sagepub.com/doi/full/10.1177/1932202X14527952">http://journals.sagepub.com/doi/full/10.1177/1932202X14527952</a>
STEM-focused high schools as a strategy for enhancing readiness for postsecondary STEM programs.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-03143-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2016-03143-001&amp;site=ehost-live</a>
Stemming the Gap	ERIC-ProQuest	<a href="https://search.proquest.com/docview/898326349?accountid=14404">https://search.proquest.com/docview/898326349?accountid=14404</a>
Students' Attitudes toward Science as Predictors of Gains on Student Content Knowledge: Benefits of an After-School Program	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1697504960?accountid=14404">https://search.proquest.com/docview/1697504960?accountid=14404</a>
Teaching and learning science and technology beyond the classroom.	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764317442?accountid=14404">https://dialog.proquest.com/professional/docview/764317442?accountid=14404</a>
The effects of an after-school tutoring program on the academic performance of at-risk students and students with LD	ASSIA	<a href="https://search.proquest.com/docview/236321003?accountid=14404">https://search.proquest.com/docview/236321003?accountid=14404</a>
The effects of implementing an innovative assessment program in senior school physics	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764155939?accountid=14404">https://dialog.proquest.com/professional/docview/764155939?accountid=14404</a>
The importance of the second loop in educational technology: An action science study of introducing blogging in a course curriculum	SAGE	- <a href="http://journals.sagepub.com/doi/full/10.1177/1476750313502555">http://journals.sagepub.com/doi/full/10.1177/1476750313502555</a>
The Invention Studio: A University Maker Space and Culture	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1076126&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1076126&amp;site=ehost-live</a>
The makerspace movement: Sites of possibilities for equitable opportunities to engage underrepresented youth in STEM.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-30197-003&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-30197-003&amp;site=ehost-live</a>
The splashdown effect : measuring the effect of science enrichment programs on science attitudes of gifted high school girls and boys.	AUSEI	<a href="https://dialog.proquest.com/professional/docview/764334408?accountid=14404">https://dialog.proquest.com/professional/docview/764334408?accountid=14404</a>
The Structural Relationship between Out-of-School Time Enrichment and Black Student Participation in Advanced Science	ERIC-ProQuest	<a href="https://search.proquest.com/docview/2013525792?accountid=14404">https://search.proquest.com/docview/2013525792?accountid=14404</a>





Transforming Schools into 21st Century Community Learning Centers	ASSIA	<a href="https://search.proquest.com/docview/210942139?accountid=14404">https://search.proquest.com/docview/210942139?accountid=14404</a>
Understanding the Delivery of a Canadian-Based After-School STEM Program: A Case Study	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1181896&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1181896&amp;site=ehost-live</a>
Using Science Centers and Museums for Teacher Training in Turkey	ERIC-ProQuest	<a href="https://search.proquest.com/docview/2101401613?accountid=14404">https://search.proquest.com/docview/2101401613?accountid=14404</a>
Variations on a Theme: Characteristics of Out-of-School Time Science Programs Offered by Distinct Organization Types	ERIC-ProQuest	<a href="https://search.proquest.com/docview/1373086655?accountid=14404">https://search.proquest.com/docview/1373086655?accountid=14404</a>
Vitalizing Creative Learning in Science and Technology through an Extracurricular Club: A Perspective Based on Activity Theory	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ997902&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ997902&amp;site=ehost-live</a>
Volunteering in school science lessons : expectations and experiences of university students	AUSEI	<a href="https://dialog.proquest.com/professional/docview/1925331893?accountid=14404">https://dialog.proquest.com/professional/docview/1925331893?accountid=14404</a>
Ways of Using Science Clubs to Bridge into Secondary Schools	ERIC-ProQuest	<a href="https://search.proquest.com/docview/881467445?accountid=14404">https://search.proquest.com/docview/881467445?accountid=14404</a>
We could think of things that could be science': Girls' re-figuring of science in an out-of-school-time club.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2013-36734-004&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2013-36734-004&amp;site=ehost-live</a>
What discourse of science dominates lower post-primary education in Ireland?	RIAN	<a href="http://hdl.handle.net/10344/1939">http://hdl.handle.net/10344/1939</a>
What If? Building Creative Cultures for STEM Making and Learning	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1138042&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1138042&amp;site=ehost-live</a>
What science and for whom?: An introduction to our focus on equity and out-of-school learning.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-26102-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-26102-001&amp;site=ehost-live</a>
Who wants to learn more science? The role of elementary school science experiences and science self-perceptions.	PsycINFO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-42560-001&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=psyh&amp;AN=2017-42560-001&amp;site=ehost-live</a>
Whose Banner Are We Waving? Exploring STEM Partnerships for Marginalized Urban Youth	ERIC-EBSCO	<a href="http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1173397&amp;site=ehost-live">http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1173397&amp;site=ehost-live</a>
Foundations for a New Science of Learning	JSTOR	<a href="https://www.jstor.org/stable/20536639?Search=yes&amp;resultItemClick=true&amp;searchText=foundations&amp;searchText=for&amp;searchText=a&amp;searchText=new&amp;searchText=science&amp;searchText=of&amp;searchText=learning&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffc%3Doff%26amp%3Bgroup%3Dnone%26amp%3Bacc%3Don%26amp%3Bwc%3Don%26amp%3Bquery%3Dfoundations%2Bfor%2Ba%2Bnew%2Bscience%2Bof%2Blearning&amp;refreqid=search%3Aa7f215952de0a6d001ce8243af">https://www.jstor.org/stable/20536639?Search=yes&amp;resultItemClick=true&amp;searchText=foundations&amp;searchText=for&amp;searchText=a&amp;searchText=new&amp;searchText=science&amp;searchText=of&amp;searchText=learning&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffc%3Doff%26amp%3Bgroup%3Dnone%26amp%3Bacc%3Don%26amp%3Bwc%3Don%26amp%3Bquery%3Dfoundations%2Bfor%2Ba%2Bnew%2Bscience%2Bof%2Blearning&amp;refreqid=search%3Aa7f215952de0a6d001ce8243af</a>



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Science Buddies: Advancing Informal Science Education	JSTOR	<a href="https://www.jstor.org/stable/29784166?Search=yes&amp;resultItemClick=true&amp;searchText=Science&amp;searchText=Buddies%3A&amp;searchText=Advancing&amp;searchText=Informal&amp;searchText=Science&amp;searchText=Education&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffilter%3D%26amp%3BQuery%3DScience%2BBuddies%253A%2BAdvancing%2BInformal%2BScience%2BEducation&amp;refregid=search%3A3e3ff8e82bf11f8aaa2a4f862127534d&amp;seq=1#metadata info tab contents">https://www.jstor.org/stable/29784166?Search=yes&amp;resultItemClick=true&amp;searchText=Science&amp;searchText=Buddies%3A&amp;searchText=Advancing&amp;searchText=Informal&amp;searchText=Science&amp;searchText=Education&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffilter%3D%26amp%3BQuery%3DScience%2BBuddies%253A%2BAdvancing%2BInformal%2BScience%2BEducation&amp;refregid=search%3A3e3ff8e82bf11f8aaa2a4f862127534d&amp;seq=1#metadata info tab contents</a>
Learning and Scientific Reasoning	JSTOR	<a href="https://www.jstor.org/stable/20402954?Search=yes&amp;resultItemClick=true&amp;searchText=Learning&amp;searchText=and&amp;searchText=Scientific&amp;searchText=Reasoning&amp;searchUri=%2Faction%2FdoBasicSearch%3FQuery%3DLearning%2Band%2BScientific%2BReasoning%26amp%3Bfilter%3D&amp;refregid=search%3Aa333d7c62cd5fcb0f3cc83bc9c2e97f4&amp;seq=1#metadata info tab contents">https://www.jstor.org/stable/20402954?Search=yes&amp;resultItemClick=true&amp;searchText=Learning&amp;searchText=and&amp;searchText=Scientific&amp;searchText=Reasoning&amp;searchUri=%2Faction%2FdoBasicSearch%3FQuery%3DLearning%2Band%2BScientific%2BReasoning%26amp%3Bfilter%3D&amp;refregid=search%3Aa333d7c62cd5fcb0f3cc83bc9c2e97f4&amp;seq=1#metadata info tab contents</a>
The 95 Percent Solution	JSTOR	<a href="https://www.jstor.org/stable/25766726?Search=yes&amp;resultItemClick=true&amp;searchText=The&amp;searchText=95&amp;searchText=Percent&amp;searchText=Solution&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffilter%3D%26amp%3BQuery%3DThe%2B95%2BPercent%2BSolution&amp;refregid=search%3A28b8737afa11b87eb2759005e0091d88&amp;seq=1#metadata info tab contents">https://www.jstor.org/stable/25766726?Search=yes&amp;resultItemClick=true&amp;searchText=The&amp;searchText=95&amp;searchText=Percent&amp;searchText=Solution&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffilter%3D%26amp%3BQuery%3DThe%2B95%2BPercent%2BSolution&amp;refregid=search%3A28b8737afa11b87eb2759005e0091d88&amp;seq=1#metadata info tab contents</a>
Technology and Informal Education: What Is Taught, What Is Learned	JSTOR	<a href="https://www.jstor.org/stable/20177122?Search=yes&amp;resultItemClick=true&amp;searchText=Technology&amp;searchText=and&amp;searchText=Informal&amp;searchText=Education%3A&amp;searchText=What&amp;searchText=Is&amp;searchText=Taught%2C&amp;searchText=What&amp;searchText=Is&amp;searchText=Learned&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffilter%3D%26amp%3BQuery%3DTechnology%2Band%2BInformal%2BEducation%253A%2BWhat%2BIs%2BTaught%252C%2BWhat%2BIs%2BLearned&amp;refregid=search%3A476dd6041ff8d7a7294128280517a508#metadata info tab contents">https://www.jstor.org/stable/20177122?Search=yes&amp;resultItemClick=true&amp;searchText=Technology&amp;searchText=and&amp;searchText=Informal&amp;searchText=Education%3A&amp;searchText=What&amp;searchText=Is&amp;searchText=Taught%2C&amp;searchText=What&amp;searchText=Is&amp;searchText=Learned&amp;searchUri=%2Faction%2FdoBasicSearch%3Ffilter%3D%26amp%3BQuery%3DTechnology%2Band%2BInformal%2BEducation%253A%2BWhat%2BIs%2BTaught%252C%2BWhat%2BIs%2BLearned&amp;refregid=search%3A476dd6041ff8d7a7294128280517a508#metadata info tab contents</a>
Igniting Girls' Interest in Science	JSTOR	<a href="https://www.jstor.org/stable/20053617?Search=yes&amp;resultItemClick=true">https://www.jstor.org/stable/20053617?Search=yes&amp;resultItemClick=true</a>



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Getting Science Education Right	JSTOR	<a href="https://www.jstor.org/stable/25766746?Search=yes&amp;resultItemClick=true&amp;searchText=Getting&amp;searchText=Science&amp;searchText=Education&amp;searchText=Right&amp;searchUri=%2Faction%2FdoBasicSearch%3FQuery%3DGetting%2BScience%2BEducation%2BRight%26amp%3Bfilter%3D&amp;refregid=search%3A48524237d3544f21543e93c3757539c8&amp;seq=1#metadata_info_tab_contents">https://www.jstor.org/stable/25766746?Search=yes&amp;resultItemClick=true&amp;searchText=Getting&amp;searchText=Science&amp;searchText=Education&amp;searchText=Right&amp;searchUri=%2Faction%2FdoBasicSearch%3FQuery%3DGetting%2BScience%2BEducation%2BRight%26amp%3Bfilter%3D&amp;refregid=search%3A48524237d3544f21543e93c3757539c8&amp;seq=1#metadata_info_tab_contents</a>
Bridging in-school and out-of-school learning: Formal, non-formal, and informal education	JSTOR	<a href="https://www.jstor.org/stable/40188686?Search=yes&amp;resultItemClick=true&amp;searchText=Bridging&amp;searchText=in-school&amp;searchText=and&amp;searchText=out-of-school&amp;searchText=learning%3A&amp;searchText=Formal%2C&amp;searchText=non-formal%2C&amp;searchText=and&amp;searchText=informal&amp;searchText=education&amp;searchUri=%2Faction%2FdoBasicSearch%3FQuery%3DBridging%2Bin-school%2Band%2Bout-of-school%2Blearning%253A%2BFormal%252C%2Bnon-formal%252C%2Band%2Binformal%2Beducation%26amp%3Bfilter%3D&amp;refregid=search%3Ad64eaa7e4cf472abd8f540f69a834c43&amp;seq=1#metadata_info_tab_contents">https://www.jstor.org/stable/40188686?Search=yes&amp;resultItemClick=true&amp;searchText=Bridging&amp;searchText=in-school&amp;searchText=and&amp;searchText=out-of-school&amp;searchText=learning%3A&amp;searchText=Formal%2C&amp;searchText=non-formal%2C&amp;searchText=and&amp;searchText=informal&amp;searchText=education&amp;searchUri=%2Faction%2FdoBasicSearch%3FQuery%3DBridging%2Bin-school%2Band%2Bout-of-school%2Blearning%253A%2BFormal%252C%2Bnon-formal%252C%2Band%2Binformal%2Beducation%26amp%3Bfilter%3D&amp;refregid=search%3Ad64eaa7e4cf472abd8f540f69a834c43&amp;seq=1#metadata_info_tab_contents</a>
Beyond the classroom walls: Technology infusion advancing science education	ProQuest	<a href="http://elib.tcd.ie/login?url=https://search.proquest.com/docview/1822382441?accountid=14404">http://elib.tcd.ie/login?url=https://search.proquest.com/docview/1822382441?accountid=14404</a>
Science education through informal education	ProQuest	<a href="http://dx.doi.org/10.1007/s11422-014-9639-3">http://dx.doi.org/10.1007/s11422-014-9639-3</a>
The opinions of science and technology teachers regarding the usage of out-of-school learning environments in science teaching	ProQuest	<a href="http://elib.tcd.ie/login?url=https://search.proquest.com/docview/1777500439?accountid=14404">http://elib.tcd.ie/login?url=https://search.proquest.com/docview/1777500439?accountid=14404</a>
A non-formal student laboratory as a place for innovation in education for sustainability for all students	ProQuest	<a href="http://dx.doi.org/10.3390/educsci5030238">http://dx.doi.org/10.3390/educsci5030238</a>



Competencies of science centre facilitators	ProQuest	<a href="http://elib.tcd.ie/login?url=https://search.proquest.com/docview/1752792911?accountid=14404">http://elib.tcd.ie/login?url=https://search.proquest.com/docview/1752792911?accountid=14404</a>
Using science centers and museums for teacher training in turkey	ProQuest	<a href="http://dx.doi.org/10.1007/s40299-013-0085-x">http://dx.doi.org/10.1007/s40299-013-0085-x</a>
The presentation of science in everyday life: The science show.	ProQuest	<a href="http://dx.doi.org/10.1007/s11422-013-9484-9">http://dx.doi.org/10.1007/s11422-013-9484-9</a>
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