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Edited by Maria Ampartzaki and Michail Kalogiannakis

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Meet the editors

Dr. Maria Ampartzaki is an Associate Professor of Early Childhood Education in the Department of Preschool Education, University of Crete, Greece. Her research interests include information and communications technology (ICT) in education, science education in the early years, inquiry-based and art-based learning, teachers' professional development, action-research, and the pedagogy of multiliteracies, among others. Dr. Ampartzaki holds a degree in Early Years Education, an MA in Music Education, and an EdD. She has published her research in numerous academic publications and is widely referenced by educators worldwide. She has run and participated in several funded and non-funded projects regarding early childhood education, values education, science education, and ICT in education.

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Contents

Preface

Creativity and creative pedagogy

While there is a consensus that creativity is a complex and all-encompassing concept, the psychological tradition defines it as consisting of two main components: originality and usefulness. However, this definition only focuses on the characteristics of a creative product and may not capture the full extent of creativity [1, 2]. There have been other ideas put forth to better understand creativity, including those that focus on the processes involved and the characteristics of creative individuals. A comprehensive approach to creativity involves three interacting systems: (1) the sociocultural system that has symbolic rules, (2) the personal system that incorporates individual traits into the process, and (3) the system that experts use to frame the creative process by recognizing, evaluating, and validating the end product [1–3]. On this basis, Walia [3] suggests that creativity is an action that results from perceiving an imbalance in the environment, leading to productive activity that challenges conventional thinking and norms. This process generates something new in the form of a physical, mental, or emotional creation.

Further, a proposal was made for a triangular model of creative pedagogy, which aims to bring together different but interconnected perspectives on encouraging creativity. This model also seeks to critique educational practices that prioritize knowledge transfer and neglect the active involvement of learners. The model encompasses three interrelated components: *creative teaching, teaching for creativity, and creative learning*. These elements mutually reinforce each other, fostering a harmonious teaching and learning process. *Creative teaching* emphasizes the innovative efforts made by educators in the development and delivery of instructional materials. This involves employing inventive strategies to enhance the appeal, engagement, relevance, and efficacy of the learning process [4–6]. *Teaching for creativity* places emphasis on the goals and methods involved in fostering learners' creative abilities [4, 7]. *Creative learning*, as the third component, emphasizes the active and creative involvement and agency of learners rather than their passive acquisition of knowledge from authoritative sources [4–6]. According to Craft [5], there is still ongoing exploration and definition of the connections between creative teaching, teaching for creativity, and creative learning. Although it may not cover every aspect of creative pedagogy, this book aims to identify some significant challenges that teachers, schools, policymakers, and researchers must address to effectively promote creativity among young people and learners. The book is organized into two sections: "Creative Pedagogy in School Education" and "Creative Pedagogy in Higher Education."

Creative Pedagogy in School Education

In Chapter 1, "Utilizing Creative and Critical Thinking to Build Knowledge and Comprehension Through Inquiry-Based and Art-Based Learning: A Practical Tool for Teaching Local History in Pre-Primary and Primary Education", the study of local history is approached in a contemporary manner that fosters the development of critical thinking skills and the cultivation of creativity through inquiry and art-based learning. By using inquiry-based and art-based learning, young students can learn to analyze data from primary and secondary sources, critically examine structures and phenomena, and communicate their understanding through diverse modes of communication and symbolism. This chapter outlines standards for inquiry and art-based learning environments and provides a tool for improving local history classes. The tool focuses on four dimensions: learning interactions, historical understanding, art-focused learning, and practical solutions.

Chapter 2, "Coding and Creativity: Reflections and Design Proposals", explores creative and critical thinking skills in coding education. It suggests four paradigms to perceive coding and its potential benefits for students. By adopting the emancipatory and interpretative paradigms, students can enhance their creative thinking abilities and cultivate the skills necessary to become active and engaged global citizens. In this analysis, the authors elucidate the design components inherent in these two paradigms while also exploring their interrelation with a media educative perspective. Hence, they undertake an analysis of coding practices via the lens of emancipatory theory, employing critical thinking as a means to mitigate the potential for subjugation within the context of the digital society.

In Chapter 3, "Science Education and Beyond: Citizen Science in Primary School Potentially Affects Conceptual Learning and Socio-emotional Development", the authors present examples of creative learning through Citizen Science (CS). Three assessments show that CS can help students acquire factual knowledge, apply it creatively to new situations, and control impulsive behavior. The application of knowledge to new situations demonstrates flexible thinking, which is a key component of creativity. Additionally, the ability to control impulsive behavior is a sign of meaningful learning, as evidenced by children who successfully executed naturalistic observations. The project utilized fieldwork as a learning method, which is considered a holistic and multisensory approach that exposes children to a diverse range of experiences, making it an overall creative learning framework.

Chapter 4, "Bridging the Digital Divide in Design and Mathematics through an Immersive Maker Program for Underrepresented Students", shows how maker spaces offer a dynamic environment for students to explore concepts and problem-solving skills with digital and physical tools. An interdisciplinary program was created to address the educational success gap among underrepresented and minority students. The program combined design and mathematics education using maker spaces to provide equitable opportunities for underrepresented and marginalized students. Creativity flourished in two ways: through learning and understanding the connections between different fields, and through effective project implementation despite financial obstacles.

Chapter 5, "Full STEAM Ahead with Creativity", discusses how flow emerges in STEAM activities. Flow is a state of complete immersion and intense concentration that increases productivity. The Horizon 2020 project CREATIONS promoted the combination of arts with science education to create engaging STEAM activities. The study showed the significance of self-efficacy in facilitating the flow experience within the setting of classroom activities and across multiple age groups.

Creative Pedagogy in Higher Education

Chapter 6, "Collaborative Creativity in International Social Pedagogy Educational Settings", reports the results of a three-year educational project among five universities that aimed to improve teaching methods for bachelor of social work programs. The project focused on enhancing collaborative creativity among students, instructors, managers, and professionals. The study found that collaborative creativity is influenced by structural and intuitive factors and requires integrative, functionalist instrumental, and adaptive forms of creativity development. The authors suggest that creativity concepts can serve as a theoretical framework to analyze a process of change.

In Chapter 7, "The Future of Education: Strengthening the Relevance of Lifelong Learning", the authors examine educational strategies aimed at enhancing the applicability of knowledge and skills in lifelong learning educational programs offered by Higher Education Institutions (HEIs) . The main contention posits the necessity of establishing a dynamic and mutually influential connection between the work environment and educational content and practices to bridge the divide between the curriculum and the work context, thereby enhancing the likelihood of applying educational content driven by innovation in the workplace. Relevance is a crucial feature, and the authors propose a conceptual model that offers additional insights into the interconnectedness between educational and job-related aspects.

Reading through this volume will give readers a clearer picture of why creativity is important and in what ways it can be realized in teaching and learning processes. We would like to express our gratitude to all the authors for their valuable contributions and the collaboration they provided during the review process.

In loving memory of George Ampartzakis, who left us too soon, but will never be forgotten.

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Section 1

Creative Pedagogy in School Education

Chapter 1

Utilizing Creative and Critical Thinking to Build Knowledge and Comprehension through Inquiry-Based and Art-Based Learning: A Practical Tool for Teaching Local History in Pre-Primary and Primary Education

Maria Ampartzaki

Abstract

Studying local history can be approached in a modern way that encourages young students to utilize the methods and skills of a historian. This includes collecting, recording, comparing, and interpreting data from primary and secondary resources. Inquiry-based and art-based learning are effective frameworks for exploring local history. Students can gain a deeper understanding of the subject by focusing on inquiry, fieldwork, thorough recording, and constructing historical narratives based on critical interpretation of all information, including opposing and alternative views. Art-based learning allows students to analyze the forms and social aspects of artifacts, constructions, events, and phenomena and then express their knowledge and understanding in various multimodal and symbolic ways. It's essential for children to take the initiative, and be involved in the learning process, and work in collaborative environments that support their free thinking and exploration. This approach is conducive to critical thinking and encourages creativity in learning history. This chapter outlines the conditions that define inquiry and art-based learning environments and offers a tool with practical suggestions for pre-primary and primary teachers to develop their local history lessons. The tool covers four major dimensions: learning interactions, understanding historical times, art-based learning, and practical strategies specific to local history.

Keywords: local history, pre-primary and primary education, inquiry-based learning, art-based learning, practical strategies

1. Introduction

Local history is localized history. The study of local history is focused on a specific geographical area and the societies that existed there in the past, viewed through the lens of individuals who lived in these societies. This area could be a small community, a town, or even a wider geographical area [1]. Often, local citizens who are not professional historians take on the task of writing about their community's history, driven by a desire to preserve and share what they believe is important. By delving into local history, one can gain a deeper understanding of the broader national narrative, as the two are closely intertwined [2].

Stefaniak et al. [3] argue that influencing memories through teaching local history could become a powerful strategy for enhancing place connection and, by extension, fostering more community participation. History classes do not have to be boring if teachers plan activities that encourage students to use primary sources to learn interesting, relevant, and applicable information about the past. The study of local history is one of the best ways to gain insight into the relevance of the past. Public historical materials and re-creating individual histories could be the subject of such research [4, 5]. Stories about real-life local heroes or landmarks in a children's community capture their attention and captivate their minds. Also, a great technique to get children interested in history is to find interesting links to their own family and community's past. The Bradley Commission on History in Schools [6] argues that teaching children about their local history might serve as a "robust bridge" to teaching them about larger historical periods.

The "new history" concept moved away from the traditional emphasis on chronology and historical facts. Instead, it highlighted the importance of history as a unique field of knowledge that required specific skills and conceptual understandings to fully comprehend. It has been argued that students can achieve a higher level of understanding of history if it is perceived as a unique form of knowledge and a means of reasoning through the use of second-order concepts such as change and continuity, causation, significance, accounts, and evidence [7, 8]. Research came to a consistent conclusion that children can possess remarkably advanced ideas at a young age. This presents an opportunity for educators to develop a structured curriculum that builds on their existing knowledge, allowing for a more comprehensive understanding of history. One of the key concepts presented in this work is that students should have a solid grasp of the foundational principles of their subject. This includes understanding how historical knowledge is created, evaluated, and debated. Therefore, history education's main focus is to examine students' ideas and beliefs about the past. To acquire or develop their knowledge, they must be able to comprehend and apply key concepts. As a result, history educators and scholars must be attentive to students' conceptions and perceptions of history as both a subject and a discipline [9, 10].

Academics have suggested the need for "big picture" frameworks to help students understand their place in time [11]. They also propose a "conceptual framework of human history" that would allow students to connect different elements of the past and present in a meaningful way ([12], p. 93). Lee ([11], p. 68) emphasizes the importance of developing a comprehensive historical literacy that promotes an "active historical consciousness," enabling students to navigate the constantly evolving past and present. Historical consciousness relies on historical competence that involves a multifaceted approach. It requires the ability to ask meaningful questions, analyze sources, and evaluate historical accounts. It also involves connecting the past to our own lives and society and developing a deep understanding of historical concepts. By honing these skills, we can better appreciate the richness and complexity of our shared history [9, 13].

2. The creative perspectives of learning local history

Historians become creative when they use their imagination to make sense of the past, which often involves striving to understand unfamiliar practices, frameworks, and worldviews. Good historians can put themselves back in time and visualize the world as it was. Historical imagination is crucial for learning about other cultures, times, and worlds. Thinking creatively and imaginatively is the key to the capacity to see situations under different parameters and frameworks [14]. This is the capacity we call historical empathy [10].

The following are also signs of creative thinking in history [14, 15] in addition to the capacity to place oneself in an alternative time and space framework:

- Inquiry approaches such as, tackling historical problems; collecting and analyzing data; evaluating and verifying previously established accounts and pieces of evidence; interpretations, revisions, readings, and understandings; discovering new sources; applying new modes of communication; and altogether new historical narratives. Understanding the past in new ways sheds light on how it influences the present.

- The capacity of the historian to make connections, discriminate between, and draw similarities between different, intriguing, and valuable aspects of history, situating the information within a broader context.

- Borrowing ideas, concepts, theories, and methods from other frameworks or disciplines (e.g. philosophy, anthropology, cultural studies, literature, the arts, etc.) in order to examine a problem from a fresh angle.

- Alternative history is also a good way to be creative, as long as the goal is to get people to think.

- Historians face the challenge of interpreting and making sense of the past's intricate social structures by using a big-picture approach, all the while working with limited data. Making meaning of contradictory and partial evidence requires imagination too.

- Being a part of a bigger team that carries out in-depth investigations can also require the use of creativity.

In the present chapter, we are focusing on two learning strategies that can promote creative and critical thinking in studying local history: the strategy of inquiry-based and the strategy of art-based learning [16–18].

3. Inquiry-based learning

Inquiry-based learning is an approach that prioritizes the learner by encouraging questioning and discovery. Students are given the opportunity to explore their interests to find answers to their inquiries. Students collect, record, and organize relevant data and information and prepare summaries, reports, and/or presentations of the culminated knowledge at the end of the process [19]. Personal assessment and reflection are important components too [20]. The core of inquiry-based learning is discovery, which is achieved through research using primary and secondary resources. Fieldwork is also an important component, which includes not only site visits but also measurements, experimentation, object examination, and oral source investigation. This approach requires active learning, both individually and in groups, necessitating a supportive learning environment that caters to the material, emotional/psychological, and social needs of the learners [21–23]. In a spiral mode, the components could evolve in any sequence and traverse through phases. An inquiry may take the shape of cycles, with each cycle including querying, investigating, and concluding, or formulating new, more specific questions and returning to the research cycle.

When the aforementioned procedures are not confined to strict guidelines, they have the potential to encourage creativity. This is primarily because handling, utilizing, and examining information, materials, and ideas is a key aspect of creative endeavors for individuals of all ages. The cultivation of critical thinking skills (which are imperative for comprehending information) is equally vital. Moreover, knowledge and creativity are interconnected. Creativity can be a product of engaging with the regulations and principles of particular domains. The aforementioned necessitates excellent investigative abilities, which will empower learners to discern, obtain, and assess intricate structures and data to fuel their own creative pursuits [24, 25].

4. Art-based learning

Encouraging children to present what they have learned in various ways that incorporate multiple modes of expression can transform inquiry-based learning into a powerful, constructive, and expressive process, as stated by Wallace [26]. Art offers numerous avenues for expression and can serve as an additional means of discovery. Exposure to diverse cultural artifacts allows children to investigate different perspectives, ideas, and cultures, particularly when introduced in a social studies context, such as geography, history, citizenship, etc. One effective method to fight against prejudice is to educate oneself about various cultures and ethnicities. By assimilating new knowledge into their pre-existing frameworks, children can develop a deeper appreciation for the differences and similarities among individuals, rather than relying on broad racial or ethnic stereotypes [26–28].

In addition, artmaking provides a platform for exploring various means of expression and symbolically conveying personal experiences. Through visual, verbal, musical, and physical semiotics, art serves as a medium of communication and a way of constructing meaning [29]. According to Atkinson ([30], p. 77) children "use drawing and other practices such as painting or constructing, for a rich variety of expressive and representational purposes. Children use such art activities to construct narratives, to depict time sequences, to play games, to represent actions, to describe objects, to describe object and spatial relations, and much more. In these activities, children are developing semiotic strategies as well as conceptual understanding" (see also [22, 31]). In essence, artmaking is a valuable tool for exploring and constructing concepts, ideas, and perspectives.

5. The benefits of inquiry-based and art-based learning for creative and critical thinking

Both the inquiry-based and the art-based learning approaches, promote and strengthen children's social-emotional and creative development and the development of their critical thinking skills in several ways:

- Inquiry-based and art-based learning foster the holistic growth of students as they engage their cognitive, social, and psychological aspects [32–34].

- When students participate in inquiry-based learning, they are able to acquire genuine, practical knowledge that is relevant to their personal lives as it occurs in a particular social and individual setting, which encourages students to form connections and engage actively in the learning process [32, 35]. Experiential learning is beneficial for the development of practical life skills with emotional and social dimensions that are closely linked to personal and social values [21]. This benefits creativity which is primarily driven by personal relevance and meaningfulness [36–38].

- When students have control over the timing, materials, and participation in the process of inquiry or artistic creation, they tend to develop a sense of personal ownership and self-worth. This, in turn, helps them regulate themselves better and increases their self-efficacy [35, 39, 40]. Considering the student's desires, thoughts, and perspectives during discussions can also enhance their self-assurance, self-respect, sense of belonging, and self-worth [35, 41]. The development of well-being matters for creativity. Self-identity, self-awareness, self-confidence, and a sense of belonging enable individuals to unfold their creativity with confidence [42]. Moreover, the development of well-being is also a product of creativity [43].

- Students experience cognitive, social, and emotional growth when they take charge of their own learning [32]. Additionally, engaging in creative pursuits fosters a sense of independence and agency, enabling individuals to better understand themselves [42].

- Collaborative learning allows learners to pool their unique knowledge, skills, and attitudes toward a shared goal. This approach, as noted by Chu et al. [44], fosters co-construction of learning outcomes. Similarly, creativity in the humanities and creativity, in general, celebrates diversity and inclusivity [42, 45].

- Explorations such as those carried out in inquiries into history and the artistic and cultural creation of different societies promote children's social development and comprehension. This also helps them develop historical empathy and empathy in general, which involves understanding the emotions, viewpoints, and motives of others [16, 35].

- Working together in inquiries and artistic creation fosters a space for learning and growth, where effective communication skills are developed and refined, ultimately enhancing creativity [35, 42, 44].

- Inquiry-based and art-based learning allow students to enhance their analytical abilities, which can lead to sharp and perceptive interpretations of real-world situations [44, 46]. This skillset can greatly improve their quality of life. Additionally, since inquiries often stem from the world around us, this type of learning promotes "social knowing" ([47], p. vii; [35]). Developing analytical skills and insightful interpretations is a hallmark of creative thinking [38, 48, 49].

- Interactions are important to inquiry-based, art-based learning and creativity since they enable children to develop a healthy reliance on each other, vivid social interactions, good relationships, and "positive feelings towards peers" ([40], p. 10; [46]). According to Zhou [50], an effective method of recognizing creative learning and its qualities is through social interaction with others. Engaging in positive peer-to-peer interaction can enhance learners' motivation to build interpersonal connections through collaborative efforts. Such efforts may foster creative thinking, generate innovative ideas, and lead to practical solutions.

- Inquiries cater meaningful engagement to learning, which means that children are emotionally involved in learning activities. This affects dispositions as it breeds children's natural curiosity, eagerness, and motivation to learn [28, 40]. Moreover, art allows for the expression of emotions, thereby promoting emotional intelligence [35]. Helm and Katz report that "research suggests that there is a relationship between the role that children have in determining their own learning experiences and the development of social skills" ([22], p. 5). They also argue that "when students are energized by their own work, their disposition to solve problems and to seek deeper understanding can be developed and strengthened" (p. 5; see also [51]). According to a study by Nakamura and Csikszentmihalyi [52], persistence is a key trait for creativity in the later stages of life.

- Art can facilitate emotional regulation and positive emotional development in children [53]. Moreover, it enables children to express emotions and fears visually, providing control and reflection on their triggers, and contributes to the reduction of stress since pursuing art boosts serotonin levels, fighting depression, and promoting well-being [35].

- On the whole, inquiry-based and art-based learning can contribute to resilience, therapeutic healing [54], and a "stronger performance regardless of race, gender, or prior achievement" ([40], p. 4).

6. Conditions that embed and enhance creativity and critical thinking in inquiry-based and art-based learning

6.1 Conditions that empower the role of the teacher

Whether in history or art, conducting an inquiry or implementing inquiry-based lessons requires a teacher with advanced skills. In order to promote student involvement in personal inquiry or artistic exploration, it is essential that teachers first become proficient in inquiry and remain up-to-date with the latest advancements in art education. It is critical for teachers to possess a thorough understanding of the inquiry process and maintain a solid grasp on current developments in the field of art education [19, 20, 55–58].

Moreover, for children's investigations to be successful, teachers' research on the area of interest is crucial. Thus, before or simultaneously with children's investigations, teachers should take the following necessary steps:

- Seek out various sources of information, techniques, and ideas in order to gain knowledge on a particular topic. This can involve reading books, conducting interviews, visiting museums, and verifying through cross-checking [23, 59]. Especially in art, teachers can seek to explore diverse forms and genres, media, and techniques before introducing them into their class [59, 60].

- Explore other perspectives and opposing information related to the topic at hand [23].

- Explore the underlying concept behind a topic (the big idea) or important questions, or the message behind an example of artwork and conduct thorough research [59, 61].

- If fieldwork is planned, visit the location and take note of various details such as exciting features, potential discoveries for children both independently and with adult guidance, the presence of people in the area, any safety hazards, areas where children can make observations and recordings, places for rest, and areas requiring adult supervision [22].

A crucial aspect of inquiry-based teaching is for teachers to relinquish control [23]. According to Kidman and Casinader [19], this means teachers must be willing to shed their title and authority and instead take on the roles of coach, mentor, facilitator, and critical friend. However, it's important for teachers to make this transition gradually. Students may not possess the necessary skills, maturity, or intellectual sophistication to take on full responsibility for their learning. Teachers can encourage students to lead the creative process and sometimes engage in playful interactions with them to create a more relaxed and enjoyable learning environment [46]. Therefore, teachers must teach students the necessary skills and gradually increase their independence and intellectual capacity over time [55].

Teachers can adopt several key roles during the transition process: "direct instruction provider," "organizer," "questioner," "discussion facilitator," "mentor," and "facilitator of interpretation" ([19], p. 44; see also [56, 61, 62]). It's important for teachers to switch between these roles depending on the needs of their students. For instance, with less experienced students, teachers should focus more on direct instruction, while with more independent and advanced students, they should take on a facilitator role. The balance between these roles may also vary depending on the topic being studied. For new and unfamiliar topics, students may require more guidance in the initial stages of exploration. Studies have shown that presenting challenges to children and empowering them to find solutions can enhance their creativity [59].

The teacher's feedback plays a critical role in this process, as it guides the learners in making decisions and taking independent actions [63]. Collaboration and inquiry-based processes are fostered in both inquiry-based and art-based learning, leading to the development of trust among students, which allows them to take risks and learn from their failures without fear, creating a positive classroom climate overall [31, 64]. Furthermore, students are encouraged to be open and honest about any outside issues that may affect their work [23, 46, 65].

Teachers play a crucial role in helping children interpret data and information without bias. As a "facilitator of interpretation," they can guide children to differentiate between theories, opinions, and evidence, while also encouraging them to generate and evaluate new interpretations and ideas. This support promotes children's independence as inquirers and problem-solvers, as well as their conceptual knowledge, metacognitive strategies, and creativity. To ensure effective teaching, assessment should also be used to inform responsive teaching, with modes of assessment tailored to the varying capabilities of young children [63].

Another important condition in inquiry-based and art-based learning is exploring the materials, instruments, and tools involved. Skilled teachers select materials that aid their students' learning and are appropriate for the key concepts being taught. The equipment provided should encourage experimentation and exploration, and risk-taking which are aspects of intellectual quality [20, 23, 31, 46].

6.2 Conditions that empower children's learning processes

Studies have revealed that children possess the ability to plan various things, such as deciding what they want to learn or where they wish to go. To facilitate planning with children, teachers can adopt the K-W-L pattern, which involves identifying what they already Know about a subject, what they Want to learn about it, and what they have Learned after investigating it [66].

Research (see, for example, [40]) has shown that children often struggle to express their knowledge or learning interests about a subject. This can be attributed to various factors:

- Children may be unfamiliar with asking inquiries. In learning processes, it is necessary to cultivate a culture of inquiry and inquiry-based discovery [63]. In this case, teachers must place children in the proper mindset and engage them in activities that cultivate their question-asking and discussion skills [62, 67]. If teachers switch to a different mode of instruction or interaction, children who are accustomed to sitting and listening silently do not comprehend what is expected of them [55]. Children must also be taught to observe and respond to one another in brief conversations on a topic. They must comprehend and acknowledge the significance of waiting their turn and maintaining composure during a discussion. Finally, children must develop an understanding of what a query is and how it facilitates learning and information gathering. In other words, teachers must ensure that they address the aforementioned concerns and devote sufficient time to familiarizing students with the inquiry and discussion processes [16, 20, 23, 56].

- Another factor that could prevent children from asking pertinent questions is a lack of information about the topic at hand. Children may know very little about certain subjects, while others may know only the bare minimum. If that's the case, children might have trouble articulating what they find engaging. Here is a case in point: The town square features a memorial. Many children have seen it and walked by, but they have not been able to process it any further. They have no other information, and they are unable to formulate any questions. In this situation, educators are tasked with sparking students' curiosity and pique. There are several ways to ignite curiosity, which can be used separately or in combination. These include going on a field trip to the place of interest, reading a book, story, or poem, or utilizing audio-visual resources such as TV shows, videos, websites, newspapers, magazines, and films. Teachers can also initiate classroom discussions, create incidental experiences, or establish ongoing projects that can lead to new areas of interest as experiencing a situation is necessary before questions develop [68, 69]. Additionally, arranging a learning environment that showcases related objects or creating interactive learning centers can pique children's curiosity and stimulate conversations about the materials and where they can take us [23, 66, 70].

Intellectual quality in children's learning is an indication of their empowered voice in both inquiry-based and art-based activities. This is demonstrated by certain features in children's work:

- Extensive knowledge and profound understanding of objects, images, phenomena, or events, which is elaborated with clarity and repleted in detail in their artwork or other types of work [23, 31, 46, 58, 71–73].

- Complex problem-solving skills, and advanced thinking abilities which allow children to combine semiotic elements, and form messages and ideas in new creations [23, 31, 46, 58, 71, 73].

- Use of technical terms and/or art language with mastery and understanding, for effective communication by students in their work (although with young children, teachers might downplay the vocabulary to the benefit of concrete exploration and learning of the major concepts) [20, 31, 46, 58, 71].

- Originality which brings unusual or unexpected results. Rather than copying or emulating someone else's work, students are encouraged to be innovative, explore new possibilities, and tap into their creativity to produce original and authentic pieces of work. In this effort, children are encouraged to use their own knowledge, thinking, expressive skills, and semiotic modes [23, 31, 42, 46, 72–74].

- Flexibility in thinking which allows children to move beyond the boundaries [31].

- Enjoying the process of inquiry and art and feeling positive about them is a crucial aspect of intellectual quality [23, 31, 46, 58, 71].

- Creating compositions that present "unity, balance and harmony" and the expression of emotions ([31], pp. 128–129).

Intellectual quality involves also understanding the technical and expressive aspects of art forms or other artifacts. This is achieved through analyzing carefully chosen works of art and artifacts [18, 46, 58].

Meaningful learning is closely the empowerment of children [75]. According to Gibson, Anderson, and Fleming [46], this is accomplished by tapping into prior knowledge and personal identities, as well as taking into account external contexts and diverse viewpoints beyond the classroom. With reference to young children, meaningful learning might as well occur when children are given the opportunity to satisfy their natural curiosity and when they are involved in the planning of learning activities [28, 76].

In addition, it is vital for students to collaborate with others to express their emotions, co-construct or share their knowledge and creations, consider diverse perspectives, offer constructive feedback, and critically evaluate both the learning processes and outcomes of inquiry-based and art-based learning. Classes are turned into a "community of learners" or a "community of practice." Encouraging students to express themselves beyond verbal critique and feedback is important. There are various means of communication available to them ([46], p. 117; see also [64, 72, 74]).

The conditions mentioned above are prevalent in both learning approaches (inquiries and art-based approaches) and the contemporary interpretation of studying local history. Additionally, a high-quality learning environment is crucial for facilitating these intricate processes.

7. Creating conducive learning environments for creative and critical thinking in inquiry-based and art-based learning

A quality learning environment in inquiry-based and art-based learning is characterized by deep focus, sustained engagement, and a loss of sense of time, similar to Csikszentmihalyi's concept of "flow" [46, 77].

The learning experience encompasses not only the curriculum but also the physical surroundings and the timeframe within which artistic expression takes place. The environment should be practical [46] and offer students the appropriate materials and technical guidance or demonstrations at key moments [31, 73]. In Reggio Emilia schools, space and environment are regarded as the "third teacher" [78], and it is critical to provide physical spaces that serve, showcase, and recognize the students' own work, enhancing their confidence and sense of ownership [23, 31, 46, 73].

According to Kidman and Casinader's proposal ([19], p. 39), there are two distinct types of learning environments: the classroom learning environment (CLE) and the field learning environment (FLE). It would be beneficial to explore the characteristics of these environments further.

7.1 Classroom Learning Environments (CLEs)

CLEs could feature resource displays and interactive learning centers. Teachers must select and evaluate these materials with great care. Books and audiovisual or multimedia content must be chosen based on their compatibility, with large pictures and photographs and appropriate content being two major considerations. Teachers can mediate if there are challenging terms used, either by explaining them to students or by including additional narration into a multimedia piece (such as a video, PowerPoint, or movie segment) created with modern technology [23].

Choosing appropriate resources can be challenging, particularly in the early years, when children may not have the skills to conduct independent research on primary and secondary sources [19]. In order to optimize the use of resources by young children, it's important for teachers or designers to carefully choose resources that align with the learning objectives and assist children in making appropriate selections [20]. This approach not only enhances the effectiveness of resources for young children but also benefits older children who may struggle with processing information. Additionally, it promotes the perception of information resources as a means to an end, rather than the end itself [79]. If teachers read books to children, they may want to avoid reading complex sentences and focus instead on reading the most important parts. Children that are at a reading level are free to peruse the content and read as much or as little as they can manage [80]. Fiction and nonfiction books for children of all ages are accepted, if available [16].

As previously stated, resources on alternative perspectives, nontraditional or sidelined genres, and conflicting information (as long as they do not infringe on human rights) should be included [16, 17]. This has the potential to promote democratic values and foster children's attitudes of tolerance and acceptance toward diversity, while also enhancing their ability to analyze and interpret multiple viewpoints (see, for example, a discussion by Jones [81]).

7.2 Field Learning Environments (FLEs)

The Field Learning Environment (FLE) [19], commonly known as Fieldwork, is highly valued by educators due to the significant role sensory learning plays in education. Field trips offer a complete sensory experience of the environment, making them an essential teaching tool. Classroom learning cannot offer the same level of firsthand and sensory experience as other forms of education. Children can explore and become acquainted with their surroundings through movement. This also helps them to orient themselves and navigate their way [66, 82]. Excursions also offer chances to practice map-reading, introducing children to decoding and understanding spatial diagrams and representations [15, 66, 83]. This could also be achieved with support from ICT [84].

Moreover, children have the opportunity to interact with a variety of workers or experts (art and history experts included) and observe how they each play a role in daily life [22, 23]. For example, they may encounter the bus driver, the shop owner, a housewife shopping, a museum guard, or individuals working at a ticket desk.

One of the primary benefits of fieldwork is that it allows children to utilize inquiry skills and tools, such as observing and recording information about their surroundings [16, 22]. In addition, it offers chances for children to engage in shared experiences and participate in group activities [66]. Visits can be accompanied by parents, providing ample opportunities for parental involvement [22, 23, 66]. And as previously mentioned, it has been argued that this approach stimulates fresh ideas and promotes learning by piquing children's curiosity and presenting new inquiries that require solutions [22, 66].

Seefeldt, Castle, and Falconer ([66], pp. 66–68) identified various types of fieldwork including "walking" trips around the school or neighborhood, "small-group trips," "specific purpose field trips" that focus on a particular issue, "virtual field trips" to distant places, and "WOW" trips that offer an element of surprise without being tied to any particular project or topic. Our focus is on "repeated fieldwork" trips, which can enhance in-depth investigations. The excitement of the first visit may cause children to miss details and opportunities for exploration. Experience shows that returning to the same place allows for a re-examination of the subject, uncovering new issues for observation and recording. This may prompt new questions and perspectives, leading to further visits that build on the findings of the initial trip

[22, 23, 66, 85]. From a social-emotional perspective, returning to a familiar location can provide children with a sense of mastery and security to take risks in new learning opportunities. Continuity in field trips can also enhance learning, connecting the intentions of repeated trips or complementing different trips. For example, a visit to a monument could be followed by a trip to a museum or library to gather additional information about the topic. Lastly, an initial visit to a place of interest can serve as a starting point for children's investigations, inspiring good questions and guiding their inquiry toward deeper levels of learning [23].

7.2.1 Preparing fieldwork

As previously stated, adequate preparation is crucial for a successful trip. Teachers should involve the children in the planning process, encouraging them to consider transportation options, map usage, and necessary equipment [16, 23].

Explicitly discussing and laying out standards of behavior and safety rules is also important. Seefeldt, Castle, and Falconer [66] suggest reviewing these standards with both children and adults attending the trip. When everyone is clear on what is expected of them, the trip becomes safer. It can be helpful to chart certain rules for quick and easy reference. As part of an emergency plan, parents and children need to be aware of what steps to take in case of an accident, such as identifying an emergency meeting point, understanding who is responsible for calling emergency services, and knowing who is certified to administer first aid.

According to the literature on inquiry-based learning, it is recommended that children have a background experience and some questions prepared before going on a trip to aid in their investigations. However, this may not always be possible or necessary, especially if the children lack prior knowledge on the topic. Teachers may choose to wait until visiting the place to encourage the children to ask questions and support them in expressing their curiosity about the situation, object, or phenomenon. Sometimes, direct experience is needed to truly observe and appreciate something, which can lead to a desire to learn more [23].

When visiting a new place, there is an important issue to consider: When it comes to children and travel, simply visiting a site and listening to a tour guide is not enough for an enriching experience. Teachers should avoid acting solely as guides and instead focus on creating opportunities for inquiry-based learning. While adult involvement is still important, it should be thoughtfully planned out [22, 23].

Here are some suggested activities for children to engage in during fieldwork:

- Observing, listening, or experimenting and then attempting to answer questions that were previously recorded in the classroom before heading out. Move around in an organized manner, and use their senses to smell, touch, hear, look, and feel everything around them. They can also discuss their thoughts and feelings with each other and with adults [22, 23].

- Completing assignments such as collecting leaves, stones, or bugs, recording details in journals, or checking off items on a list. Children can also take pictures themselves or use a audio recorder and camera to collect evidence that is going to be used in the classroom afterward to recall important information and discuss their findings [22].

- Organizing a treasure hunt where children can search for clues and answer questions that guide them through historical sites or museums. This encourages children to collect information in a playful way and allows them to work in groups or individually with appropriate adult supervision. Still, it is best for children to work in groups with minimal adult guidance.

The aforementioned conditions allow for the creation of CLEs and FLEs that aid and encourage the exploration of local history through creative and critical thinking processes.

8. Focusing on local history: the importance of space and time concepts

As children interact with their daily and local surroundings, they naturally begin to take notice of places, monuments, objects, and ceremonies. This familiarity allows their surroundings to gain meaning and significance [16]. Through hands-on exploration and observation of historical objects, children can actively develop their historical thinking and learn the so-called "procedural concepts of history" which are "cause and effect" "continuity and change," "similarity and difference" ([16], pp. 27, 43). They can also develop historical empathy, that is a greater understanding of how past individuals may have thought, felt, and acted differently due to knowledge, societal, economic, and political differences [16].

Children's innate curiosity about history aids in developing their personal identity in relation to others and time. Studying local history increases children's awareness of how society's members are interconnected and helps them embrace differences by recognizing that a community can consist of individuals with diverse cultural backgrounds [16, 22].

Exploring historical sites, monuments, and museums, or conducting research using primary and secondary resources can foster inquiry skills and be a focal point in history studies [18]. Such experiences help children appreciate the connection between the past and present, the importance of cultural heritage, and the necessity of preserving it. Additionally, they develop a love for the environment, which enhances their sense of responsibility and care.

Children, like adult historians, learn about the past by tracing the causes and effects of changes over time or continuity, understanding that there can be multiple accounts of the past and making deductions and guesses about remaining artifacts. Thus, working with time concepts is essential because if children become aware of the skills and concepts involved in learning about the past, they can become independent learners [16, 83]. To become increasingly aware of historical changes, children need to build and apply knowledge of cause and effect, motivation, and consequence; to become able to draw parallels and dissimilarities (what shared features existed between the 'before' and the 'now,' and what new features emerged, and why); to gradually determine how much time has passed (hours, days, weeks, months, and years); and learn to organize the order of events (from personal experience, recent memory, and future projections) [83].

Studying space concepts is also vital for understanding history. Children can better comprehend time and change by identifying and describing features of places, observing and recording patterns and processes related to space and the environment, reading spatial representations, and recording places and routes themselves using all senses [83]. Therefore, it is highly beneficial to work systematically on understanding concepts and language related to direction, measurement, positions, perspective, spatial patterns, feature names, and spatial representation skills such as maps, maquettes, floor plans, and birds-eye views [83, 86, 87].

9. A four-dimensional tool with practical suggestions for developing creative and critical thinking in learning local history

I would like to share a helpful tool for teachers who want to develop local history lessons using inquiry-based and art-based learning methods. The tool is comprised of four lists of practical strategies, covering important aspects such as learning

Practical strategies teachers may consider and apply	The reasoning behind the strategies
Instead of relying heavily on whole-group instruction or carpet time, teachers focus on group work. Group work involves 2–4 children at their desks or moving around the classroom.	This approach can help promote collaboration and active participation among students. It can nurture children's ability to engage in meaningful conversations, take the lead in various situations, and work collaboratively with others to overcome challenges.
It is best to use open-ended questions. For example, instead of asking, "Did you understand" it's preferable to ask, "What did you understand"?	This promotes children's verbal contributions and allows them to share their ideas, insights, and interpretations, including those related to history, using their own vocabulary.
It is important that teachers refrain from offering explanations to children. Instead, they could focus on understanding their thoughts, perceptions, and interpretations of their findings.	For adults, the goal is to avoid imposing their own interpretation on children. Instead, we encourage them to develop their own understanding of events, people, and objects.
Instead of simply answering children's questions, teachers suggest that they become co-researchers with the children to better understand and explore the topic together.	Teachers can be positive role models by promoting inquiry-based learning and openly expressing research-related emotions like curiosity, determination, and persistence, even in the face of failure. By demonstrating processes such as conducting library searches, seeking information from specialists, and closely examining relevant artifacts, teachers can help students learn important skills. It's also important to teach students that it is acceptable not to know everything and that knowledge gaps can provide valuable opportunities for learning.
To avoid the effect of continuous questioning the children, teachers should consider increasing group discussions. This can be achieved when a central question is provided, and students are encouraged to discuss it among themselves (in small groups) before presenting their answers and share their conclusions with the rest of the class. This offers the class the opportunity to expand upon the conversation.	It's important to foster questioning and answering skills among students. To achieve this, teachers should relinquish some control during discussions and allow students greater freedom and initiative. By implementing this method, teachers can facilitate a more engaging and interactive learning experience for their students.
Teachers could prompt young students to articulate their reasoning, requesting that they clarify the basis for their assertions and the evidence that supports their conclusions. This may involve explaining the reasoning behind their perspectives or outlining the thought process that led them to a particular viewpoint.	As part of their history education, children must learn to formulate and express explanations and interpretations, particularly in a historical context. They need to learn to utilize their research to back up their arguments and viewpoints. Additionally, they are trained to identify and articulate cause-and-effect relationships that are observable in events or phenomena.

Practical strategies teachers may consider and apply	The reasoning behind the strategies
Teachers aim to provide their students with diverse resources on a given topic, rather than relying on a singular resource such as a book, picture, or computer. In situations where a unique resource is available, rotating groups can take turns utilizing it. It is important to avoid limiting children's interaction with a unique resource through teacher-directed teaching and provide opportunities for students to explore resources in a more open manner.	Children should have ample time to interact with various objects such as books, computers, and other resources to enhance their personal perceptions and gather information from the environment using their senses. This helps them develop their independence and self-confidence in handling situations like turn-taking and waiting patiently. The aim is to reduce teacher control and provide more freedom to children in using available resources.
Teachers motivate children to document their discoveries as much as possible. Whenever something piques their interest, they urge them to find a method to "preserve" what they observed. If they need to recall research findings, a captivating story, or something that left a deep impression on them, they must figure out a way to document the specific details they wish to remember. This can be achieved through manual means, such as writing or drawing, or via electronic devices like an audio recorder, a camera and more.	Children will learn that taking notes and making recordings is essential to the research process. By doing so, they can store information for future reference and easily compare it with other pieces of data. It is also important to understand that recordings showcase not only their knowledge but also their personal perspectives.
Children are encouraged to learn how to make recordings using different methods such as drawing, note-taking, sound recording, and video recording. It is important for children to review their recordings and compare them later to enhance their learning experience. Additionally, older children can create engaging multimedia presentations such as PowerPoints, animated films, or movies that combine visual, sound, and kinetic elements.	The aim is to encourage children to explore and utilize various semiotic modes and modes of communication and technology to express their knowledge, ideas, thoughts, findings, analyses, conclusions, and messages.

Table 1.
Dimension 1—Practical strategies for learning interactions.

Practical strategies for fundamental work on concepts of time	The reasoning behind the strategies
As an educational tool, teachers can introduce lessons centered around time concepts like yesterday, today, tomorrow, before, after, and now. For older students, exploring concepts like prior to, simultaneously, in the past, period, century, millennium, and between events can deepen their understanding of time and history.	The goal is to enhance children's grasp of time and improve accuracy in using the relevant vocabulary.
Children are encouraged to organize their thoughts and memories by creating timelines. Younger children can start this process by keeping daily diaries and constructing a routine timeline each day. Gradually, they can create monthly and yearly timelines to record important events and moments of the school year. At a later stage, children can also make timelines for significant events they learn about in their history lessons. It's essential to incorporate digital resources such as word processors, online tools, and visual graphics programs, in addition to traditional paper and pencil methods.	It's important for children to comprehend the reasoning behind using a number line or following a storyline. They should also be taught how to interpret and decipher the information presented on a timeline.

Practical strategies for fundamental work on concepts of time	The reasoning behind the strategies
Children can create a timeline that outlines important events and pivotal moments in their personal narratives.	By examining the events that have occurred throughout their lives, children can better understand the developmental process. Creating personal timelines can help students find significance in this process and increase their motivation. Additionally, children can learn that certain things or circumstances may change over time, while others remain consistent.
Teachers prompt students to share their news with a small group of 2–4 peers, followed by the option to share with the entire class.	One can enhance children's storytelling abilities and practice the utilization of past tenses to describe events that commenced and concluded in the past, or those that began in the past and are still ongoing in the present.
The teachers intend to teach their students about time sequence, change, continuity, cause, and consequence by encouraging them to create short stories in small groups. This exercise is also suitable for older students who can analyze the structure of a narrative, a report of connected events, or a longer story, whether it is fiction or non-fiction. Following this, they can examine other events, whether they are contemporary or historical, and apply the same analytical approach.	The aim is to comprehend the concepts that are crucial for understanding and learning about historical events or sequences of events, such as the progression of an experiment.
Teachers aim to improve children's observational skills through systematic observations that involve recognizing changes in life, nature, school history, and society. Children are encouraged to record their observations and changes using various tools, materials, and methods.	One way to enhance children's observational skills is by encouraging them to pay attention to changes and specific events.
In a classroom setting, teachers can present various versions and adaptations of a story, such as the classic tale of the big bad wolf. They encourage students to analyze and compare these versions to develop diverse interpretations.	It is important for children to learn that events can be viewed and interpreted from various perspectives.
Practical strategies for fundamental work on spatial concepts	**The reasoning behind the strategies**
Teachers devise activities that aid children in comprehending and utilizing spatial concepts, such as forward, backward, in front of, behind, left, right, next to, near, far, and so on.	It is important for children to gain a confident and accurate understanding of concepts such as space, direction, and movement.
Teachers create engaging activities to help children comprehend the concepts of size, scale, and perspective.	It is important for children to develop skills in reading, drawing, and using maps.
Teachers organize activities that focus on spatial representation, such as constructing maquettes, and creating maps of the classroom and the neighborhood, among others.	It is important for children to develop their skills in spatial representation.

Table 2.
Dimension 2—Concept work to understand historical times.

interactions, understanding historical times, art-based learning, and specific strategies for local history (see **Tables 1**–**4**). Each strategy is backed by reasoning to justify its effectiveness. In general, this tool ensures that the conditions discussed earlier are met, and it allows teachers to establish a setting that promotes creative, critical, and analytical thinking while exploring local history.

Practical strategies teachers may consider and apply	The reasoning behind the strategies
After completing a phase of inquiry, we encourage the children to showcase their knowledge and understanding through artistic expression. They can work individually or in groups and are encouraged to use various materials, including recycled items like plastic water bottles, newspapers, and cartons, as well as wire and plaster.	The main objective is to teach children how to communicate effectively using various forms of expression and semiotics. It is essential to provide children with a wide selection of materials in order to unleash their expression ways.
Children are encouraged to develop a message related to the "big idea" and use art to convey it in a way that reflects what they have learned and how it connects to real life.	Multiple semiotic modes enable the conveying of ideas that may be difficult to articulate through words, as well as linking acquired knowledge with personal experiences, thoughts, and perspectives.
To inspire the children, we showcase representative artworks that demonstrate different techniques for handling materials, combining materials and elements, discussing the artwork's size, scale, and perspective, and the message conveyed through the artwork.	It is anticipated that increasing the children's exposure to a variety of mediums, processes, and styles of artwork will boost their expressive capacity.
Exploring works of art in their natural surroundings is recommended for optimal results. Whether it's the original or a copy, the experience can be enriching. Alternatively, virtual tours offer exciting opportunities to visit places with works of art. If there are copies of artifacts in the classroom, it's best to have multiple copies or organize group rotations to ensure every child has a chance to appreciate them up close. Ultimately, combining these methods can create a comprehensive learning experience.	It's imperative for children to spend ample time observing works of art and artifacts from various distances and angles to fully grasp their significance.
The analysis of a piece of artwork includes three levels:	
Practical strategies on the descriptive level	**The reasoning behind the strategies**
The artwork on display features various elements such as people, animals, and plants which children are encouraged to describe. Its purpose is to enhance children's observational skills and ability to derive information from artifacts by studying these elements. This includes the behavior and attitude of the subjects depicted, as well as their clothing and facial features. Indicative questions that can be asked about the artwork include its medium (such as sculpture, painting, engraving, or woven/ceramic), and what it represents.	One way to enhance children's skills in observation and information gathering is by encouraging them to study artifacts and derive insights from them.
Example questions to consider: Could you please specify the type of artwork you are referring to? Is it a sculpture, painting, engraving, woven piece, or ceramic? Also, what is the intended meaning or representation of the artwork? Could you kindly give me a detailed description of the artwork, including any movements or multimedia used?	
Practical strategies on the interpretive level	**The reasoning behind the strategies**
Considerations include the mental state and emotions of those involved, the impact of the artwork on children, and the relationships between the elements within the piece. Additionally, one can generate questions or hypotheses to explore the immediate past and develop historical interpretations.	One can use the process of formulating questions or hypotheses to find answers about events that have occurred in the recent past. Additionally, it is important to be able to develop and express historical interpretations.

Practical strategies teachers may consider and apply	The reasoning behind the strategies
Example questions to consider: What emotions does this artwork evoke in you? Can you describe your feelings about it? What words come to mind? What do you think causes these emotions? Do you think you can guess what the artist was feeling when creating this piece? Would you say this artwork is quiet or noisy, happy, or sad, calming or disturbing? Can you create a story based on it? Can you provide different interpretations of the elements in the artwork?	
Practical strategies on the technical level	**The reasoning behind the strategies**
Children focus on the colors, the materials, the techniques, and other forms of expression used.	Encourage children to explore and engage with various semiotic modes and forms of communication.
Example questions to consider: Can you speculate about the techniques employed by the artist in creating this artwork/artifact? Additionally, what materials and tools were utilized? Are there any notable colors or any one color that stands out in particular? Does the artist incorporate any shapes or symbols, and if so, what types?	

Table 3.
Dimension 3—Art-based learning.

Practical strategies teachers may consider and apply	The reasoning behind the strategies
Children acquire the skills to analyze and gather information from relevant local sources, irrespective of their significance. Furthermore, children are provided with access to a diverse selection of historical sources. Teachers aim to help children identify the connection between events and aspects of national or general history and their reflections on local history.	It's important for children to recognize that we can gain knowledge about the national or general history through various local sources such as oral stories, pictures, artifacts, literature, artwork, museums, stamps, games, and digital media. They should also realize that the significance of these sources may have differed in other historical periods.
Practical strategies teachers may consider and apply when introducing children to artifacts and furnishings	**The reasoning behind the strategies**
Children carefully observe and then document their discoveries about the artifact or furnishing (hereafter object) through various methods.	Teachers can enhance children's understanding by utilizing various semiotic techniques and technologies to acquire knowledge, generate ideas, communicate messages, conduct research, draw conclusions, and more.
Children develop hypotheses about the construction, time period, and purpose of the object. To ensure accuracy, they scour various information sources to cross-check their findings.	The objective is to formulate questions and hypotheses about events, behaviors, and usage and attempt to answer them. Children are encouraged to discover connections among events, individuals, and objects. This will aid in cultivating a chronological understanding, particularly for younger children.

Practical strategies teachers may consider and apply	The reasoning behind the strategies
Example questions to guide observation and observation recordings: Can you help me identify this object? What are your thoughts on what it could be? How would you describe its appearance and functionality? Do we have any information on its age and origin, and if not, where could we research it? Additionally, what other relevant details should we gather? Who used or wore it, in what context, and from what materials was it made? Is it still in existence, and if not, what could be the reason behind its disappearance? If it still exists, has it undergone any changes over time, and for what reasons?	It is important for children to recognize that people, especially children, lived differently and engaged in different activities in the past. They should also understand that while some things and situations change over time, others remain the same. Additionally, children should be encouraged to consider and understand the cause-and-effect relationship between events and their consequences.
Practical strategies teachers may consider and apply when introducing children to monuments, historical buildings, and other large constructions	**The reasoning behind the strategies**
Example questions to consider – Descriptive questions: Can you identify the building materials used for the walls, such as bricks, stones, wood, or cement? Please describe the various shapes present in the structure and indicate their number. Are there any doors and windows? What is the roof like? Does it have any specific shape, such as hollow or flat, quadruple, or with pediments? Could you provide an interpretation of the patterns and symbols?	The goal for children is to understand that people, especially children, lived differently and had different lifestyles in the past. They should also comprehend that some things or situations change over time, while others remain the same. Additionally, children should be encouraged to think critically, develop and articulate historical interpretations.
Questions to develop hypotheses: Why did they build it like this? What was it used for? Can you guess who lived in it and why?	Children must formulate hypotheses about the immediate past and try to answer them. They attempt to develop and articulate historical interpretations.
Concluding questions: Can you determine if it's an old or new item? What characteristics suggest that it is "old"? When you describe something as "old," what do you mean? Any idea about the time period it was constructed and the builder's identity?	One way to enhance children's skills and ability to observe and gather information from artifacts is by providing opportunities for practice and refinement. Thinking critically over cause-and-effect relationships or conclusions is also important.
Classification questions: Does it resemble the buildings, fountains, or doors of today? What do you think?	One of the goals is to teach children about the differences in how people, especially children, lived and acted in the past. Additionally, it is important to help them comprehend that while some things and circumstances change over time, others may remain constant.
Practical strategies teachers may consider and apply when visiting museums	**The reasoning behind the strategies**
When organizing museum visits and programs, it is important to handle each stage with care, including preparation, fieldwork, reflection, feedback, presentation of results, and final product.	Museum visits pertain to fieldwork. The circumstances necessary for successful fieldwork are those that have been addressed previously.
To ensure a successful visit, it is recommended to focus on a specific area or artifact rather than attempting a comprehensive tour of the entire museum.	The sheer volume of information and artifacts housed in museums can make for daunting environments. Children can better sustain their attention and depict info pertinent to their inquiry when the subject of the visit is narrowed down.

Practical strategies teachers may consider and apply	The reasoning behind the strategies
It may be beneficial to visit the museum multiple times to fully explore and understand its offerings.	Children's inquiries can benefit from revisits because they allow for reprocessing as well as the addition of details and depth.
General questions that enhance the understanding of History	
Has anything changed since then? (What we spent our time learning about).	Question that helps children comprehend the concept of *change*.
How does it function in the modern world? Do we still make use of it, or is it more of an artifact from the past that we consult for information? In what ways does it still impact us today?	These questions help children grasp the concept of *continuity*, which is a crucial concept for understanding history.
What does this have to do with the era that we are currently studying?	A question that assists children in comprehending and drawing *connections* with the historical period or periods that are the subject of the discussion.

Table 4.
Dimension 4—Approaching local history.

When approaching local history several sources can be utilized: artifacts and furnishings; monuments; buildings, entrances, and fountains; artworks; museums; places of worship such as monasteries, churches, mosques, and temples; photographs, books, albums, and sound recordings; letters and stamps. Different sources call for unique approaches and provide distinct opportunities. In **Table 4**, we focus on strategies for work with artifacts and furnishings, monuments, buildings, and other large constructions, and museums.

10. Conclusions

Learning about local history can help children develop a historical perspective and better understand the connections between different groups, cultures, and civilizations. This can also help children become more self-aware and learn about the challenges of their time. Inquiry-based and art-based learning methods can create a learning environment where children act as investigators, gathering and analyzing information from primary and secondary sources, and expressing their conclusions creatively. I hope that the learning principles, practical strategies, and conditions outlined above, will give teachers the confidence to develop their own creative approaches to teaching local history in pre-primary and primary students.

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Chapter 2

Coding and Creativity: Reflections and Design Proposals

Simona Ferrari and Federica Pelizzari

Abstract

The aim of the chapter is to reflect on and guide the design of coding from the perspective of creativity and the development of critical thinking. The assumption is that coding is seen from a functionalist perspective: it is used to know and practice languages that allow and force a culture of market-driven schooling. Starting from presenting and discussing four different paradigms for viewing code, we will show why emancipatory and interpretive paradigms could introduce coding to develop creativity and give students the capacity to be true democratic citizens of the world. We will describe design elements of these two paradigms and the connections with a media educative point of view. Therefore, this chapter examines coding from an emancipatory perspective and uses critical thinking to reduce the risk of being controlled by the informational society.

Keywords: coding, creativity, paradigms, media education, critical thinking

1. Introduction

The term coding, although now widely and variously mind used, "suffers" from a certain underlying ambiguity that conditions a consistent and homogeneous application in different educational contexts.

This ambiguity derives primarily from the fact that the literal translation of the term is that of "making code", the sense of which is not unambiguous and can be understood as "assigning a code", "translating into a code," and "writing code" with the purpose of providing a machine or other entity with the instructions necessary to make them operate according to our intentions.

Some confusion of perspectives also results from this in the definition of the concept of "computational thinking" [1–3] which has always been connected to the concept of coding.

Definitions include that of Wing [4], who considers computational thinking to be the ability to solve problems, including those related to understanding human behavior, using systems and approaches specific to the computer sciences, such as abstraction, debugging, and remixing.

Aho [5] takes up this perspective in part and considers computational thinking as the set of thought processes involved in formulating and solving problems through solutions that can be represented as computational steps and algorithms.

The equivocal of the coding concept strongly conditions its development and the possibility of grasping its real opportunities to "teach thinking," proliferating visions of its application: the possibility of supporting the development of logical thinking, the development of specific problem-solving skills [6], and the opportunity to further engage students in the study of science subjects and computer science.

Against this background, this chapter investigates the relationship that coding can have with creativity and how both can be developed within instructional designs in preschool and elementary school.

2. Conceptual framework of creativity

Creativity starts from the idea of contrasting divergent and convergent thinking.

According to Guilford [7], convergent thinking operates within established patterns, approaches the problem with a certain method and, through the latter, and finds the only possible solution. However, using divergent thinking outside the established patterns allows one to approach the problem with a fresh perspective, arriving at original solutions and identifying the creative process with the typical dynamics of problem-solving. Thus, divergent thinking is expressed in not only the search for exact solutions but also in the multiplicity and originality of the answers given, the richness of ideas, and the restructuring of the subject matter.

Various models have been developed to explain the mechanism that regulates or from which creativity originates, including the factorials (cognitivist-oriented) models, which consider creative thinking to be an articulated unit that can be broken down into parts called factors and identified through surveys and statistical analysis [8–10].

Sternberg and Lubart [11] carried out a comprehensive survey of the landscape of creativity studies and observed that historically, this line of research has faced several obstacles, probably due to a broad cultural legacy that regarded creativity as something "mystical" and unexplainable.

According to these studies, creativity consists of the "ability to produce something new (original, unexpected) and appropriate (useful, adaptable to the set task)," thus elaborating the investment theory of creativity [12].

Finally, Resnick [13], analyzing the ways in which children learn, seeks to identify and enhance the creative dimension as the key to meeting and overcoming the challenge facing today's children to become tomorrow's adults.

As Resnick argues in the TED Talk "Let's teach kids to code" (https://www.ted.com/talks/mitch_resnick_let_s_teach_kids_to_code), when children create a coding project, they also learn to program; however, more importantly, they also program to learn. Because by learning to program, they learn a thousand other things, thus opening up new learning opportunities.

From these considerations, Resnick opens up to the view of the learning process represented as a "spiral of creative learning" (**Figure 1**): exploration of the world (and consequent knowledge) occurs through manipulating objects and experimenting, building things and testing their functionality, reasoning by prototypes and identifying errors...all ways in which children learn and through which they develop knowledge of the fundamental laws of the environment in which they live.

This should be the training ground for exercising creative thinking throughout life, during which each individual must continue to learn to exist in the world. Imagining, creating, experimenting, sharing, and reflecting should be the stages of

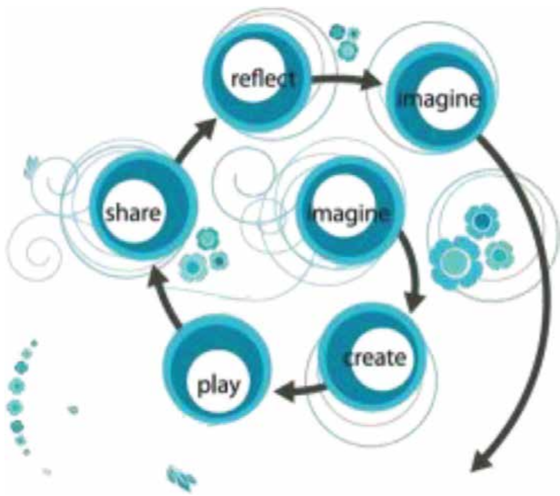

Figure 1.
Resnick's spiral of creativity. Source: https://www.flickr.com/photos/wfryer/37920982305. Author: Wesley Fryer. License: CC-BY 2.0.

a process to be reproduced continuously, the cyclical repetition of a sequence (to use an appropriate metaphor, in terms of programming) to be applied and cultivated throughout life, as the inexhaustible engine of one's learning process.

Resnick [14] goes further to think about how design that works with coding and creativity can work. This led to the 4P model, which consists of designing teaching around four key words: Project, Peer, Passion, and Play. The four P indicate:

- Projects: people learn best when they are actively working on meaningful projects, generating new ideas, designing prototypes, and iteratively improving them;
- Peers: when learning becomes a social activity, people can exchange ideas, collaborate on projects, and grow together;
- Passion: when people work on projects they care about, they work longer, harder, overcome challenges, and learn more along the way;
- Play: learning involves fun experimentation. Try new things, tinker with materials, test your limits, take risks, and do it repeatedly.

From this perspective, coding should be introduced in school as a cross-curricular activity precisely because cross-curricular is the skill it enables. Computational thinking does not require technology, and it precedes technology.

The adoption of coding as an activity to exemplify concepts, describe procedures, solve problems, and find solutions can be entrusted to teachers of any discipline; in fact, this activity does not require specific computer skills, as it provides an interdisciplinary perspective, combining creativity and imagination with logic and mathematics.

Learning to be effective must be meaningful [15], which means it must motivate and engage pupils actively, bringing both logical and creative competence to bear.

3. Paradigms of coding

Creativity and coding do not always stand together. It depends how teachers perceive them. To reflect on coding from the perspective of creativity's conceptual framework presented, it is necessary to introduce four possible paradigms of coding [16]: postmodernist, functionalist, interpretivist, and emancipatory.

The first understands coding as a creative activity oriented to the think-make-improve process; it finds its natural application in informal settings, within spaces such as FabLabs or communities such as CoderDojo. In addition to being oriented by what the media returns on the topic, it focuses attention on coding as a tool that—in line with digital media—calls for the revision of teaching practices, the return of the laboratory, the flipped lesson, and interrelationships between informal and formal learning.

In contrast, the functionalist paradigm approaches coding as a language useful for better understanding school subjects, on which programming activities can be grafted. Strongly recalling an idea of school as a space of instruction for profit [17], it approaches coding from a disciplinary perspective [18–20].

The third, interpretive, uses coding to develop critical analysis; coding is a device to develop critical thinking. The actions of disassembling to understand and reassembling to create [21] are the basis of the creative approach based on problems and solutions [22] that well activates the use-modify-create transition [23].

Finally, the emancipatory paradigm resorts to coding to overcome the dictatorship of the script [24]. In a political-social context, it starts from self-awareness and empowerment and goes beyond the digital into the outside world, trying to unhinge its logic.

In order to better understand the implications of these four paradigms for constructing implementation paths, it is possible to think of an organization that works on a dual axis.

On the one hand, the first axis is what we might call functional enrollment: from this perspective, coding can play a facilitating function with respect to the adaptation of subjects to a society like ours marked by the cultural and productive prominence of information technology, or a critical function of soliciting suspicion with respect to the risk of homogenization and the renunciation of thought.

On the other hand, the second axis is what we might refer to as the axis of educational enrollment: from this perspective, coding can be thought of both as a pedagogical logic through which to build the citizen of tomorrow and as a social logic aimed at releasing energies and activating resources. In the former case, we move within formal contexts (such as school), while in the latter, we occupy nonformal contexts. In the first case, coding is an education; in the second, it is a form of expression, a way of being, even an experience of media-activism.

Constructing the two axes in the form of a Cartesian plane, four quadrants are identified to examine as many ways of thinking about coding (**Figure 2**).

The hypothesis emerging from discussing with teachers and working in the classroom is that the adaptation perspective prevails in the teachers' representations. Either coding is an activity that serves primarily to prepare future professionals in school by getting them accustomed to interacting with the languages of computer science (functionalist paradigm), or to unleash the creative possibilities of children who are finally allowed to express themselves in their most natural ways (postmodernist paradigm).

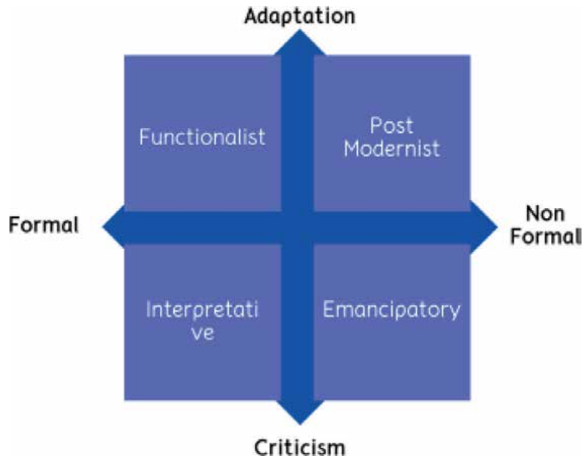

Figure 2.
Matrix of the four paradigms with respect to coding education.

Education's interest is on the lower end of the quadrant. The protagonist here is critical thinking, the call for deconstructive reflection, the systematic teaching of suspicion as a means of gaining meaning at a deeper level. From this perspective, coding ceases to be thought of as a gymnasium of future computing and is seen in its more specific pedagogical valence, namely that of being a media education activity, moving beyond the dictatorship of the script. This expression refers to the inherent ambiguity of the 2.0 logic; in fact, while merely filling in the format presents itself as a winning aspect of these applications, by virtue of the ease and navigability this entails, it also results in standardization. The script encourages the dissemination and polarity of computer applications but robs the user of the ability to modify formats. Owning the code, in this perspective, means knowing what is "behind the script" and being able to modify it if one wants to.

Therefore, the problem is not the new technology itself but how it is used; one can opt for games and activities that make one passive in this interaction or one can devise tools and programs that open up a thousand possibilities and engage children in the process of creative learning and playing.

To understand how teachers see coding, it is important to collect their representations of it.

Representations are cognitive systems, processes adopted by subjects to control the natural fear of the unknown, "to understand and act upon society, serve them as a reference frame for their thoughts and decisions, and color their imagination" ([25], p. 952). Moscovici had studied anchoring and objectification as systems that allow making familiar what is unfamiliar or novel. In particular, Moscovici had emphasized the role of social representations as a guide of behavior.

To investigate what is the most popular representation of coding, we recalled a set of 12 images (three images for each model) (**Figure 3**) employed in a previous study designed by Center for Research in Media, Innovation and Technology Education (CREMIT) and completed by 989 subjects [26].

The images metaphorically represent the various characteristics of the four models: the functionalist model and the postmodernist model are visualized through think-make-improve activity and more logical-mathematical research, while the

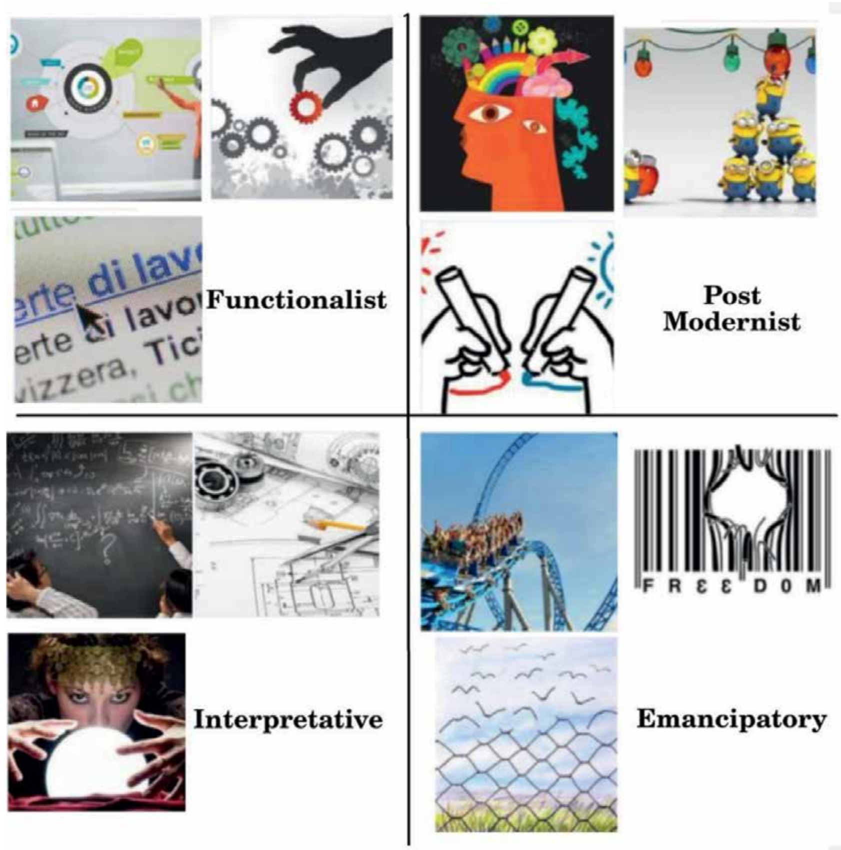

Figure 3.
Four coding paradigms and images.

interpretive model is visualized as critical analysis and the emancipatory model as overcoming the script.

Images provide an alternative to word-based surveys and are growing interest in social research methods [27]. The two surveys in this study involved 24 kindergarten educators and 23 primary school teachers in 2021 and 2022.

Educators and teachers were asked to choose the image that, in their opinion, represented the vision of coding and how it works in education. They were not told either that these images depicted approaches to coding on a symbolic level or what paradigm each image was associated with. In **Figures 4** and **5**, you can see the results. It is evident that postmodernist representation is the most common one.

Merging the data from the individual images, it can be seen that in kindergarten educators' representations of coding, the postmodernist model emerges overwhelmingly (76%), followed by the functionalist (18%) and the emancipatory models (6%).

Furthermore, in primary school teachers, the representations are even dichotomous: 74% of them represent themselves in the postmodernist model and 26% in the functionalist model (**Figures 6** and **7**). These data bring with them a reflection: it is precisely educators and teachers who need to change their perspective, leading students to be able to develop divergent thinking and meaningful learning.

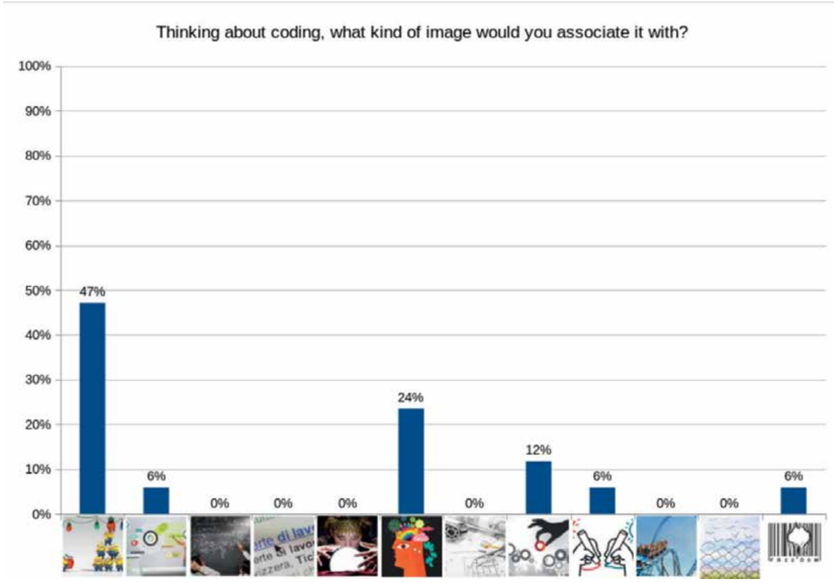

Figure 4.
Images of coding for preschool educators.

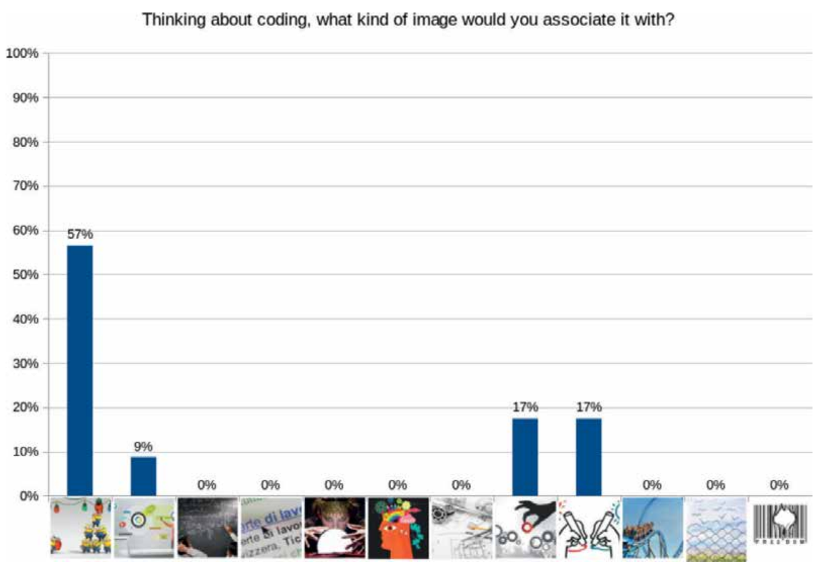

Figure 5.
Images of coding for primary teachers.

Theoretical framework on creativity and on coding with these initial data was discussed with educators and teachers to reflect about teaching and learning. This phase has been the starting point to change the design of coding, moving it from a framework related to the simple application of code to one open to creativity and to monitor and to evaluate the outcomes of learning.

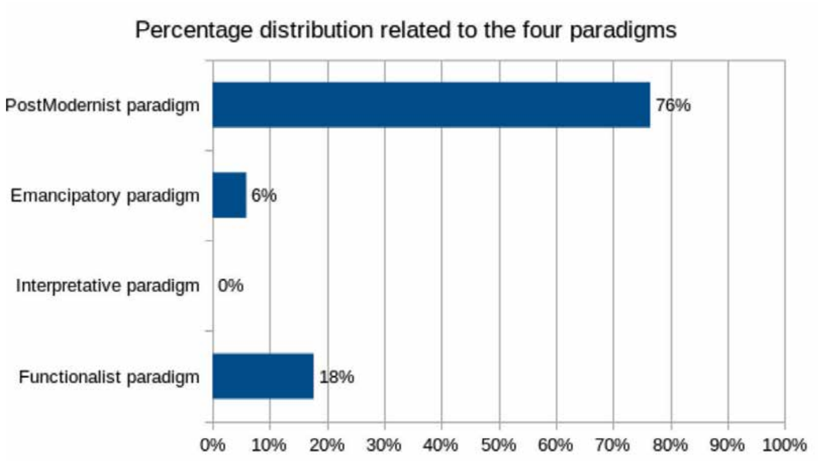

Figure 6.
Distribution of paradigms for preschool educators.

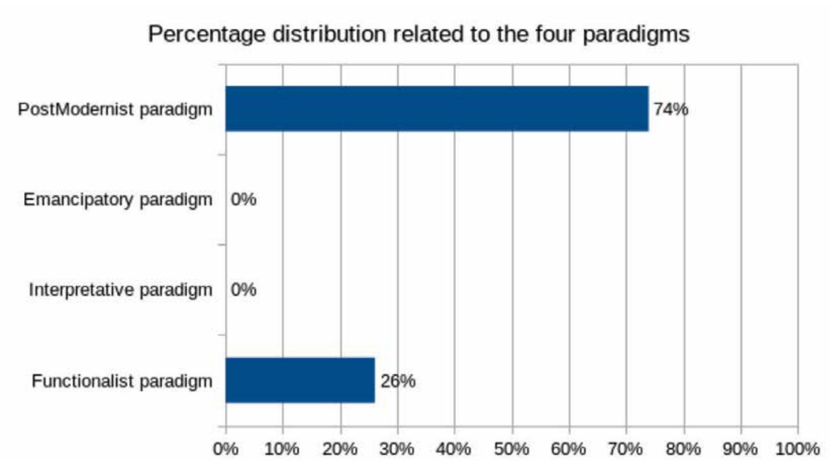

Figure 7.
Distribution of paradigms for primary teachers.

4. Good design practice

If coding can admit such a broad framework of application possibilities in education, it is possible to reason about it in terms of skills and problem-solving strategies [28]. Specifically, in response to the emerging need to shift the design of coding from an alphabetical-informational paradigm to a creative paradigm, we have moved on three sliders:

- of competence;
- of problem-solving;
- of Media Education.

Let us start with the first one. As research focus, coding is mainly developed within specific hours, referred to as code hours [29, 30], and how it is used to explore STEM disciplines or logical-mathematical skills with computational thinking [31, 32]. However, this does not show how coding allows one to go beyond skills and get to developing competencies.

According to Le Boterf [33], competence is not reducible to a set of atomic and separate performances, but rather tends to be thought of as an integration of the resources possessed by the individual, involving the activation of knowledge, skills, and personal dispositions relating to both the cognitive and the socio-emotional and volitional planes. Its expression requires bringing into play and mobilizing the wholeness of the person in its multiple dimensions [34]. It also requires going beyond behaviors observable and to pay attention to the internal dispositions of the subject.

According to this understanding, the construct of competence turns out to be inclusive of the different dimensions involved in the learning process [35], which can be traced to the following three planes:

- knowledge, understood as representations of the world that the subject constructs for himself through the prompts that come to him from the external environment and codified knowledge;

- skills, understood as operational schemes that enable the subject to act in physical and mental form on material or symbolic objects;

- dispositions to act, understood as the subject's attitudes to relate to the context in which he or she operates.

In this perspective, competences reside in the mobilization of the individual's resources (knowledge, skills, attitudes …), not in the resources themselves. Thus, they take the form of knowing how to act (or react) in a given situation or context to achieve a performance.

Moreover, developing situated competence means working not only on the subject's resources but also on the conditions that lead him or her to effectively mobilize his or her resources (knowledge, skills and personal, and social and/or methodological abilities) in relation to a situation-problem, with the aim of proposing effective responses that express their full responsibility and autonomy [36]. To "act competently," a person must be able to "read" the situation-problem [37] according to "competent" patterns, leading him or her to interpret it, assign meaning to it and, consequently, make relevant decisions. Based on such decisions, the person will take effective actions in response to the situation itself, choosing from a set of strategies available to him or her [38]. Finally, the person will have to evaluate in progress the quality of his or her interpretations and actions, revising and changing them should they prove inadequate in the course of events.

Coming back to coding, it develops skills of a significant and transversal type, leading to a model of "competent action" that continues to review, deepen, and bring into play the learning system of the individual student and the class group.

From this perspective, in line with Le Boterf [39], we can place the coding actions designed by educators and teachers on the slider of competence (**Figure 8**).

The competence's slider makes it visible and questions the design of student's requests: complex situations require multidimensional understanding of needs; mobilize resources (knowledge, skills, and attitudes) at individual level or social one;

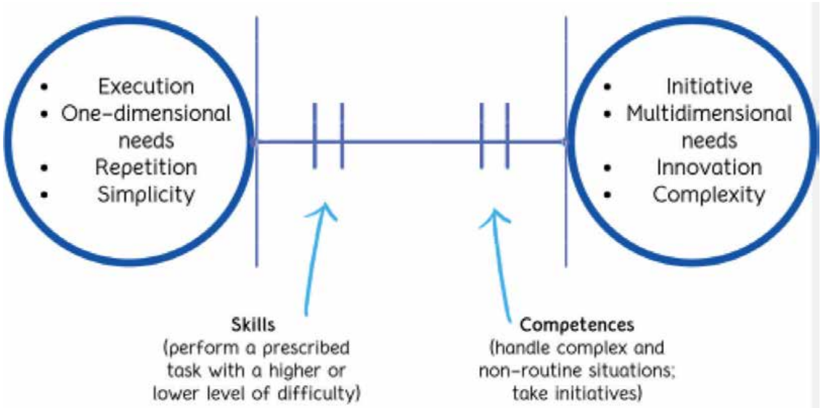

Figure 8.
Le Boterf's slider of competence.

broad visions in terms of resolving possibilities; request to take initiatives and are open to innovations; and set up a setting that allows the possibility to act safely, to take responsibility and risks without fear of negative feedback or failure. Complex situations involve students in:

- acting:
- wanting to act on an internal and external personal motivation [40];
- being able to act.

From this perspective, we can insert ourselves with a reflection on the type of task and situation-problem that it is necessary to propose within the teaching of coding. The goal of the activities must be to give meta-reflective momentum to the students [41], allowing them to re-evaluate the error as a way to learn and return to their own steps by analyzing how to adjust, improve, and change their practice.

Second slider is related to the problem-solving process and student's involvement. The scientific literature reports that problem-solving in coding is essential, and it is the first skill developed and observed [42–45].

On this basis, it is essential to propose activities that move from Veridical Decision-Making (VDM) to Adaptive Decision-Making (ADM) [46], two strategies studied within the neuroscientific understanding about how our brain makes decisions.

VDM occurs when the problem situation provides only one correct solution, and the task is to find it. Conversely, ADM occurs when the problem situation provides more than one possibility for effective solution and the task consists of finding the most functional one.

If you try to combine the slider of competence with these two decision-making strategies, you can notice how VDM is typical of the development of skills, while ADM can be inserted within the competences.

Moreover, you can then think about the design of teaching with coding from the perspective of ADM and competences, going to work on resources, setting and motivation just proposing situations-wide problem, with different possible solutions and with a collaborative and comparative expendability that allows students to be meta-reflective among themselves, thus enhancing the continuous communication-relational exchange.

If these two factors of competence and strategy work on the problem, it is possible to graft the four coding paradigms explored earlier.

Considering the representations of educators and teachers, it is possible to place the functionalist and postmodernist paradigms within the development of skills and work on VDM. This is because programming language decision-making and the think-make-improve system leads students to focus on a linear problem situation with a single solution that can be taken apart and reassembled and that has right or wrong feedback within it, without the need for meta-reflection work. In these two paradigms, the work is possible to do individually and without continuous comparison with peers.

In contrast, the interpretive and emancipatory paradigms lead students to work from the perspective of competences and AMD logic. The reason for this is precisely implicit in action design: working on critical analysis and overcoming the script require having complex problem situations, which require broad solutions and may be different depending on the type of resolution perspective. Moreover, applied decision-making must adapt to the context and be flexible with respect to possible changes and relaunches given by peers, with whom it is necessary to work to arrive at functional resolutions.

In **Table 1**, let us try to summarize the design features that coding can have, working on three types of skills: decision-making, problem reading, and its resultant and transversal competence.

The last slider refers to the media education approach. If the intention of coding is to go to work on media activism as well, from the perspective presented here, it is possible to place it within new media literacy education [47], considering critical development in terms of rethinking media and their algorithms, not only on a technical level.

The goal of the new media literacy education is not adaptation, the mere acquisition of skills to interact with technological tools that are dropped on us from above [48]. The goal of media education for democracy is to train for citizenship, for the acquisition of the skills to use and think about technologies in a critical and empowering sense [49]. In addition, in this model, coding comes full circle only if it is creative and participatory.

In addition, this can only be done through an instructional design of coding that moves away from the logic of the Hour of Code and closer to an active strategy that

	Design for skills—VDM	**Design by competence—ADM**
“Reading” the problem	“Closed” problems: only one way of interpreting the situation	Problems “open” to multiple interpretations
Way of dealing the problem	One single solution	Multiple solution strategies
Process work system	Individual	Collaborative/cooperative
Evaluation of activities performed	Right/wrong feedback	Meta-reflection on one’s strategies

Table 1.
Summary table of approaches to coding versus instructional design sliders.

fits cross-curricular with the teaching of disciplines and fields of experience, with a relaxed and vertical time.

Of course, the design shift is not easy to apply. However, if it is true that coding aims to develop complex and therefore flexible thinking, it will be increasingly necessary to move forward in this direction.

The sliders are the three important designing questions for the development of creativity through coding: put in place by teachers, it is then possible to strive and destroy simple univocal thinking to open up toward creative thinking of a thousand opportunities.

5. Conclusion

The perspective that has been outlined leads us in conclusion to look for the relationship between coding and creativity in three essential movements in education: the first is related to microlearning [50], which increasingly requires a student-centered design [51, 52] that sees the teacher as the one who not only leads but also guides the activities and thinking. The second is related to the way of reviewing and reevaluating convergent and divergent thinking; if the former leads the student to learn in a closed way, which does not allow him/her to see knowledge and skills from his/her own perspective, it is necessary to deepen and develop the latter, as forma mentis and as a modus operandi, not only of the student but also of the teacher. Finally, the third movement is that of moving from product assessment and observation to process assessment and observation [53]; it is in this process that meaningful learning takes place and enactment becomes possible, allowing one to develop one's own innovative thinking.

These three elements come together precisely in the coding methodology, not only bringing the student to the center but allowing him or her to see different solutions to real problems and looking at the work process as the focus of creation and metacognition activities [54, 55]. Moreover, if these three elements are developed in a circular sense, creativity will be developed consistently and fluently.

The final value of coding lies precisely in its educational potential: doing coding means developing critical thinking, it means doing Media Education [56].

Additional information

The chapter was jointly designed by the authors. In particular, Simona Ferrari drafted paragraphs Paradigms of coding and Good design practice, and Federica Pelizzari drafted paragraphs Introduction, Conceptual framework of creativity, and Conclusion.

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Chapter 3

Science Education and Beyond: Citizen Science in Primary School Potentially Affects Conceptual Learning and Socio-Emotional Development

Katharina Hirschenhauser, Didone Frigerio and Brigitte Neuböck-Hubinger

Abstract

Citizen science (CS) is considered a powerful supplement for teaching natural sciences (and beyond) at school. Even though involving children of primary school age in scientific activities is still uncommon, previous studies confirmed that they can contribute meaningful data as citizen scientists. Yet, the administrative efforts of organising the pupils' participation in research activities are high for both, schools and scientists. Typically, some children benefit enormously from participating in a CS project; however, others don't. To enable decisions for school representatives and funding agencies, empirical tests of the learning benefits of involving CS in routine teaching are needed. This chapter focuses on CS in the education context and wraps up the results of critical tests of (i) factual learning during a project on the social behaviour of a free-living bird species, that is, Greylag geese (*Anser anser*), (ii) conceptual learning, that is, the transfer of knowledge to new contexts and the children's concepts of 'friendship' and (iii) impulsive behaviour control in primary school children involved in a project as citizen scientists.

Keywords: education, science and schools, birds, friendship, impulsive behaviour, executive functions

1. Introduction

Citizen science (CS) is increasingly popular as a supplement for teaching natural sciences (and beyond) at school [1, 2]. However, involving children in primary school age is rather rare yet [3]. Teachers and scientists still tend to doubt the young children's capacity of contributing to CS data, although Frigerio et al. [4] emphasized that even 6- to 10-years old children may contribute serious data as citizen scientists if they were well introduced and guided through the process. Thus, CS may benefit from involving children at school as citizen scientists and meanwhile, CS involving schools has emerged as a promising field [5]. The actors involved, that is, scientists, teachers and parents tend to believe that the children will benefit in terms of learning from CS activities. There is empirical evidence that the collaboration between education and research increases the students' motivation for out-of-school learning [6, 7]. However, often it is assumed that the children will gain knowledge from participating in CS and that the benefits may go beyond learning specific contents by the potential transfer of facts to new insights into the children's personal environment and by inducing personal interest [8, 9]. These beliefs rarely have been challenged, which inspired us to conduct the studies reported in this chapter. We attempted to ask, whether CS indeed is more effective than the routine of science education in the classroom. Do extracurricular contents and the experience with CS propose extra value in (science) education at school?

2. The educational perspective

Typically, some children benefit enormously from participation in a CS project [2, 10, 11], while others don't. This may be viewed as the given individual variance in the data observed from a sample and considered acceptable when the results are within satisfying effect size range. However, from an educational perspective, every child in the class must be included in the teaching activities [3] and thus, educational research has a particular focus on those individuals, who were lacking effects of CS participation [12]. The identification of factors that contribute to the efficacy of CS projects in the school context in terms of successful learning is indeed challenging [11]. Even though this was not the focus of the studies presented here, a better understanding of such factors is desirable, and unraveling individual learning outcomes on top of science education [10] might add pieces to the puzzle. To enable decisions for school representatives and funding agencies, empirical studies are needed to test the assumed (learning) benefits of these efforts, as well as the potential developmental benefits of involving CS in routine teaching.

This chapter wraps up the results of critical tests involving primary school children in a CS project on the behaviour of free-roaming greylag geese (*Anser anser*) at the Konrad Lorenz research center (KLF) in Austria. The focus is on pedagogical aspects of CS in terms of learning specific facts about greylag geese (study 1), conceptual transfer based on the children's knowledge of goose behaviour (study 2), and experimental tests of impulsive behaviour control in children involved in the CS project with greylag geese and in a control group (study 3). We aimed at testing different hypotheses concerned with the learning outcomes of primary school-aged children participating in a CS project on the behaviour of greylag geese and the relationships between individual birds in the studied goose flock (**Box 1**). Study 1 represents tests of the basic learning assumptions for children as citizen scientists. Study 2 goes beyond that by testing one aspect of meaningful learning, which is relevant for science education, and study 3 focuses on developmental and behavioural aspects, which are relevant for successful learning.

2.1 Monitoring learning and beyond

Pupils from four primary schools were invited to participate in the CS project on the behaviour of free-roaming greylag geese. The flock of 140 individually marked greylag geese can be found along the river and on the meadows around the Konrad Lorenz research center in Grünau (Austria). The semi-tame and free-living geese are employed as a model species for animal social systems. The social relationships among

Study 1—Learning outcomes: Participation in the CS project has different effects on learning specific facts about greylag geese than being instructed based on pictures and books. Learning effects are independent of age, and similar effects are observed in children of primary levels I and II (level I: class 1 and 2 and level II: class 3 and 4). The gained factual knowledge is sustainable and applicable to new contexts.

Study 2—Concepts of friendship: Participation in CS enables 8- to 10-years old children to transfer the biological concepts of social alliances (as observed in the model bird species) to their own experiences with friendship.

Study 3—Executive functions: Participation in the CS project with free-living greylag geese promotes the children's capacity to control impulsive behaviour, that is, the project participation has an effect on the socio-emotional development of 6- to 7-year old children.

Box 1.
Overview hypotheses.

Study site: The study area is located at 550 m above sea level in the valley of the river Alm at the northern edge of the Austrian Limestone Alps (47°48′E and 13°56′N). Some of the data for the main CS project were collected at the Cumberland Wildpark (approx. 60 ha area), a game park neighboring the Konrad Lorenz research center (KLF) and used by the model avian species during the breeding season.

Study species: The greylag goose is one of the model species of the KLF, where scientists conduct basic research on the complexity of avian social systems [13]. The flock of greylag geese was introduced in the valley by late Konrad Lorenz and co-workers in 1973 [14]. The birds are unrestrained and experience natural predation mostly from red foxes (*Vulpes vulpes*) with losses of up to 10% of the flock and 90% of the goslings per year [15]. The birds are individually marked with a unique combination of coloured leg bands. No two individuals have the same combination of coloured leg bands. The birds are habituated to the close presence of humans, that is, they can generally be approached at less than 5 m. Individual life-history data have been monitored since 1973 and provide reliable information about the age of the breeding birds and social relationships among individuals within the flock (i. e. paired or not, parental and sibling relationships), as well as information on reproductive performance (i. e. breeding attempts, clutch sizes and number of fledged offspring) [15, 16]. The flock does not migrate. Rather, it is regularly fed twice a day year-round and included approximately 130 individuals at the time of data collection.

CS project: The main research objective of the project (2017–2020) was the investigation of the social behaviour of a highly social and long-lived vertebrate, the greylag goose (*Anser anser*), which can be considered a model for studying animal social systems. In fact, in group living vertebrates social context is among the major stress factors affecting physiology, behaviour, fertility and the immune system of the single individuals. Several different school classes of regional primary schools actively participated in this project. The participants contributed to surveying the temporal patterns of the local abundance of the greylag geese during the breeding season. Previous results have shown that the data collected by citizen scientists are reliable sources of information [17]. The results of the CS project that was studied here, indicated seasonal preferences of the greylag geese for certain locations. In addition, the results have shown that breeders and non-breeders often visit the same places. This aspect was particularly important for population management and public administration bodies (e. g. hunting laws and regulations). The manifold of actors and tasks involved in this project demonstrates the long-term cooperation of the KLF with several regional educational institutions and provides the basis for further research projects.

Box 2.
Additional information about the study site, the focal species and the main CS project.

these birds have been studied for decades; however hitherto, the focus was primarily on pair partners and hierarchical relationships [13]. In the presented CS project, the focus was on social allies in the goose flock (i. e. non-sexual partners), which were discussed with the children in the context of 'friendships'. The CS project (2017–2020) aimed at gathering data on the local abundance of individual geese in the valley and the modulation of activity patterns by the social context (**Box 2**).

The children from six classes from three different schools (ABC in **Table 1**) and additional two classes from a fourth school D (see Section 2.1.3) repeatedly visited the

	CS groups	*N*	Control groups	*N*
Primary level I	School A: 1a	12	School B: 1b	18
	School A: 1b	17	School A: 2b	19
	School B: 2b	17	School B: 2a	19
Primary level II	School B: 3a	19		
	School B: 3b	23	School C: 4a*	21*
	School C: 3a*	21*	School C: 4b*	21*
Total *N* (study 1)		109		98
Total *N* (study 2)*		21*		42*
Primary level I	School D: 1a	23	School D: 1b	24
Total *N* (study 3)		23		24

**The subsample of children, who were also tested in study 2 (school C only).*

Study 3 was conducted with two classes from a different school than studies 1 and 2 (school D). Control groups were from the same schools, age-matched and received direct indoors instructions based on images rather than participating in the CS activities.

Table 1.
Sample sizes for CS and control classes by primary level I and II, which were tested in the three studies.

Timeline	Activity	Indoors (I) Outdoors (O)	Study
Jan	Questionnaires (t1) experimental tests for EF	I	1, 2, 3
Feb	Introduction to Greylag geese (biology, behaviour)	I	1, 2, 3
Mar	First visit KLF (mating season, observing behaviour)	O	1, 2, 3
April/May	Second visit KLF (breeding season, observing behaviour)	O	1, 2, 3
June	Third visit KLF (goose families, observing behaviour)	O	1, 2
	Questionnaires (t2) experimental tests for EF	I	1, 2, 3
July/August	National summer holidays		1, 2, 3
Sept	Third visit KLF for EF cohort	O	3
	Questionnaires (t3) experimental tests for EF	I	1, 3

EF: executive functions, KLF: Konrad Lorenz research center, t1, t2, t3: sampling of the presented data.

Table 2.
Overview of CS project activities with school classes.

research center in Grünau (Austria) and conducted field observations of the behaviour and the relationships between individuals in the free-roaming flock of greylag geese. For assessing the basic scientific learning (study 1), a total of seven classes from three different schools were subject to the presented evaluation of learning outcomes (ABC in **Table 1**). In study 1, three classes were aged between 6 and 7.9 years, that is 'primary level I' according to the Austrian education system, and three classes were between 8 and 10 years, that is 'primary level II'. For the assessments of dynamic conceptual understandings (study 2), a subsample of older children (i. e. primary level II) was chosen because this part involved open questions, and children were required to have already firm writing skills. In the subsample of 8- to 10-year old children

Figure 1.
Children recording the behaviour of two greylag geese at a meadow around the Konrad Lorenz research center (photo: Archiv KLF).

(primary level II in school C) study 1 and study 2 were conducted in cooperation by collecting answers for both research questions during the same exams (questionnaires, which were not part of formal assessments). Study 3 was independent of the assessments in studies 1 and 2 and tested aspects of executive functions in another cohort of 6- to 7-year old children (primary level I) from school D (**Table 1**).

Initially, the scientists' team visited the school classes and provided indoor introduction to explain the biology of this bird species and its behaviour (February 2018). Then, the children started outdoor activities and visited the KLF three times, that is, during the mating season in March, the breeding season between April and early May, and the parenting season in late May/June 2018 (**Table 2**). During the visits to the KLF, the children learned to identify individual birds in the flock of 140 individually marked greylag geese and to conduct behavioural observations (**Figure 1**).

2.1.1 Study 1: learning outcomes

In study 1, we tested the specific knowledge of 109 pupils (aged 6 to 10 years; **Table 1**) about greylag geese and their behaviour before the project input had started (January 2018) and after six months of CS project participation (June 2018). Additionally, for assessing the long-term effects of CS participation on learning, we repeated the tests after nine weeks of summer holidays (September 2018). Children in control groups did not participate in the CS project (N = 98, 5 parallel school classes, same school, age-matched; **Table 1**), that is, they were not visiting the flock of greylag geese and were taught greylag goose behaviour by teacher students providing direct instructions and using images. The children from control groups were tested with the same questions and at the same times as the children who participated in the CS project (**Table 2**). The children's knowledge of greylag geese was assessed in form of written questionnaires with ten multiple choice questions. The questionnaires were not part of the formal assessments by the teachers. With the school beginners (level I, 6- to 7 years old), the teacher assisted the children with reading the questions and answers to choose (multiple choice) in the exam. In school C, the total number of questions was reduced to three questions to allow combined assessment with study 2 within a reasonable time. Therefore, the results from school C were not entirely comparable with the plots of schools A and B and thus, were not included in **Figure 2**.

The assessments consisted of nine questions addressing factual knowledge on greylag geese and one question to test transfer knowledge. This one question included in the questionnaires dealt with identifying the images of the feet of a greylag goose among images of the feet of other bird species. The morphology of the feet of the geese was not directly addressed during the CS activities or subject of instructions in the control classes. Thus, this question is aimed at the children's ability to identify the feet of a greylag goose (i. e. of waterbirds) in a comparative context. The issue was not discussed in the classroom/CS activities intentionally, to be able to ask one question, that demanded a transfer of factual knowledge to a meaningful novel context. This question was also included in the questionnaires of school C.

2.1.2 Study 2: concepts of friendship

Study 2 assessed in a subset of 8- to 10-years old children from school C the concepts of friendship with regard to both, relationships between individual greylag geese and transferred to the children's own social experiences and their subjective views of friendship (N = 63; **Table 1**). We chose an age-based subsample of children at primary level II (**Table 1**) for this part, as it was crucial for us that the children were sufficiently able to read and write down answers to the open questions. The children were asked to explain how to identify a social alliance (a 'friendship') between individual geese (open question format), whether they thought that 'friends' were important for a greylag goose (multiple choice), and whether friendship was important in their own lives (multiple choice). In the subsample, the answers to three questions from study 1 were assessed in combined questionnaires. To assess the effects of the CS activities on the children's concepts of friendship, the questionnaires were employed twice, before and after the children's CS activities, that is, in January and June 2018. The children's answers to the open format question ('How to identify friends in a goose flock?') were categorized in a qualitative approach by assessing phrases in the texts, which were indicative of the children's individual conceptions of friendship. This approach allowed for applying two categories of individual concepts related to social affiliation between individual geese (which were also applicable to concepts of friendship in humans): relationship concepts based on social support [18] or relationship concepts based on spatial proximity between the allies [19]. A third category was employed when children indicated that friendship was 'not detectable in geese'.

2.1.3 Study 3: executive functions

The focus of study 3 was on the children's executive functions [20, 21] and thus, the effects of the CS activities on their socio-emotional development. Executive functions (EF) are predestined during early childhood and are needed to regulate a number of socio-emotional competencies and behaviours that are needed for successful learning [20]. Study 3 employed experimental tests of executive functions with 6–7 years old children from the fourth school before and after

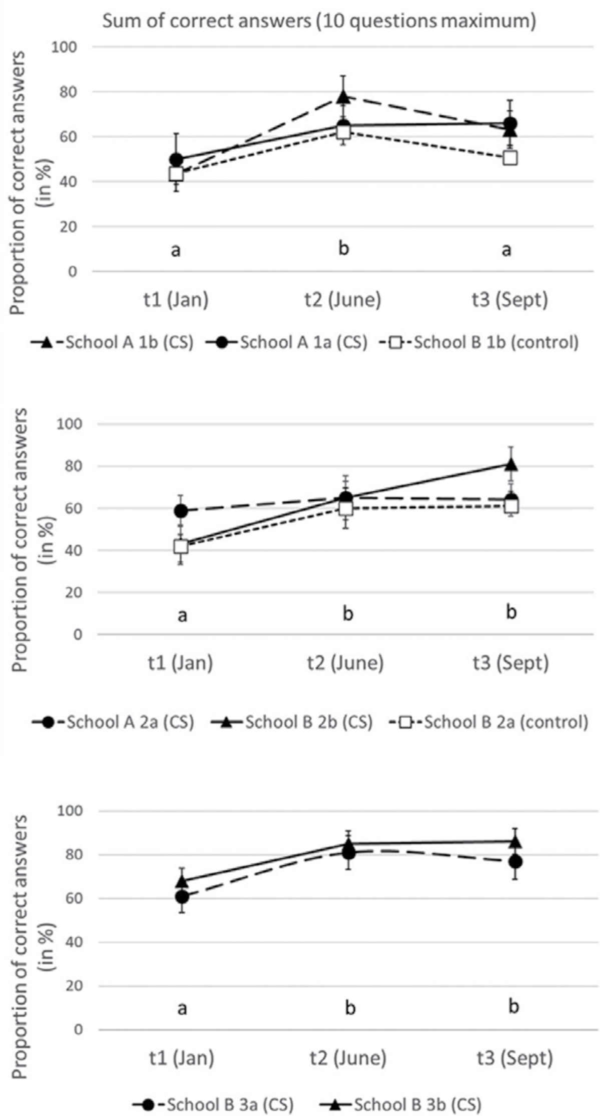

Figure 2.
Patterns of learning specific biological facts about greylag geese did not differ between CS and control groups. Plots show the mean proportions of correct answers per class (± SEM) and are presented as age matched units of analyses, upper panel 6- to 7-years, mid panel 8 years, bottom panel 9- to 10-years old children. Different letters at the bottom of each plot indicate significant changes within groups (Repeated measures ANOVA primary level I, first classes, upper panel, within groups: X^2 = 11.8, df = 2, P = 0.003; between groups: X^2 = 2.8, df = 2, P = 0.247; primary level I, second classes, mid panel, within groups: X^2 = 14.4, df = 2, P < 0.001; between groups: X^2 = 0.8, df = 2, P = 0.667; primary level II, bottom panel, within groups: X^2 = 11.7, df = 2, P = 0.003; between groups: X^2 = 13.5, df = 1, P < 0.001).

participation in the CS project (N = 23) and in an age-matched control group (N = 24) in the same school.

This research question emerged during the planning phase for participating in the CS activities. The teacher of this class recognized already at this point that the focal cohort of school beginners might have problems with impulsive behaviours [22] when approaching the free-living greylag geese. To be able to observe the free-roaming

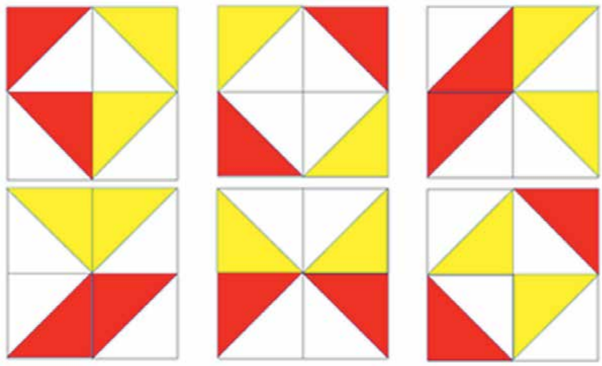

Figure 3.
Examples of images employed for the visual working memory task in study 3 (mosaique tests).

birds' behaviour, it is necessary to quietly approach the birds and behave appropriately. If children start running towards or approaching a goose in a boisterous and thoughtless way, the entire group of birds would probably fly off and stay away from the location until the next day. Thus, to be able to observe the birds' behaviour and participate in the CS project, the children were demanded to approach the birds slowly and behave appropriately. The children were very interested in participating in the CS project, and the teacher thought that interacting with the free-living birds would be a great motivation for the children to potentially improve their ability to control their impulsive behaviours (for example, see [23]). To test this assumption, a battery of individual experimental tests was conducted (N = 47) three times in total. As in study 1, these tests were run before the CS project had started (January 2018), after CS activities (June 2018, i. e. after three visits to the KLF) and after the summer holidays in September 2018.

The battery of tests for individual scores in the context of executive functions included three elements: (i) a classical test for impulsive control, the 'silly sound stroop test' using a flipbook with 14 images of dogs and cats [24]. To assess working memory function, we chose (ii) a test for age adequate (first graders) mental arithmetics with a predetermined time limit (up to 45 calculations in three minutes) and (iii) a visual working memory task with a time limit (6 images within 45 seconds; **Figure 3**). The latter tests are similar to the mosaique tests, which are elements of the WISC-V (Wechsler Intelligence Scale for Children, former HAWIK; [25]). The WISC-V intelligence test assesses different cognitive functions that are also relevant for neuropsychological diagnostics [26].

2.2 Effects of CS on learning and beyond

2.2.1 Study 1: learning outcomes

In sum, we observed that teaching facts about the greylag geese and their behaviour was equally effective whether using conservative classroom instructions with materials, such as pictures and books or when children participated in outdoor experiences as citizen scientists (**Figure 2**). **Figure 4** demonstrates with one exemplary question (e. g. young greylag geese are called goslings) that children at primary level II from control groups may reach equal proportions of correct answers as the children from CS classes. The learning progress lasted until September in both CS and control

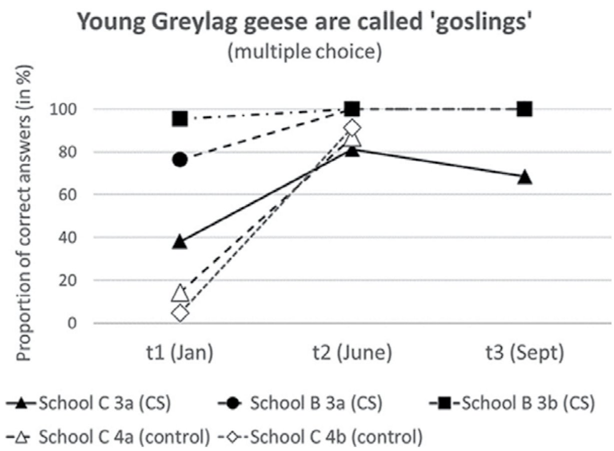

Figure 4.
One selected question to demonstrate that indoor classroom instruction in control groups resulted in similar proportions of correct answers (e. g. young greylag geese are called goslings) in children from control groups as in CS-groups (primary level II).

groups, who were retested after the nine weeks of Austrian national summer holidays (**Figures 2** and **4**).

Another selected question is worth being discussed, as higher proportions of children who participated in the CS project were able to distinguish the feet of a goose from other (non-waterbird) species feet than in the control groups (identify the feet of a goose based on multiple choice of images of the feet of a crow, a goose and a chicken, **Figure 5**). Both groups were not specifically instructed about the feet of a goose and the question was regarded as a quest for applying factual knowledge in a new context. In this case, the children from CS classes scored higher for the transfer of learnt content to a new context than children in control groups.

Thus, at the level of reproducing facts classroom instructions based on pictures and books were well effective for learning. These patterns were similar in all age

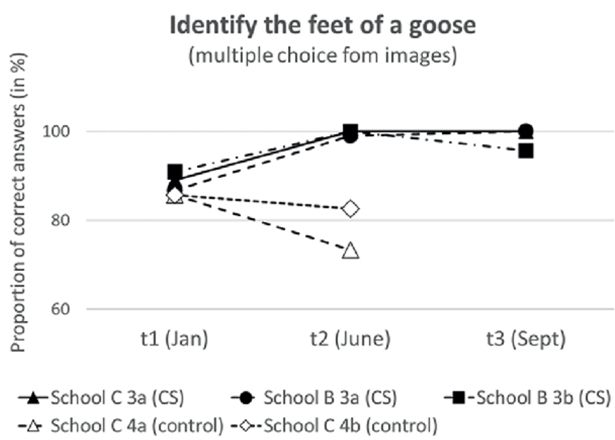

Figure 5.
Higher proportions of children at primary level II who participated in the CS project displayed correct answers than in the control groups (The task was to identify the feet of a goose based on multiple choice of images of the feet of a crow, a goose, and a chicken).

groups. Yet, when the aim is to apply factual knowledge to new contexts, that is, to reach insights and competencies rather than reproducing mere facts, the participation in CS allowed more effective learning than the conservative instructions. This dimension of learning is considered connectable (e.g., see [27]) and useful for further science education (i. e. in secondary school), and it corresponds to the demands of the Austrian curricula [28] for the learning outcomes of science education at the primary level I and II. In a previous study, we observed an additional effect of CS activities on the children's knowledge of bird diversity [11], which indicated that personal interest in the subject was triggered by the CS experiences. The results of the current study add that, potentially, CS activities stimulated the children's skills for applying factual knowledge in a new context and beyond the model bird species.

2.2.2 Study 2: concepts of friendship

The children's concepts of friendship between individual animals changed in a different way in the CS class than in the control group (**Figure 6**). The experiences of detecting social allies (i. e. friends) within a group of geese by observing the birds' social behaviour led CS children to describe the nature of 'friendships' with concepts of social support and spatial proximity (**Figure 6a**), to rate higher scores for the benefits of having an ally in geese, as well as the value of having a friend in their own lives (**Figure 6b**). This result was clearly different in one of the control groups; however, the patterns of the two control groups were inconsistent. In contrast to control groups, the pattern of the children with CS experiences confirmed the hypothesis that biological concepts of social alliances may be transferred to the children's own experiences with friendship (**Box 1**).

Concepts of friendship are not easily studied in 8- to 10-years old children, and some variance was probably added by the individually different verbal abilities in children between eight and ten years. It is also possible that the children in one control group (school C 4a in **Figure 6**) were providing random answers to the questions dealing with friendship. Alternatively, the answers of the children in this control group were already different from the other two groups at t1 (in January; **Figure 6**). Thus, we suggest interpreting these results with caution and future tests of this hypothesis will be needed. However, if the comparison of the conceptual transfer in the CS class and the remaining control group (school C 4b in **Figure 6**) is at focus, the results demonstrate clear effects of CS activities at the mechanistic level (how to detect social allies in geese), however, no effects at the functional level, that is, importance of social allies.

The potential benefits of extracurricular contents for science education have been shown before with regard to factual learning and personal interest [11]. The results presented here suggest that learning at the level of conceptual insights is potentially possible, and future focus should be on further understanding the additional factors needed to reinforce the efficacy of CS for conceptual skills in science education [27]. One promising factor is to inform and involve the teachers who plan to participate in a CS project during early project phases [29]. A close cooperation with the teachers involved is desirable, yet teachers perceive cooperation with scientists as an additional task and tend to refrain from additional tasks as time is constrained. However, the time spent with CS activities may be regarded worthy, if teachers were encouraged to connect the learning outcomes of CS activities with curricular demands [30]. Scientists who manage CS for schools need to develop approaches to catch the personal interest of the teachers involved.

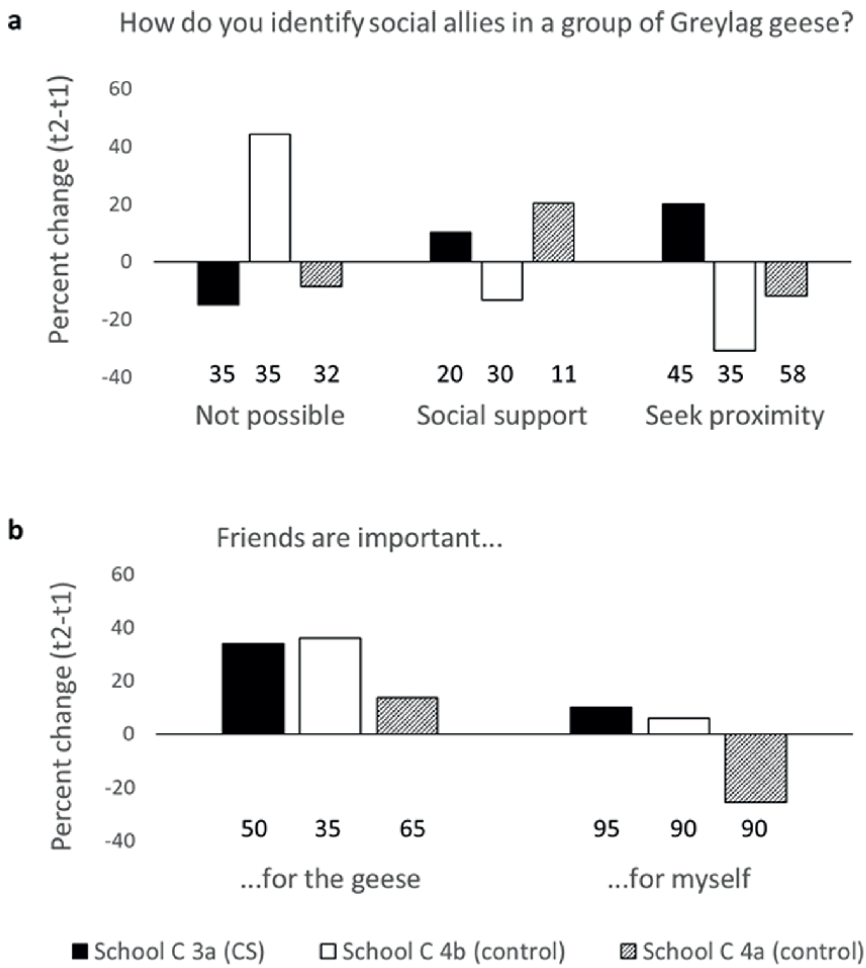

Figure 6.
Children who had participated in the CS activities (black bars) had clear concepts of how to observe friends in the flock of greylag geese (upper panel, categories of the children's statements answering an open format question, Figure 6a) and their understanding of the importance of social allies for the birds (bottom panel, children indicating high relevance of social allies for greylag geese and of friendship for own experiences, Figure 6b). Bars show percent change from t1 (in January) to t2 (in July). Numbers underneath bars are proportions of answers at t1.

2.2.3 Study 3: executive functions

The experimental tests of selected aspects of executive functions, such as impulsivity in 'silly sounds stroop tests', and working memory in mental arithmetics and visual mosaique tests revealed significantly better scores in children of the CS class than in the control group. These differences between groups were particularly evident after the third visit to the research station in September (t3 in **Figure** 7). The capacity to control impulsive behaviour was essential to involve the children in the project with the free-living greylag geese.

The observed effects of the CS participation on the children's behaviour are clearly connected to the project experiences rather than due to maturation because they differ from the control group. The curious decrease of successful hits in the mental arithmetics task (**Figure 7a**) is conceivable, as the teacher gradually increased the

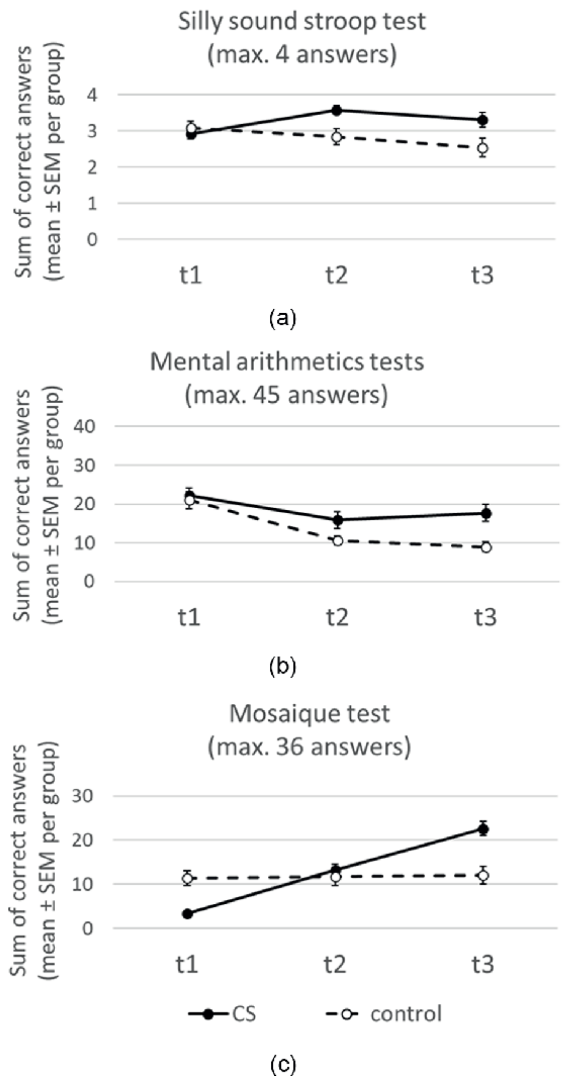

Figure 7.
Six- to 7-years old children with CS experience (t3) score higher in experimental tests of three aspects of executive functions than the children in the control group. (a) control of impulsive behaviour in silly sound stroop tests [24]; (b) working memory in mental arithmetics tests; (c) working memory in visual working memory tests (mosaique test as in [25]). (One-way ANOVA between groups df = 1: (a) t1: X^2 = 1.2, P = 0.279; t2: X^2 = 6.3, P = 0.012; t3: X^2 = 5.4, P = 0.020; (b) t1: X^2 = 0.1, P = 0.776; t2: X^2 = 3.4, P = 0.066; t3: X^2 = 12.9, P < 0.001; (c) t1: X^2 = 14.3, P < 0.001; t2: X^2 = 8.6, P = 0.327; t3: X^2 = 11.9, P < 0.001).

difficulty of the task to complement the ongoing developments of the pupils during the school year. Even if this difficulty resulted in falling patterns, the CS group was clearly ahead (**Figure 7b**).

The results confirm the hypothesis that participation in the CS project with free-living greylag geese promotes the children's capacity to control impulsive behaviour (**Box 1**). The CS experiences were an effective chance for training impulsivity and the individual development of the ability for socially adjustable behaviour [25]. We assume that this effect was strongly mediated by the animal-assisted approach of the CS activity (e.g., see [23]). Most children love to interact with living animals, a phenomenon that may be understood in the context of biophilia [31, 32]. Kelemen-Finan et al. [10] have shown that CS activities of primary school-aged children affected their motivation and attitudes towards wild animals, such as wild bees. The results of the study presented here demonstrate that involving children in CS activities may be beneficial at various levels, by adding the level of socio-emotional development and hence, there are indeed potential effects beyond the factual learning level of science education.

3. Conclusions

The results of the three empirical studies emphasize that participation in CS projects may affect the learning outcomes at different levels in primary school-aged children. In sum, primary school-aged children may benefit enormously from being involved in research activities with scientists, particularly when animals are involved [4, 33]. The presented studies investigating the benefits of CS participation from an educational perspective demonstrated that these benefits are not exclusively at the level of factual learning. Regarding factual learning, the children in control groups (who were taught the same contents with pictures and books) reached similar scores as the CS groups. However, at a conceptual transfer level (i. e. transfer to new context and the children's concepts of friendship) and with regard to socio-emotional development (i. e. impulsive behaviour control) and working memory the children in CS groups clearly scored better than the age-matched control groups. In addition, previous results showed from the scientific perspective that primary school-aged children produced high-quality data within a CS project, hence the children as citizen scientists were satisfying scientific standards [4]. The results presented in this chapter complement this observation from the educational perspective by showing that also the primary school-aged children may benefit from CS activities at various levels of learning—hence the CS project was satisfying educational standards, as well—even beyond curricular demands.

It may be argued that the efforts of organizing the participation of schools in CS research activities are high for both, teachers and scientists. Even if the costs including time resources may seem high at first, CS is a very strong supplement for conceptual teaching at school and potentially promotes competencies and advanced personal skills (even) in primary school children. Nevertheless, there was still relatively large variance in the presented data and education should keep a focus on those children who scored below the average effect. We noted some factors that contributed to the efficacy of CS projects in the school context from discussions with colleagues, teachers and children who took part in the CS project. For example, it is recommended to involve the teachers in (i) elaborated introduction to and discussions about the subject, which should include (ii) agreements on potential learning outcomes and (iii) enable the teachers to practical and theoretical guidance during CS activities with formal training before the CS activities start. Another recommendable feature of the presented CS project was (iv) the long-term and repeated nature of CS activities, which probably supported the long-term effects, that is, the children's knowledge lasted until after nine weeks of break during the summer holidays. It also seems helpful if the involved teachers develop a genuine interest in the topic and activities in order to identify connections to the curriculum, as well as in their own teaching. More understanding of the factors reinforcing these potential effects is yet needed if the aim is to teach skills and concepts, which may be transferred to new contexts in the children's personal environment.

In sum, the results of the presented studies suggest that the participation of children in CS as part of their science education at school bears great potential to advance the learning outcomes from the level of factual knowledge to contextual learning and hence, to promote the development of scientific and personal skills. The concept of contextual teaching and conceptual learning has recently been discussed in the literature on science education with a focus on advancing science education in the field of biology. The participative and motivating nature of pupils acting as citizen scientists in the field of biology satisfies the contextual teaching strategies of 'relating, experiencing, applying, cooperating and using knowledge in a new context' [34], which were originally proposed for teaching mathematics; however, they also match the educational requirements for primary science education very well [35]. The contexts experienced in the presented CS project may be related to several biological core concepts as the analyses of the observed goose behaviours may relate to past and future knowledge in the contexts of behaviour with structure and function, information flow, systems and evolution [27, 36]. These discipline-specific core concepts are not yet at the focus of citizen scientists; however, it is a great chance to advance an efficient collaboration between education and science and to encourage teachers to participate in CS activities. Finally, we want to highlight to all actors involved in CS (may it be in a school context or with adult citizen scientists) to consider potential additional learning outcomes about and beyond scientific facts for citizen scientists, for example, through the transfer of learned facts to new contexts within the citizens' personal experiences that offer meaningful insights about their environment.

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Conflict of interest

The authors declare no conflict of interest.

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Chapter 4

Bridging the Digital Divide in Design and Mathematics through an Immersive Maker Program for Underrepresented Students

Abimbola O. Asojo, Lesa M. Covington Clarkson and Hoa Vo

Abstract

Maker spaces engage students in learning by empowering them to explore ideas and problem-solving in a hands-on environment using digital and/or physical modalities. Design-based programs like this can increase learning by fostering student autonomy and promoting problem-solving and sensemaking. Our interdisciplinary team of researchers at this Midwest university, in conjunction with community partners, offered a program targeted at underrepresented and minority students in a school zone with an exceptionally high educational achievement gap, one of the worst in the nation. Our state ranks 48th and 50th in the high school graduation rates for African American and Hispanic students, respectively. Our work focused on design and mathematics learning and on using maker spaces to bridge the digital divide to create opportunities for underrepresented students. This chapter describes how we developed a culturally responsive pedagogy for underrepresented K-12 students to learn about design and mathematics. We share some short-term outcomes of providing equal access to immersive curricula to underrepresented students, and describe how we bridged learning losses due to the impact of the COVID-19 pandemic.

Keywords: maker spaces, design, mathematics, STEM/STEAM, K-12

1. Introduction

Maker spaces engage students in learning by empowering them to explore ideas and problem-solving in a hands-on environment using digital and/or physical modalities. Design-based programs like these can increase learning fostering student autonomy and promoting problem-solving and sensemaking [1]. Our interdisciplinary team of researchers at a Midwest university, in conjunction with community partners, offered a program targeted at underrepresented and minority students in a school zone with an exceptionally high educational achievement gap, one of the worst in the nation. Minnesota, US ranks 48th and 50th in the high school graduation rates for African American and Hispanic students, respectively [2]. Our work focused on design and mathematics learning. Using maker spaces to bridge the digital divide creates opportunities for underrepresented students. This chapter highlights how we developed a culturally responsive pedagogy and implemented it with underrepresented K-12 students to help them learn about design and mathematics. We discuss short-term outcomes of providing equal access to immersive curricula to underrepresented students and bridging learning losses due to the impact of the COVID-19 pandemic. Long-term outcomes include increased diversity in design and mathematics and the development of a scalable model that can be replicated in other communities.

2. Literature review

2.1 Underrepresentation in STEM

Severe underrepresentation of certain groups in science, technology, engineering, and mathematics (STEM) continues to be a serious problem in ensuring that the nation will have a well-trained and skillful workforce in tomorrow's high-tech sector [3]. Today, 30–40% of the workforce in critical areas such as aerospace engineering, next-generation computing, 2-D materials, therapeutics, and drug design is of international origin [4]. The University of Minnesota (UMN) has been successfully broadening participation in STEM for women, but so far not for Black, Indigenous and People of Color (BIPOC) students. Students enrolled in UMN are majority white female (35.5%). While the percentage of women undergraduate students in the College of Science and Engineering has risen from about 18 to 33% over the past decade, the percentage of African American students has remained around 1.6%. Demographic data on UMN enrollment show 4.04% Black or African American, 3.82% Hispanic or Latino, 3.3% two or more races, 0.309% American Indian or Alaska Native, and 0.0791% Native Hawaiian or Other Pacific Islanders. In 2020, however, BIPOC students comprised approximately 25% of the graduating classes in high schools in the Minneapolis/St. Paul area in Minnesota. The growing percentage

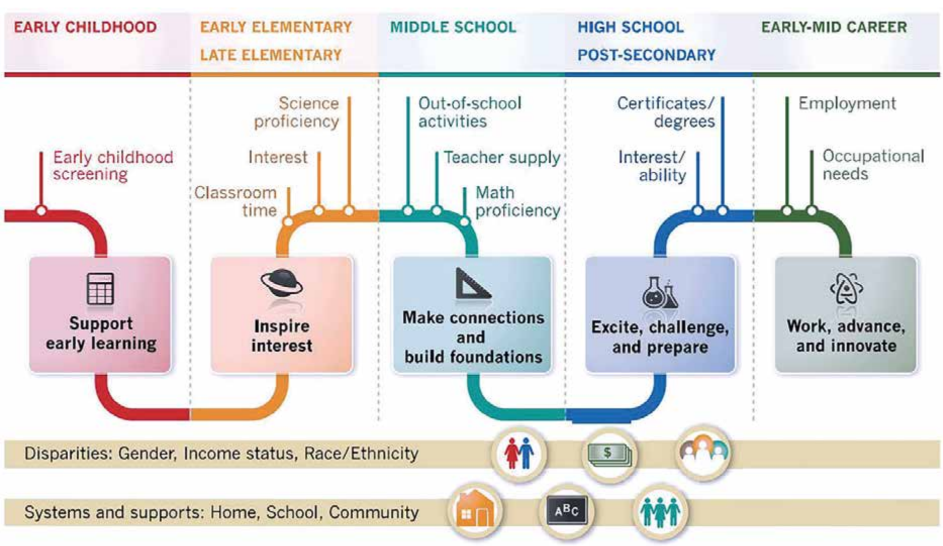

Figure 1.
STEM Cradle to Career Continuum [5].

of BIPOC students in the Twin Cities area, and in greater Minnesota, makes it an opportune time to develop programs that provide exposure to STEM, particularly in informal maker settings. MINNESOTA COMPASS, a STEM education advocacy group composed of educators and private-sector leaders from companies such as Boston Scientific and Ecolab, has championed what it refers to as the "STEM Cradle to Career Continuum." Their logic model (**Figure 1**) divides the continuum into early childhood, early to late elementary school, middle school, high school and postsecondary education, and early to mid-career. Disparities are recognized to be greatest in middle and high school, with wealthy communities having the means to provide many enriching after-school activities while under-resourced communities do not [6, 7].

2.2 Maker spaces and STEM

Exposing students to STEM using maker spaces is of great interest among educational institutions across the United States because of demonstrated outcomes [8–11]. The maker space movement was originally developed outside of the school environment and mostly involved adults. Recently, however, there has been interest in integrating it into education, specifically to create opportunities that engage students in science, technology, engineering, and mathematics [12]. Investment by funding agencies, increased coverage in the popular press, and investment in maker spaces by museums are all signs of the growing interest in and validation of this type of engaged, informal, hands-on STEM learning. Tinkering Studio at the Exploratorium in San Francisco, Ingenuity Lab at the Lawrence Hall of Science in Berkeley, Maker Space at the New York Hall of Science, and MAKEShop at the Children's Museum of Pittsburgh [13, 14] are all high-profile examples of maker space exhibits. The US government has made substantial investment in maker spaces through funding agencies and other initiatives. The White House declared June 18, 2014, a "National Day of Making," and in 2015 expanded these activities to a Week of Making from June 12 to June 18 in Washington, DC. The initiative was an overall call to action for companies, colleges, and communities to promote invention, creativity, and resourcefulness and to celebrate the maker movement. While there are many types of "making," Bevan and Ryoo [15] identified three specific types of programs: those focused on entrepreneurship (i.e., making products for market), those focused on workforce development, and those focused on educational programs.

Researchers have discussed three types of educational making—assembly, creative construction, and open-ended inquiry [15–17]. In assembly, learners are given a step-by-step process of how to make an object that results in an identical object. Creative construction involves providing learners with a challenge to address, and the resulting design/object is personalized. Open-ended inquiry involves a learner developing an individual idea and figuring how to accomplish it. This method is often called "tinkering," since it emphasizes creativity [15]. "When Making is organized to leverage students' ideas and interests, it can create powerful conditions for learning to occur particularly for students who may not already affiliate as STEM learners" (p. 3). Maker spaces support a combination of creating, craft making, and experimentation. Evidence shows that these are attributes of top-performing scientist and that these skills are highly valued by STEM educators, professionals, and industry [18].

2.3 Underrepresented students and maker spaces

The Maker Movement is "traditionally viewed as grounded in gendered, white, middle-class cultural practices" [19, 20], and researchers have argued for making it more inclusive [21, 22]. Researchers at the November 2015 NSF Maker Summit in Washington, DC, funded by the National Science Foundation (NSF), discussed four key issues crucial to advancing the Maker Movement: (1) the relationship between informal and formal learning; (2) teaching, assessment, and evaluation; (3) diversity, accessibility, and inclusion; and (4) new technologies and innovation [12]. The summit participants highlighted the importance of diversity, accessibility, and inclusion in the maker movement to foster industry growth and economic and global workforce advancement. Summit participants also noted the need for the "emergence of strong leaders from underrepresented communities and advocates for diversity" [12]. Marsh et al. [22], in *Makerspaces in the Early Years: A Literature Review*, discuss the importance of inclusion because of limited literature on underrepresented groups and maker spaces. Kafai et al. [23] discuss "ethnocomputing" in their study, which links traditional indigenous sewing methods and the evolution of e-textiles in their culturally sensitive work to broaden participation in STEM among American Indian youth. Their making process highlights how combining traditional artifacts and recent technological developments can help participants acknowledge and learn about their cultural roots. Eglash [24] describes the synergetic connection in this making process as "design agency," a notion that not only does the maker influence the design but the design influences the maker.

Barton and Tan [21] note that makerspaces that explore communities and cultural traditions are an exception, and discuss community-centered making programs as a way to foster equity, learning, and making. Schwartz and Gutiérrez [25] contend that "[i]nventing, making, tinkering, designing, are indigenous practices, that is, practices that originate and occur naturally in particular ecologies" (p. 577). They argue for a "more culturally-responsive approach," where the making experience benefits both cultures and does not privilege the dominant perspective. Vossoughi et al. [20] also advocate for an equitably framed maker process rather than a situation where "working-class communities of color are once again positioned as targets of intervention rather than sources of deep knowledge and skill, and dominant communities are reinscribed as being ahead, with something to teach or offer rather than something to learn" (p. 212).

3. Supporting programs

3.1 Building bridges to design program

The Building Bridges to Design Careers programs, conducted annually by author one, created a dialog on diversity and design between grade K-12 students, college of design students, scholars, and practitioners. Annual panels, workshops, and summer camps led by design faculty and practitioners engaged participants in creative problem-solving and prototyping exercises focused on cultural expressions in design. Since 2013, annual panels, workshops, and summer camps have engaged diverse participants in design problem-solving exercises focused on cultural expressions in the built environment. The program is structured to include after-school programs, summer design camps, lectures, and panel discussions. In the design camps, K-12 students are guided through ideation, concept sketching, and modeling exercises. The week-long summer design camp focuses on daily hands-on activities in design, three-dimensional modeling, and fabrication, and includes field trips (**Figures 2** and **3**). Lectures and

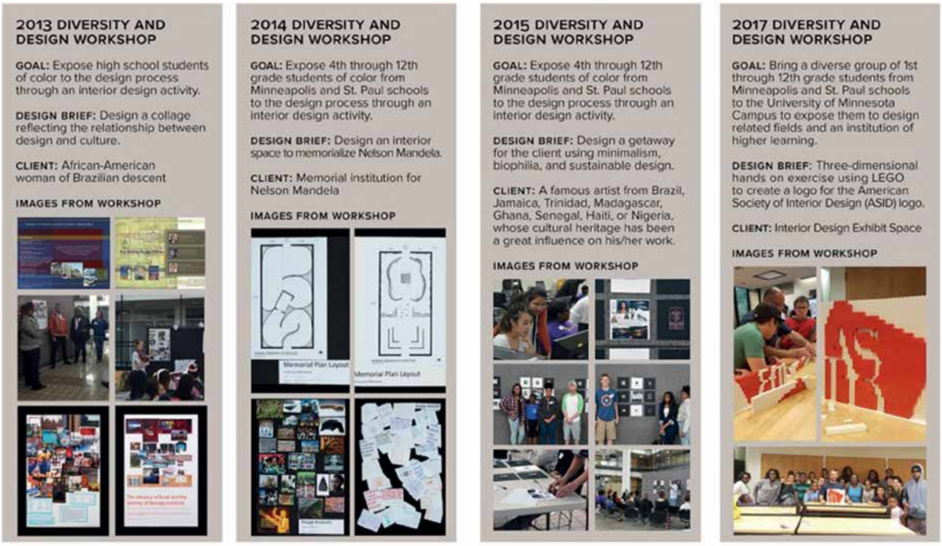

Figure 2.
Building Bridges to Design program, 2013–2017.

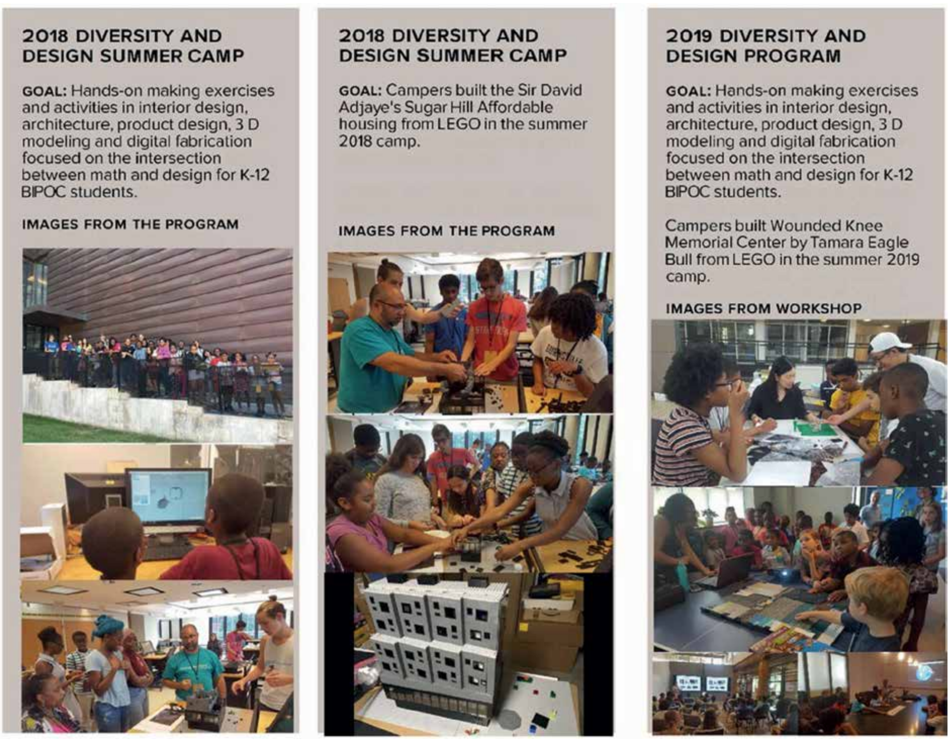

Figure 3.
Building Bridges to Design program, 2018–2019.

panel discussion for K-12 students focus on global design history, multicultural design perspectives, and diverse contributions to the built environment. Woodworking, laser cutting, and LEGO modeling experiences are used to guide K-12 students through the hands-on activities. A systematic instructional design process that engaged the learners, and included objectives, methods, and evaluation, was used in the development and execution of the program. During the programs, feedback was obtained through pre- and post-surveys from student participants to learn about their experiences and improve the programs.

3.2 Woodworking and laser design experiences

Design experiences such as woodworking and laser cutting are found to nurture STEM-related skills such as problem-solving, creativity, and innovation in K-12 students [8, 26, 27]. Using digital and physical tools in woodworking and laser cutting, K-12 students experienced the making of objects from scratch. The Product Realization Lab in RMIT used woodworking and laser cutting as components of design courses to provide students with equipment access and manufacturing training [28]. Similarly, underrepresented K-12 students designed their name tags on the laser cutter. They also participated in open-ended experimentation in the wood shop by building imaginative objects from recycled wood.

3.3 LEGO design experiences

In a recent study, participants ages 8–10 reported profound accessibility, curiosity, enjoyment, and collaboration with peers through experiences using LEGO [26]. At the University of Westminster, Gauntlett [29] found LEGO a powerful tool to facilitate creative thinking [29]. It is compact in size yet flexible, affordable, and applicable for a wide range of age and gender. Building on this literature, we engaged K-12 underrepresented students in different LEGO experiences, from small to large scale. For the small-scale projects, K-12 underrepresented students created the logos of the American Society of Interior Designers (ASID), the International Interior Design Association (IIDA), and the American Institute of Architects (AIA) in one-day after-school programs. For the large-scale project, they recreated the Sugar Hill Building designed by Black Architect Sir David Adjaye, the Architect of the African American Museum in Washington DC.

3.4 Prepare2Nspire

Prepare2Nspire (P2N) is a multi-grade, multi-ethnic, near-peer mathematics tutoring and mentoring program that was developed and implemented in an urban community. Higher than average unemployment and crime rates plague the residents of the community and cause social, economic and cultural challenges [30]. P2N provides more than just support in doing mathematics homework; it is a supportive, safe space that students describe “as friendly and alive. I feel accepted. I feel like I belong…” (field notes, October, 11, 2017).

3.5 Rationale

The mission of Prepare2Nspire is to prepare marginalized students to succeed on grade-level and high-stakes mathematics exams and to inspire them to continue their study of mathematics. This mission is accomplished by developing mathematics confidence, content knowledge, connections, communication skills, and community through its cascading tutoring and mentoring model. P2N also works to create a STEM pipeline for urban underrepresented students to post-secondary education and opportunities.

Prepare2Nspire uses the terms *mentutor* and *mentutee* to signal the combination of the mentoring and tutoring roles. Recognizing that mentoring is a function of building relationships and that tutoring entails the process of assisting in problem-solving and working through mathematics content, the program merged the roles of tutor and mentor and the roles of tutee and mentee. Tutoring without mentoring, however, removes the important leverage of building relationships. Mentoring mirrors tutoring, in the beginning, because it passes the expertise of the tutor onto the tutee. Furthermore, mentoring cultivates both study skills and positive behavior, creates resilience and self-reliance, provides context for the exchange of information and knowledge (which, in the case of P2N, bridges the gap between mathematical theory and practice), and cultivates leadership competencies in both mentor and mentees. For mentees, it also increases the capacity for service to others in the future just as their mentors are currently serving them.

3.5.1 Culturally responsive mentoring

Prepare2Nspire works to incorporate culturally responsive mentoring into the daily lives of students as a way to empower and strengthen the relationship between tutors (mentutor) and tutees (mentutee). Particularly troubling is the myth that culture does not matter in the teaching and learning of mathematics [31], especially when many states continue to have large academic and opportunity gaps between students of color and white students [32]. Paying attention to "issues of race and culture in the way we teach mathematics has incredible power to disrupt the troubling opportunity gap" [31]. Using what students already bring to class acknowledges that such issues exist and addresses them by providing a strategy to mentor African American students from urban schools.

3.5.2 The shaping of mathematical identity

Small learning communities form the foundation of Prepare2Nspire. These table groups are named for underrepresented STEM scholars like Mae Jemison, an African American astronaut and scientist, and Katherine Johnson, an African American mathematician known for her computation work for NASA. The naming of the communities using underrepresented scholars is intentional. To help students see themselves as people who can excel in science and mathematics, they should see and know previous scholars who have succeeded in STEM fields this way.

While mathematical identity is a social construction [33, 34], participating in mathematics classes has a profound effect on the development of that identity. Racialized narratives [35, 36] are among the factors that influence it. More often than not, schools have perpetuated deficit narratives by placing students from underrepresented populations into remedial courses that make it nearly impossible to participate in advanced study. Students, in turn, begin to identify as being incapable and unable to perform academically, believing the implicit message that they aren't capable of doing and being better. Such messages are internalized, creating these deficit narratives and low self-worth even when students have the skill set or prior experiences to demonstrate they can be successful. These "[deficit] identities intersect with already existing stories about other kinds of social identities" [35, 37, 38]. P2N pushes back against this notion by transforming student mathematical identity.

Cultivating positive peer relationships [39, 40] through the use of learning communities is an approach to influencing the formation of mathematical identity. Lieberman [41] asserts that learning among low achieving students increases when they are placed in empowering roles. Situated learning suggested by Lave and Wenger [42] is a model that places learning within social relationships. Thus, community participation is imperative when cultivating mathematical identity, and positively affects the mathematical identity of the tutee [43]. The P2N near-peer model is an example of mathematics support situated in a social setting. Positive encouragement from peers is an effective and motivating strategy. As one P2N participant states, "I really like how when we come here we build community, and at the same time we're also learning [math]. And we meet people who are from different backgrounds" (personal interview, December 2017).

3.6 Structure of Prepare2Nspire

3.6.1 "Prepare": reverse the current trend

In almost every accountability measure in Minnesota (Minnesota Comprehensive Assessments MCA-II and Minnesota Comprehensive Assessments MCA-lll) and nationally (National Assessment of Educational Progress—NAEP), certain groups of students consistently lag behind their White peers [44]. African American, Native American, and Hispanic students, as well as students from low socioeconomic backgrounds, perform behind their peers in academic preparation, high school graduation, and college attendance and completion. In addition, these students are often enrolled in fewer STEM courses in high school and college. The STEM job market is growing, with specialized fields that will not include students from the aforementioned groups if they do not have a background in mathematics and other STEM courses. Studies by NAEP and Jett [45] reveal that the "overwhelming number of low-achieving students in algebra are black and Hispanic and attend big urban, high-poverty schools where they are more likely to fall through the cracks" [46] and that African American and Hispanic students are disproportionately underrepresented in advanced mathematics courses. Jett [45] and others [35] assert that the highest predictor of college readiness and completion is the taking of higher-level mathematics courses during high school. Prepare2Nspire is located in an urban community where mathematics failure is common. If the trend of disproportionate underrepresentation of marginalized students is to be reversed, foundational math failure must be made a high priority in urban educational settings where the numbers are most staggering. Succinctly, prepared students can reverse this trend.

3.6.2 "2": the participants

Prepare2Nspire was developed to support two cohorts of students: eighth graders and eleventh graders. Students in these cohorts are referred to as mentutees, since they are recipients of both mentoring and tutoring [47]. The design of the program is strategic, with middle school and high school students seeing college undergraduates pursuing higher education especially in mathematics or other STEM fields. These undergraduates, called mentutors, are also active participants in the program as they develop different skill sets like leadership and teaching (**Figures 4** and **5**).

Figure 4.
Prepare2Nspire.

Figure 5.
Prepare2Nspire at UROC Spring 2017.

The original design of the program matched one undergraduate with three eleventh graders and six eight-grade participants. As the program has developed and evolved over the last 10 years, outside circumstances may have altered the exact number of students from each cohort within a community, but the near-peer model has only become stronger, regardless of the changing number of participants. The undergraduate remains the foundation of each community while supporting both eighth and eleventh graders and as eleventh graders support eighth graders.

3.6.3 "Nspire": the role of technology

Graphing calculators have transformed how students think mathematically in a classroom and on assessments. Prepare2Nspire is influenced by the graphing calculator with the same name. Each participant receives a graphing calculator and is taught how to use it effectively. Since mathematical thinking is influenced by technology, and technology can be used on standardized assessments, participants are taught how to move between the multiple representations which are incorporated into the teaching and learning of mathematics in general, and in algebra specifically. Given that technology is an integral part of STEM occupations, this tool can be an advantage when preparing for this pathway IF students know how to use it.

When students attend each week at their table communities, they work, eat and talk with the same people. All of these activities are an intentional part of building relationships which, in turn, enable authentic conversations about algebra. The sense of community transforms how participants think about mathematics.

3.7 The immersive maker space program

Building on prior literature and experiences from the supporting programs Building Bridges to Design and Prepare2Nspire, we used an inclusive lens to create and deliver immersive maker space programs for underrepresented students in grades 4–12 in summer 2020, 2021 and 2022. The project-based making exercises focused on the intersection of design and mathematics, drawing on historic design precedents from ethnic minority communities including African, African American, Hmong, and Vietnamese communities, where underrepresented student participants in this program came from. Using design precedents from diverse communities helped our team create a "culturally-responsive approach" that is inclusive and relevant to student participants. We exposed K-12 students to design, engaged them in hands-on experiences, and created opportunities for them to collaborate with underrepresented mentors. We also used design precedents from underrepresented designers to illustrate contributions to the built environment.

Through extensive literature review on maker spaces and underrepresented students, focus group meetings, ideation and mockup sessions with University researchers, and collaboration with community and school partners, we co-designed and created a curriculum for an immersive maker space in a city with a poor record of inclusive excellence. Our goal was to offer hands-on experiences in design, 3D modeling, online experimentation, making, and digital fabrication to promote STEM/STEAM learning. The immersive maker space was implemented online in 2020 and 2021 due to the COVID-19 pandemic and in-person in 2022 with grade 4–12 students at the Robert J. Jones Urban Research and Outreach-Engagement Center (UROC) in

North Minneapolis, a school zone with an exceptionally high educational achievement gap. Throughout the program, students' learning was measured through survey responses and informal interviews.

3.8 Program curriculum and activities

The program curriculum included College of Design students from diverse backgrounds sharing their career interests and projects via videos. The design and STEAM videos included introductions to fractals, geometric principles, the golden rectangle, and the Fibonacci sequence. Fractals in design and architecture were presented through a cross-cultural lens, showcasing fractal geometry in the work of underrepresented designers like David Adjaye, including his design of the African

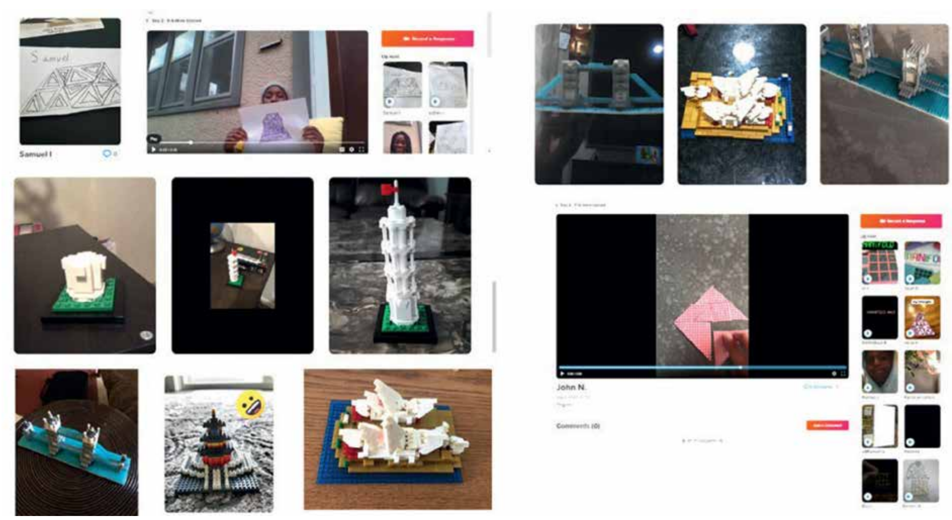

Figure 6.
Summer 2020 student sketching, paper folding, and LEGO and building blocks projects.

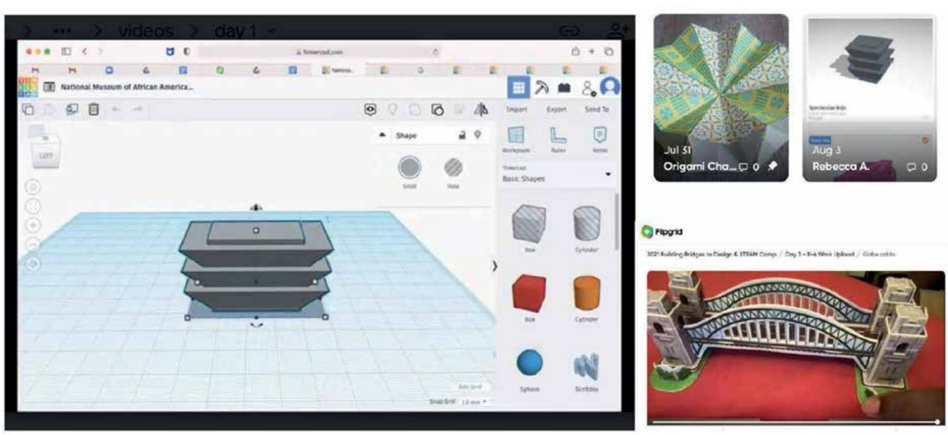

Figure 7.
Summer 2020 3D modeling in TinkerCAD and paper folding projects.

American Museum in Washington DC. For the introduction to mathematics, graphing calculators, and coding, students engaged in hands-on learning about how to code and automate devices. Hands-on paper folding exercises were integrated so students could learn about various math principles while folding structures and origami forms.

For sketching, 3D modeling, and 3D printing, students were introduced to 3D modeling in TinkerCAD using Cartesian coordinate systems, points, lines, and basic geometric shapes such as cubes, planes, and spheres. They learned rapid prototyping through 3D printing of the TinkerCAD models they created. For example, they created massing models of the African American Museum in DC in TnkerCAD. They learned about the massing and composition of the structure, which are extruded trapezoidal geometric shapes stacked vertically to form the building facade. This exercise provided students with the opportunity to learn about the intersection and relationship between mathematics and design principles.

Figure 8.
Summer 2022 3D modeling in TinkerCAD and 3D printing.

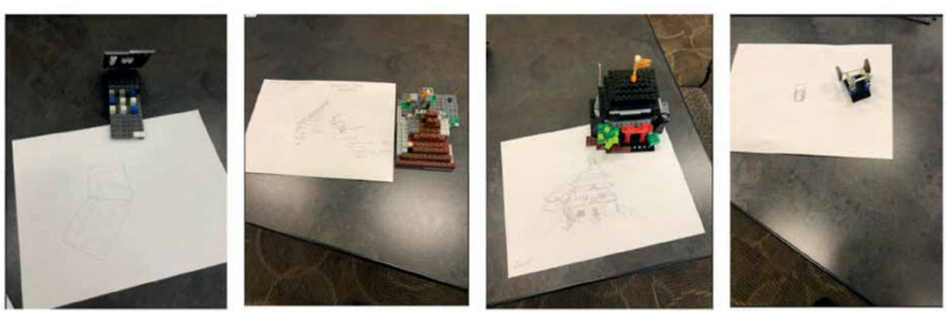

Figure 9.
Summer 2022 sketching and LEGO exploration.

For LEGO and building block modeling, students experienced and learned about design and mathematics by building models of global buildings, including the Khufu Pyramid, the Sydney Opera House, the Tower Bridge, the Pisa leaning tower, and skylines in Japan and Dubai Skyline (**Figures 6–9**).

4. Discussion and findings

To support our goal of implementing the maker space program and engaging underrepresented students to promote future success in STEAM, we measured students' learning throughout the program using surveys and informal interviews. Students completed pre-surveys prior to participating in the program and post-surveys after the program. To help the authors learn about the effect of the program on student learning, attitudes, and engagement in the program, sample survey questions were targeted towards asking participants about their experience before and after the camp. For example, participants were asked about the design and mathematics careers they know, the STEAM skills they were learning, and their best experience in the program (**Figure 10**).

The 2020 camp had to be delivered virtually due to the COVID-19 pandemic lockdown. From the 2020 cohort of 64 campers (34 grade K–6 and 30 grade 7–12 students), the majority of the campers—81.5%—considered the camp informative and interesting on a Likert scale of 1–5 points. No camper rated the program as not informative or interesting. When asked what they learned in the virtual summer camp, students reported learning about design. For example, one participant quotes "you can start designing and drawing and someday that dream of yours might come true." Another noted "I learned about the different types of designs people do on a daily basis which made me into design." Another participant noted "I learned about possible career paths in design. I also learned about certain buildings." When asked about the best experience in the virtual summer camp, participants reported enjoying the virtual design firm visits, origami, and LEGO building. One participant reported "The best part was when people that do different types of designs and when they showed us what they do every day on the job and explained how things work at their

Figure 10.
Word cloud illustrating best experience in Summer 2021.

offices." Another reported "Building the Origami helps me think better." Another reported "I really liked how challenging the LEGO building was."

The 2021 camp was also held virtually due to the COVID-19 pandemic. From the 2021 cohort of 30 campers (18 grade K–6 and 12 grade 7–12 students), the majority of the campers—72.2%—considered the camp informative and interesting on a Likert scale of 1 to 5 points. No camper rated the program as not informative or interesting. When asked what they learned in the virtual summer camp, students reported learning about mathematics and design. For example, one participant noted "I learnt that math and art have a good way in incorporating itself in designing projects." Another noted "Fractals is a concept in math that deals with space and dimensions." On modeling, another participant noted "I learnt that 3D printing is sometimes used to small-scale a building like a model." When asked about the best experience in the virtual summer camp, participants enjoyed the origami, sketching, LEGO building, and modeling exercises. For example, participants reported their best experiences as follows: "seeing the different people and what branches of engineering they worked in," "trying to build the Japanese skyline," "drawing the fractals and building the origami," and "I liked the crafts and the origami, and it was interesting."

The summer 2022 camp was delivered in-person. For this summer experience, the Arts were included in the STEM focus, so the focus was Science, Technology, Engineering, Arts and Mathematics (STEAM). The program followed Minnesota COVID-19 protocols to ensure a safe environment, and all participants wore masks during indoor activities. Since the camp was delivered in-person, more detailed pre- and post-surveys and informal observations were conducted. From the 58 registered campers, 23 attended the full 2 weeks of the summer camp and participated in the pre-and post-survey (7 grade K–6 and 16 grade 7–12 students). When asked in the post-camp survey how the experience would contribute to their future plans, participants reported wanting to become engineers, architects, entrepreneurs, fashion designers, computer programmers, and animators. Notably, a participant reported that the program taught "me how to create and provide helpful things to the economy." Additionally students reported that the experiences helped them with mental mathematics, technology, and logical skills. These findings, demonstrating stronger STEM/STEAM self-efficacy (**Figures 11** and **12**), support the program directors' intentions to use creative project-based learning exercises to promote future success. **Figures 11** and **12** summarizes the average Likert score of summer camp participants attitudes towards STEAM pre-and post-camp. For example, as illustrated in the diagrams the average Likert score for the following questions increased from the pre to post: *I think I can do well in STEAM (3.82 to 4.45), I think STEAM will help me even when I am not in school (3.73 to 4.00), I am interested in thing I learn in STEAM (3.73 to 4.05) and I enjoy doing STEAM projects (3.70 to 4.35).*

As seen in comparison of **Figures 11** and **12**, most participants reported that the program helped them understand STEAM as much as they can. The average Likert score of the other five questions shows an increase after the camp, indicating an increase in students' interest in the STEAM class. All students thought STEAM is important and enjoyed doing STEAM projects. Through the camp, they mastered many new skills, and believed STEAM would help them even when they are not in school. The summer design camp helped them improve their interest in STEAM. However, it looks like students were not looking forward to their STEAM classes in school. A paired-sample t-test was conducted to the pre-and post-test survey questions to determine if there was significant difference at the end of the camp experience. As

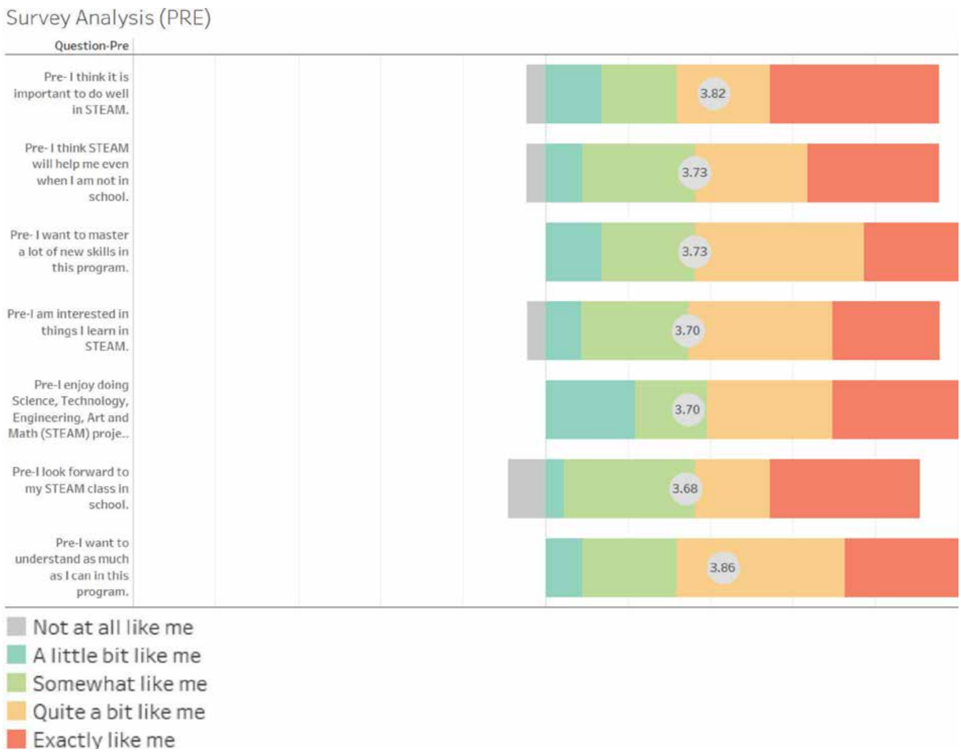

Figure 11.
Pre-Survey of 2022 Summer Camp participants attitudes towards STEAM.

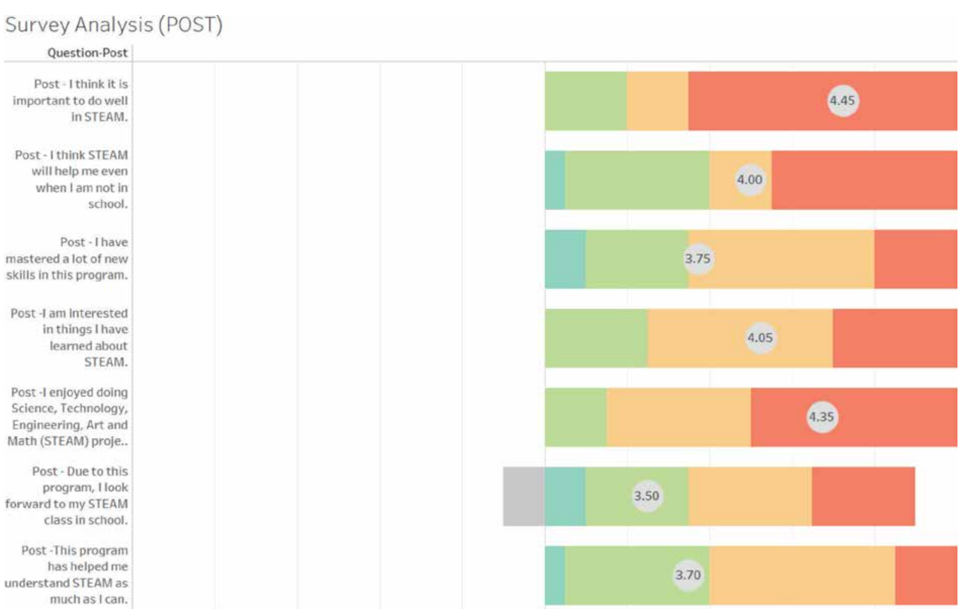

Figure 12.
Post-Survey of 2022 Summer Camp participants attitudes towards STEAM.

Survey questions		Pre-test		Post-test		Sig.
Pre	**Post**	**Mean**	**SD**	**Mean**	**SD**	
I think it is important to do well in STEAM.	I think it is important to do well in STEAM.	3.82	1.26	4.45	0.83	0.06
I think STEAM will help me even w hen I am not in school.	I think STEAM will help me even when I am not in school.	3.73	1.16	4.00	1.03	0.43
I want to master a lot of new skills in this program	I have mastered a lot of new skills in this program.	3.73	0.98	3.75	0.91	0.94
I am interested in things I learn in STEAM.	I am interested in things I have learned about STEAM.	3.70	1.11	4.05	0.76	0.23
I enjoy doing Science, Technology, Engineering, Art and Math (STEAM) projects.	I enjoyed doing Science, Technology, Engineering, Art and Math (STEAM) projects.	3.70	1.15	4.35	0.75	0.03
I look forward to my STEAM class in school.	Due to this program, I look forward to my STEAM class in school.	3.68	1.29	3.50	1.28	0.65
I want to understand as much as I can in this program.	This program has helped me understand STEAM as much as I can.	3.86	0.94	3.70	0.80	0.55

Table 1.
Student Interest in STEAM pre- and post- summer camp. Mean, Standard Deviations for Pre- and Post-test data and t Test results (n = 23).

shown in **Table 1** there was significant difference in pre-and post for the question *I enjoy doing STEAM projects*. Our limitations are the small sample size in the in-person summer 2022 camp due to the COVID-19 pandemic. A larger sample size will be needed to show any statistically significant difference before and after camp.

In terms of the program directors' goal to close the learning gaps due to the COVID-19 pandemic, the hands-on experiences in 3D modeling in TinkerCAD and in coding and 3D printing provided the opportunity to tackle digital inequities and the lack of access to current technologies faced by underrepresented students. Overwhelmingly, student participants mentioned 3D printing, modeling, and coding when asked about their best experience post-camp.

In terms of the goal to use an inclusive lens of STEAM learning, the project-based curriculum used a "culturally-responsive approach" incorporating design examples from underrepresented and minority designers to teach about fractals, geometry, design, and architecture. The visual and design examples came from patterns, visuals, architecture, and ornamentation from African, African American, Hmong, Vietnamese and global cultural examples, helping student participants see role models and a reflection of themselves in the project materials.

5. Conclusion

Findings from the program across the years indicate a high level of engagement and positive learning experiences among program participants. By learning about design and mathematics, participants gained broader perspectives and discovered new interests and career paths. Additionally, our findings highlight how understanding the connections between different disciplines helps foster creativity and innovation. Our findings are consistent with those of authors such as Gauntlett [29], that found LEGO experiences offer students creative thinking opportunities [29], and Marsh et al. [22], that highlighted the importance of exposing underrepresented students to maker spaces [22]. Similar to previous authors, we found that anecdotal evidence from this program showed underrepresented students learned about their cultural roots from the program experiences [23].

As the UMN student body is not diverse, programs like this can provide pathways to future careers and bridge educational disparities. The program instills in participants the motivation to continue exploring these disciplines, and helps them develop relevant knowledge and skills for the future. Universities and educational institutions play a critical role in promoting diversity, equity, and inclusion in education and future careers. Programs aimed at increasing the representation of underrepresented students, such as those from low-income or minority backgrounds, can reduce educational disparities and provide these students with the skills and resources they need to succeed in their chosen fields. By creating inclusive and supportive environments, universities can help foster a sense of belonging and empowerment for underrepresented students and help them reach their full potential.

The COVID-19 pandemic caused widespread learning losses, particularly among students from underrepresented communities who may have faced additional challenges such as limited access to technology and disrupted home environments. To bridge these learning losses, this program introduced initiatives such as:

- Implementing remote learning technologies and online resources to make education more accessible.

- Offering summer programs to help underrepresented students develop knowledge and skills in disciplines like design and mathematics.

- Providing access to digital experiences, technologies, and digital fabrication that are crucial in today's technology-driven world. Specifically, via this program, underrepresented students learned how to design via 3D printing, laser cutting, and mathematical calculations.

It is important to address the learning losses caused by the pandemic and to ensure that all students have access to the resources they need to succeed in their education. By working together, educators, policymakers, and communities can help mitigate the impact of the pandemic and ensure that students have the opportunities they need to reach their full potential.

One of the biggest challenges in carrying out the above initiatives is funding. Scaling up these initiatives to reach more underrepresented students and have a greater impact requires significant financial resources. It is crucial to find innovative and sustainable funding models that can support the scaling up and larger impact of these initiatives. This could include partnerships among government, business, and non-profit organizations, leveraging existing infrastructure and resources, and exploring alternative funding sources such as crowd-funding and social impact bonds. Ultimately, the key to overcoming funding challenges is a combination of creativity, persistence, and collaboration. By bringing together stakeholders from different sectors and working together towards a common goal, it is possible to secure the funding needed to provide access to digital experiences, technologies, and digital fabrication for underrepresented students.

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Chapter 5

Full STEAM Ahead with Creativity

Catherine Conradty, Sofoklis A. Sotiriou and Franz X. Bogner

Abstract

The integration of arts in science education (STEAM) aims to provide innovative activities to reach deeper learning levels and generally promote student engagement in (science) education. The European Horizon 2020 project CREATIONS with 16 partner institutions addresses this challenge with more than 100 initiatives over three years. All initiatives followed our STEAM guidelines based on the fundamental principles of responsible research and innovation (RRI). The positive effects of STEAM on cognition and motivation were evident in all initiatives with a sufficient empirical database. Besides the intention to integrate creativity, our study focused on flow that is experience of total immersion and exhilarating absorption in an activity that is experienced as effortlessly mastered. The productivity resulting from the self-rewarding creative rush makes flow particularly interesting. This chapter contributes to the open question of how flow is triggered with an exemplary meta-analysis of motivation and creativity scores of ten interventions ranging from complex projects at CERN to art-centred, play-based, laboratory-oriented projects or almost classical school initiatives. The regression analysis decoded self-efficacy as the crucial factor enabling the flow experience—which was demonstrated in this study for the first time, moreover, in a variety of age groups in the context of classroom activities.

Keywords: creativity, flow, self-efficacy, secondary school students, arts and science, STEM, European-wide study

1. Introduction

The need of creativity in science has been highlighted over the last 50 years [1]. Researchers such as Moravcsik [2] allocated creativity even as the key element of science (education): "Without [creativity], science turns into a sterile manipulation of fixed rules and their embellishment without any tangible result, whether in the conceptual or practical sense" (p. 222). Science, like arts, requires a high degree of open network thinking and the ability to question established knowledge to ask the right question and find the appropriate ways to answer it [3]. Both, scientists and artists alike, are fond of understanding the world although their methods and choice of means differ and often misunderstand each other by disregarding potential benefits. A well-known historical example is Leonardo daVinci, who acted as both, a scientist and an artist. His scientific work on mechanics, proportions or anatomy is hardly distinguishable from art, and one would not have been possible without the other.

It has been a long definition process of creativity as it is a rather complex construct [4]. Starting from a rather general definition which regards creativity as a pivotal competence to solve current problems and to meet the requirements of the post-industrial age [5, 6], the view became increasingly broader as the complex problems of our global, post-industrial culture required education that fostered skills such as self-responsibility, creativity and reflection [7]. Dealing with that requires complex products that need multi-level creativity to develop [8]. For a possible solution, the ability to generate and pre-select ideas through imagination is needed [9]. Thus, creativity is not only declared to be the key element of science [2] but is also considered to be the key competence of the twenty-first century [10]. Reactive real-time creativity is characterized by spontaneity with improvisational and immediacy skills [9]. This high level of cognitive creativity is not innate and requires constant training. Hsu [11], for instance, indicated an incubation period prior to creativity as crucial for various individual traits relevant to creativity.

Today, as knowledge is always accessible and with constant updates, it seems to be increasingly an erroneous path to teach knowledge instead of creative competencies. Formerly, education was optimized for standardization and conformity, leading to compulsory curricula and strict testing requirements. Arts was reduced to a mere element of subject teaching, ignoring more or less the essence of creativity rather than using it as an element of learning across all classroom subjects [12]. For a long time, little had changed in the curricula. Nowadays, a fundamental shift in teaching objectives is emerging, away from the traditional teaching of “knowledge” (cognition) toward the promotion and development of students’ “skills” (competence orientation) [13]. After the extensive discussion of art and the definition of creativity and the investigation of the connections, STEAM instead of STEM is now gradually finding its way into the classroom.

Because of its importance in science, creativity is recognized as a critical component of STEM at school [14, 15]. Many educators consider science as creative and regard the relationship between knowledge and creativity in science as a special opportunity [16]. Creative approaches in science education are supposed to generate alternative ideas and foster everyday creativity, which results in purposive, imaginative, activity-generating outcomes. Although creativity is not limited to a particular subject area, Torrance [15] argued that science offers a much broader range of activities that can be used to foster creativity than other school subjects. The process of creativity, preparation, incubation, illumination and verification, follows similar steps to the scientific method: observation, hypothesis, experiment and verification [17, 18]. All scientific processes require a creative mind: hypothesis generation and observation require high levels of open-mindedness to experience and sensitivity, which in turn are components of creative thinking [19–21].

Despite the emergence of Science, Technology, Engineering, Arts, Mathematics (STEAM) as a popular pedagogical approach to foster students’ creativity, problem-solving skills and interest in STEM subjects, definitions and goals of STEAM education remain inconsistent [22]. The Horizont2020 STEAM project CREATIONS was set up to support this link by including partners from different fields for preparing and implementing innovative examples of STEAM [23]. A roadmap guided the development of more than 105 interventions within the three-year project period. The idea in a nutshell: why are students more creative in their leisure time than in school and how can school be designed to provide the same research environment as creative leisure time [24–27]?

All STEAM interventions followed the key principles of Responsible Research and Innovation (RRI). The creative elements followed the 5E teaching model by proposing the five phases: engagement, exploration, explanation, elaboration and evaluation

Creativity killer (modified after [34]	Creativity supporter (CREATIONS)
Surveillance: Hovering over students, making them feel as if they are constantly being monitored while they are working	Student-oriented **self-regulated** learning environment with a teacher as a tutor;
Evaluation: Making students worry about how others judge what they are doing	Students and teachers in the role of research colleagues; excellent **error management culture**: There are no failures, only experiences with falsification of an experiment;
Competition: Putting students in a win/lose situation in which only one person can come out on top	Confidence within the **team**; each team member contributes valuable;
Overcontrol (perfect structured lessons): Telling students exactly how to do things and forbidding any exploration	Well-prepared **working material** for self-regulated learning with space to elaborate and even fail;
Pressure (closely defined goals): Establishing grandiose expectations for a student's performance.	*Error management culture:* **open-minded** for new, even unconventional proposals. Everything is a step toward a bigger goal;

Table 1.
Killer of creativity and supporters.

[28, 29]. Creativity was integrated in the classroom environment as students were able to imagine, explore, experiment, test, manipulate, take risks and speculate as well as to make mistakes [30]. Inquiry-based learning in the CREATIONS modules promotes deeper learning [31]. What has been worked out independently is understood and thus rarely forgotten but transferred and used in other contexts [32]. Special attention was given to the creativity supporters as well as of "killers" in learning environments (**Table 1**) [33].

Teachers offered this creativity-supporting social environment by adopting the role of a tutor [62]. They were responsible for a well-structured learning environment but left enough room for self-responsibility to deal with problems and scientific questions [35, 36]. This provides space for self-experience; it practices dealing with failure in a safe environment and recognizes failure as an elementary part in scientific work [37]; furthermore, this way of teaching supports self-efficacy because every increase in knowledge and success is based on students' own work [34, 38]. As an example of some of the teaching interventions analyzed, we briefly describe the structures below. These show the variability in which the basic structure of a CREATIONS intervention can be applied.

Gen-ious is an intervention carried out in a student laboratory in addition to the classroom. The engagement with the technology-loaded genetics lab and the DNA replications model, which has a reputation for being complex, is split up by a creative inquiry-based construction phase. Students can craft models that can symbolize the DNA structure while observing the creativity facilitators. The lightness and playful creativity relieve the fear of making mistakes, which would basically reveal misconceptions that can then be identified and corrected on one's own. With the creative teaching structure, the motivation to finish difficult (thought) processes, work on science and learning increased, as did long-term learning performance. More information about the intervention design of *Gen-ious* is described in [39, 40].

Art of Flying—the Jurassic fossil bird Archaeopteryx. The instructional content of the module on bird flight approached the topic in an interdisciplinary way with biology and physics. Introductory phase and final plenary provided the safe framework in which the teacher provided rules and basic information about the work processes. Within this framework, the students worked cooperatively in small groups of 3–4 participants (assembled by free choice) and completed the working stations' tasks autonomously. With a focus to support self-efficacy, tutoring should be provided without negative feedback or too much help. For this, not the teacher but instead a workbook with instructions for each task supported the autonomous learning process. The educational module followed the concepts of open Inquiry-Based Science Education (IBSE) by integrating elements of creativity and arts to extend STEM to STEAM instruction. Within the creativity approach, the arts aspect in science education was applied via two workstations with collaborative handicraft artwork on natural fossils and paper glider models [41, 42] (**Table 1**).

DNA-dance—simulating a double helix in schoolyards. As an example of involving one cohort of a total school, that simulation game was implemented within a schoolyard (**Figure 1**). All 7th-graders assembled in the schoolyard by wearing six different colors of T-shirts: white (= Desoxyribose) and black (=phosphate) formed the helix backbone, while blue, green, red and orange symbolized the different bases (cytosine, guanine, adenine and thymine) containing the genetic information (purple = enzyme helicase). Half of the cohort danced in the manner of a row dance and symbolized a double helix (see **Figure 1**; 1 + 2). In the second step, the double helix has been split up by the appropriate enzyme helicase (see **Figure 1**; 2 + 3). In order to duplicate the double helix, the other half of the cohort substituted the emptied places and finalized two identical separate double helices (see **Figure 1**; 3 + 4). In summary, this inquiry-based laboratory module about

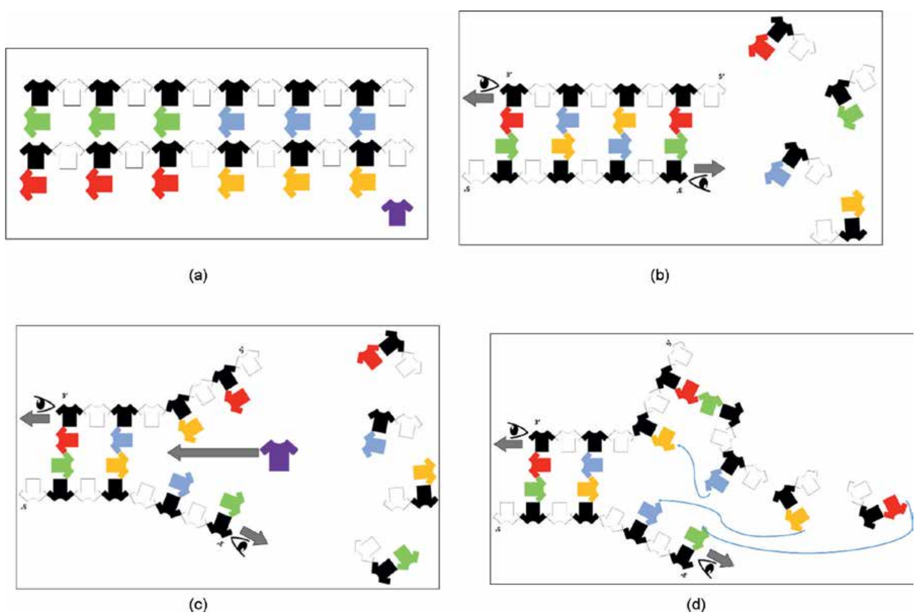

Figure 1.
DNA—Dance in a school yard: Dancing scheme for the replication of a short double-stranded DNA molecule. 1. The students with the T-shirts symbolizing the single "players" of a DNA-double helix 2. Preparation: "Constructing" a double-stranded DNA molecule. 3. Separating the double helix into strands with the enzyme helicase. 4. Complementing each strand by supplementing base-pairings with free nucleotides fitting in a 5′ to 3′ direction.

genetics needs about one lesson and, beforehand, theoretical background knowledge by regular classroom lesson about genetics.

Altogether, the STEAM CREATIONS projects addressed all areas of science (Physics, Mathematics and Biology). We investigated the relationship between self-efficacy and flow. Flow is often misjudged as a special feeling of happiness of talented artists. Due to the positive effects of flow experiences on well-being and productivity, the feasibility of consciously provoking flow in everyday life is being explored. The present study investigates the hypothesis that self-efficacy experiences can trigger flow. For this purpose, students participated in creative STEAM projects that were developed according to CREATIONS guidelines and monitored by a pre-post-test evaluation design.

2. Methodology

Students completed an online questionnaire before and after participation. Bias was avoided as participants were never aware of any testing cycles [43]. The basis of subject selection was participation in the standard test design. We applied the subscale "self-efficacy" of the science motivation questionnaire [44], using a 5-point Likert scale pattern ranging from "never" (1) to "always" (5). To improve applicability, we have chosen the four best-loading items of each subscale. The strong factor structure of the total toolset allows for this reduction in the item count, which has been confirmed in many studies [45–47].

For creativity measurement, we focused on the level of motivation and attitudes associated with personal creativity, as well as on the cognitive (thinking) and non-cognitive (motivation) dimensions of creativity [4]. We applied two subscales modified by [48]: "Act" quantifies cognitive processes of conscious and active thinking which can be trained and taught. "Flow" monitors typical elements of an individual flow experience [1] which is supposed to assess motivational experiences at school related to creativity. The creativity measure employed a 4-point Likert scale ranging from "never" (1) to "very often" (4). For the present analysis, we focused on flow.

Data from ten randomly selected projects with large numbers of participants with pre- and post-tests were analyzed (N per project: 100–330). In the total data set, complete question sets of 1358 students (aged 10–18 years, $M \pm SD = 12.82 \pm 2.6$) were analyzed. The gender ratio was almost balanced with 51% female students. This proportion by chance was the same in all STEAM implementations.

For statistical analyses, IBM SPSS Statistics 29.0 was used. Outliers were rejected. Following the central limit theorem, we assumed normal distribution of the data [49], p. 9. A Wilcoxon test was applied to calculate potential differences in gender. A regression model was calculated with flow as the dependent variable and SE, age and gender as predictors. We calculated this regression model for both the pre-test and the post-test data.

3. Results

No gender effects appeared. To analyze the dependence of flow on self-efficacy, a regression model was calculated with flow as the dependent variable and SE, age and gender as predictors. We calculated this regression model for both the pre-test and the post-test data.

The technical prerequisites for the regression were given in both data sets: After analyzing the student-sampled excluded residuals, only four outliers were excluded. Leverage and Cook distance showed no outliers. The P–P diagram of standardized residual suggested normal distribution. The Durbin–Watson statistic suggested that

	R	R^2	Corrected R^2	Durbin–Watson statistic
Pre-Test	.335	.112	.119	1.720
Post-Test	.469	.220	.218	1.659
Influencing variables: (constant), SE, gender and age; dependent variable: Flow				

Table 2.
Model summary of regression analysis (incl. The influencing variables).

		df	F	sig.
Pre-Test	Regression	3	56.935	<.001
	Non-standardized residuals	1355		
	total	1358		
Post-Test	Regression	3	106.200	<.001
	Non-standardized residuals	1129		
	total	1132		
Influencing variables: (constant), SE, gender and age; dependent variable: Flow				

Table 3.
ANOVA of regression analysis (incl. The influencing variables).

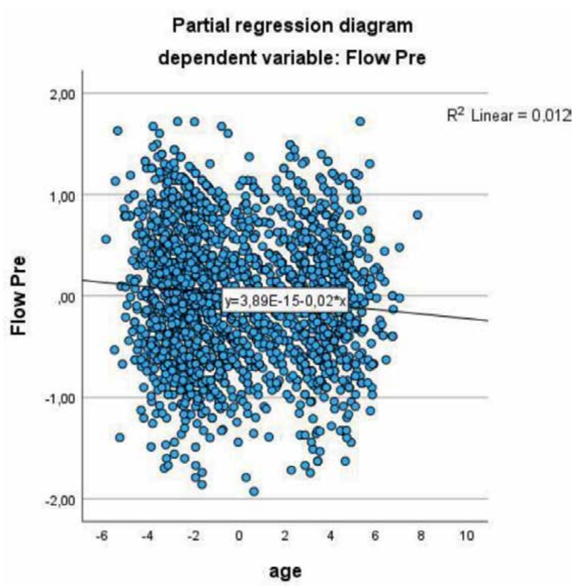

Figure 2.
Scatterplot of residuals illustrating the relationship between age and flow. Pre- and post-test showed an identical trend (not illustrated here).

there was no autocorrelation (**Table 2**). The Pearson correlations proved the data set to be very suitable with Person Corr. max. 0.387 (which should be <0.7). Multicollinearity was excluded with values above 0.77 (tolerance openness: 0.838; treatment 0.773; SE 0.914) (tolerance should be >0.1). Homoscedasticity of the residuals

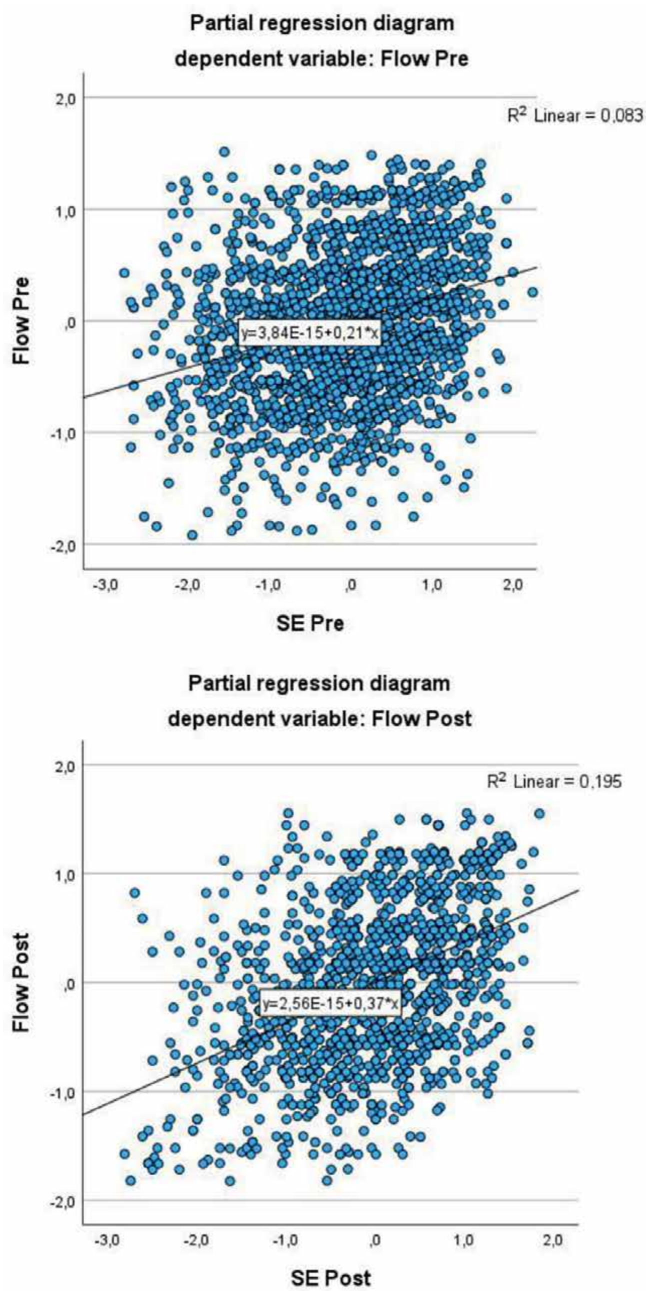

Figure 3.
Scatterplot illustrating the relationship between SE and flow. Pre- and post-test show the similar trend upper vs. lower plot, whereby it is stronger for post-STEM scores lower plot.

was ensured, which indicated that our model did not make better predictions for some values than for others.

Thus, all prerequisites for a meaningful interpretation of the regression analysis of the two data sets were proven. For the post-test data, collected after students participated in a STEAM intervention following the CREATIONS guideline, the R for the overall model was 0.48 (adjusted $R^2 = 0.22$), indicative for a high goodness-of-fit according to Cohen [50] (**Table 2**). Self-efficacy, gender and age were able to predict flow statistically significantly, $F(3, 1129) = 106.200$, $p < 0.001$ (**Table 3**). Even in the pre-test, when students have never received explicit creativity-enhancing STEAM education, the effects of SE, gender and age on flow were found. The R for the overall model was 0.34 (adjusted $R^2 = 0.11$), indicative for a medium goodness-of-fit according to Cohen [50] (**Table 2**). Self-efficacy, gender and age were able to statistically significantly predict flow, $F(3, 1358) = 56.935$, $p < .001$ (**Table 3**).

The effect of the predictors gender and self-efficacy on flow can also be seen in the scatterplots. There is a trend toward a decrease in flow with increasing age. This is identical at both test times (**Figure 2**). Self-efficacy strengthens the ability to experience flow. This strengthening of flow through SE became even stronger in the post-test (**Figure 3**).

4. Discussion

CREATIONS projects implementation has demonstrated innovative approaches and activities that involve teachers and students in scientific research through creative ways that are based on art and focus on the development of effective links and synergies between schools and research infrastructures to spark young people's interest in science and in the following scientific careers. In this framework, the present work demonstrates self-efficacy experiences as a trigger of flow which is considered to greatly contribute to students' motivation and achievement in science [51]. Work in the field highlights the role of time, place and attention for setting up conditions for flow experiences, in general, and in scientific inquiry in particular [52]. Furthermore, the use of innovative tools and advanced technologies contributes to both student performance improvement and the appearance of flow [53].

Not physiology but also culture may cause gender differences [54]. Csikszentmihalyi [55] reported that traditional gender discrimination in education determines how boys and girls develop. In line with other studies in Germany [32, 42, 56, 57], this meta-analysis of various STEAM projects found no differences, probably suggesting a gradually changing gender equality culture. Education that naturally integrates all genders ensures that it is less social desirability and more personal interest that decides which talents and career aspirations young people develop [58]. The teacher's attitude in particular can be inspiring in role development [59, 60]. Teachers may educate students to become creative democrats, but they need a modern, open-minded attitude as tutors of scientifically working students [61]. Such teacher trainings need modern forms that train the development of attitudes and ways of communication [62].

In our CREATIONS project, designing a number of learning experiences was the main focus that met the conditions for the development of flow. The term "experience" plays a special role in the framework of the current study and is defined as perceiving, discerning or understanding something that stands out in the student's consciousness, or how personal experiences stand out in their consciousness [63]. Students had numerous chances to pose questions and explore techniques and various approaches, or they were given a scientifically oriented question to investigate. Balance and navigation through dialog supported teachers and students in creatively solving educational tensions. Questions arose through dialog between students', professionals' and educators' scientific knowledge or through dialog inspired by interdisciplinary and personal, embodied learning.

Ethics and trusteeship were important considerations in experimental design and collaborative work, as well as in the initial choice of question. Students gave priority to evidence, which came from individual, collaborative and communal activity such as practical work or from sources such as data from professional scientific activity or from other contexts. To maintain the flow experience, we had to restore the balance between challenges (situations in which a student has major freedom of action) and skills (the capabilities or tools that a student needs to be able to cope with a challenge like and experiment or a project) [1]. One of the things analyzed in our study was what characterizes the students' approaches to restore this balance in group work while working with 3D environments and visualizations. Immersion and play were crucial in empowering pupils to generate, question and discuss evidence.

Students used evidence they had generated and analyzed to consider possibilities for explanations that were new to them. They used argumentation and dialog to decide on the relative merits of the explanations they formulated, playing with ideas. Students connected their explanations with scientific knowledge, using different ways of thinking and knowing to relate their ideas to both disciplinary and interdisciplinary knowledge to understand the origin of their ideas and reflect on the strength of their evidence and explanations in relation to the original question. Experiencing a phenomenon is the same as discerning aspects of the phenomenon in question [61]. For this to be possible, the student must be given opportunity to experience multiple aspects of the same phenomenon simultaneously [64]. This means that students need to be able to compare their previous experiences with the current one and then to adopt them for applicability in solving a problem in a new situation.

Communication of possibilities, ideas and justifications through dialog with other students, with science educators and with professional scientists offered students the chance to test their new thinking and to be immersed in a key part of the scientific process. Such communication was crucial to an ethical approach to work scientifically. Finally, it has to be noted that individual, collaborative and community-based reflective activity for change both consolidates learning and enables students and teachers to balance educational tensions such as that between open-ended inquiry learning and the curriculum and assessment requirements of education. This is likely to be an appropriate form of feedback that reinforces students' self-efficacy and thus enables flow experiences.

Having created the conditions for the development of flow, our analysis indicates that the conditions the students have at their disposal to create a balance between challenges and skills relate to the intended projects and activities that they were involved. The results of this study show that the versatility of the proposed STEAM approach offers a modular framework for the design of similar activities in the field. The analysis of the students' work on the selected challenges in the different learning settings shows that variation exists in the balance between skills and challenges.

This study shows that we can systematically analyze characteristics of flow within the framework of inquiry lessons in science. Although this study does provide an applicable flow model and offers certain insights into some of the generic properties of flow, it is too early to specify how the model can be used in various science lessons.

Further systematic research is needed, and the concepts should be studied in other areas to see if similar conclusions can be drawn.

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Section 2

Creative Pedagogy in Higher Education

Chapter 6

Collaborative Creativity in International Social Pedagogy Educational Settings

Irena Dychawy Rosner

Abstract

My contribution to understanding the various creativity logics stemmed from the research outcomes of a three-year educational developmental project. Based on previous experience and collaborative work, five universities started a project aiming to develop their teaching practice. The project was carried out with help from participating students, teachers, managers, and professionals working with youth issues. This study explored the elements of co-influencing collaborative creativity in the context of bachelor of social work programs. The repertoire of development strategies includes such techniques as research overviews regarding actual issues in the young people's living conditions, studying formal documentation, joint work in developing a course curriculum, and piloting pedagogical practice. I investigated the practices retrospectively, since the subject may be of interest to professionals and students in social sciences disciplines, who make use of qualitative research methods where the investigator may interact with research subjects and produces data from narratives, written texts, and discourses.

Keywords: collaboration, creativity, curriculum development, social work, health and society

1. Introduction

This chapter is mainly focusing on collaborative creativity within national and international collaborative knowledge networks in social pedagogy and social work education institutions. These institutions were working together (n = 5 universities) in a project funded by the EU and called social professions supporting youth in a European solidarity context—Erasmus+KA 203 (SP Young). The aim of this international workshop was to encourage strategic partnerships in higher education. The overall purpose of this chapter is to investigate, both conceptually and empirically, creativity attached to the role of shared learning and professional communities of teaching practice. Further, to share various illustrative examples of the dominant tradition that sees rational, explicit, and articulated understandings as the central ingredient in both practice and development. Such a tradition may stigmatize or ignore other ways of creating knowledge. These other ways—in opposition to logistic sequential development—may include, for example, processes involving more intuitive problem-solving approaches of supplementary holistic perceptions of the elements in the existing relationship, shared ways of thinking, and generating a creative alternative form of action. This chapter will illustrate how the ongoing creativity, development, and sharing perspectives, as well as determined project actions, uncover creativity within the existing academic and professional realities. This creativity construction and its transfer to other contextualization is undertaken on an individual level or combined within a process of formal educational programs in a specific sociocultural environment.

2. Conceptual perspectives

Creativity in this study understands as a new way of using imagination, or ideas to create something, for example, as having creative skills important for daily life and self-esteem or as the prerequisite for change. Various understandings of creativity, in relation to purposes, contents, and structural frames, are likely to produce different epistemologies about how creativity perceives and acts [1, 2]. In this way, creativity can be perceived every time when action takes place, based on different preconceived frameworks. Both social and relational factors can inspire or limit us. Creativity means a challenge and places us in a position to confront opportunities for change. People refine ideas and action patterns grounded in their knowledge experience, thus generating individual and unique creativity development patterns [3]. It has been argued that the major challenge for western countries is to contextualize education and knowledge about local and global transformations and how they influence life conditions for young people [4]. This study has its roots in universities' educational environment, where the organization of learning influenced by curriculum theories acknowledges the development of competence important to equip students in their role of helping clients in vulnerable situations. The role of social education should be to use a creative approach to existing professional rationales or discriminating societal structures [3–5].

Educational institutions that provide higher education within the organizational field comprising social professions have many similarities and address specific professional fields of actions, clients, technology, and theoretical approaches. Although they have different missions and different practical conditions, they can show some similarities, as they are knowledge-building organizations that work to combine the interests of the individual, state, and society. They have different prerequisites and can be organized on different principles and prevailing institutionalized perceptions, which give each institution its own identity. Further, educational institutions can be isomorphic despite offering education for similar types of professions. This is because their organization addresses different areas of knowledge based on public. This project case explored social work and social care related to young people's living conditions in Sweden, Poland, Lithuania, and Eastland. Five social work and social pedagogy departments participated. The existing differences lie in each institution's mission and role as an actor in the various national contexts. It was of interest to exchange experiences and, in an international joint collaboration project, develop new forms of education adopted for the social professions working with youth. The creative forces focused on collaborative logics, occurring pedagogical factors, and capacity building when dealing with professional issues arising from work with vulnerable young populations [6]. This also creates cooperation between individuals as bearers of competence and/or function. Individuals are deliverers of competence while functions carry qualifications.

2.1 Perspectives on importance of creativity logics

It is acknowledged in social professional's everyday work that increasing socio-economic inequalities and growing social problems are often individualized and considered as related to an individual's shortcomings or established cultural backgrounds [7]. The polish sociologist Zygmunt Bauman [8] claimed that the aspirational and individual independence of modern times has, in fact, rendered us incapable of interacting with other people. Through his concept of fluid modernity, he formulated thoughts and theories of individualism, loneliness, and current vulnerability. Freedom choice, without deep ties to each other, causes cumulative effects such as emptiness, resorts to consumption, and the economization of society's institutions.

Contemporary studies that deal with young people's living conditions demonstrate social vulnerability through problems regarding access to the labor market, high levels of unemployment, risk of increased criminal behavior, various addictions, increased poverty, and need for financial support [9]. Research investigating increasing immigration and challenges of localized social practices in Sweden found that global transformations influence the traditional methods of social work practices (for example, see [10]). It is, among others, within this context of socio-cultural structures, which limit an individual's opportunity to improve their living conditions, that conventional ways of social interventions articulate a need for progress and development.

Nonetheless, in this development project, it was important to discover how to help social work students play an effective role in the growing diversity of social problems beyond the particular individual case [11, 12]. It was also important to include their viewpoint to embrace both a unique individual perspective and the systemic structure surrounding their client [7, 13]. Such a position includes practicing multilevel social work and requires critical standpoints on hindrances at micro, macro, local community, and globalized levels [9, 12–14]. Subsequently, the overall inquiry question that guided the developmental process and collaborative creativity in this developmental project related to—How can educational programs support students of social professions in their function within local arenas and in a globalized world when improving young people's life chances?

In the context of personal and environmental factors, this scholarship implemented a variety of creativity concepts [1, 2, 15–17]. Furthermore, perspectives in the project created communities of practice [18], notions of activity theory [19], and the concept of a dialectical process between objective and subjective reality were important tools in co-construction of collaborative creativity [20, 21]. Additionally, creativity concepts in Ref. [1] and handbook for students and teachers developed by the project team [10] were found to be very important tools to stimulate curricular learning and the development of a learning environment that effectively energizes creative thinking skills growth.

The notion of proposed functionalist and interpretative concepts for understanding creativity in the context of this scholarship was consciousness-creating tool when retrospectively analyzing the project work process and its outcome [1, 2, 15, 20]. The interpretative approach focuses on the individual micro level and quality of communication between concerned participants [1, 3, 22]. Aspects of relationships in meetings, and the trust they create, are considered influential in how creative process unfolds [2, 23–25]. Furthermore, cultural aspects influence relationships in organizational meetings, that is, cultural aspects of individual and organizational everyday lifestyles [21, 24, 26]. The functionalist approach is to see creativity as a goal from macro-perspective placed upon the national power holders, such as the national EU agency and the international Erasmus+agency, which have distributive power over resources and bureaucratic goals. In this project's development work, consideration was also given to societal values in laws, regulations, governing documents, etc.

2.2 Creativity in a professional space

Operations in social field practices include, among others, empowering people, helping, communicating, assessing, providing social service, collaborating, and leading change process—but also making use of a large measure of creativity [2, 6, 22, 27]. These types of professional positions, actions, and roles have been described in Michael Lipsky's concept as front-line bureaucrats or street-level bureaucrats [28]. The thought models in social work, and social contexts, take into account the development ecology and see process as mutual interactions and as ongoing development, which affects relationships within and between both the individual's immediate environment and larger social context [14]. Since the 1990s, much has happened in society that has affected social work. For example, the client groups have changed and bureaucratic governance, digitalization, and marketing have been prominent factors [13, 29, 30]. Furthermore, the work expanded in other ways, for example, through educational development and specialization [7, 31].

In relation to professional life, the literature has shown some recurring and overlapping broad forms of creativity [1, 6, 22, 32]. Freedman [15] proposes that creativity, as a process in context and a learning process involving critical reflection, which is functional and provides a form of leadership. This creative process cannot be considered per see since it does not appear in a historical vacuum but, in fact, always refers to some past experience being reconsidered in the present. Consequently, the task and professional space of creativity are characterized by the framework that the organization has for the task the practitioner has [13, 22, 23]. According to Czarniawska-Joerges [20], human organizations create structural and practical aspects and capture symbolic and intersubjective understandings of meaning, which constitute and influence one another. Departing from studies on general notion of creativity in organizations creativity research recognizes the multifaceted nature of the creativity constructs ranging from minor adaptations to radical break troughs. It has been argued that organizational factors, such as work resources and organizational climate, lead not only to creative and innovative changes but also be beneficial for the individual in terms of better psychological well-being [16, 24, 25]. Consequently, because social work, educational approaches, and the practice of social interventions are so multifaceted and relative, the meaning of creativity is never neutral but always connected to historical, situational, organizational, and dialogic interpretations.

Furthermore, applied working methods have, to large extent, personal professional significance but can change due to the culture of community of practice and the improvisations that become necessary [11, 22, 29, 32]. Thus, the practitioner's creativity as a professional is shaped in part by the individual and their mission. Other factors, such as routines, professional interpretations, and traditions, as well as individual factors of the social worker and client and the interaction between them, are also significant [16, 17, 32, 33]. Another pattern in literature in the concept of creativity within professional space is the importance of building the knowledge base and presenting something new [16, 22]. A further important aspect relates to the so-called "community of practice" designed collaboratively by the project's team members. It is defined that communities of practice are groups of people who share a concern, a set of problems, or passion about the topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing establishment [18]. An important aspect within such structures is that creativity develops through knowledge creation such as building the knowledge base, while lifelong learning is acknowledged as existential base for the individual's intuition and cognitive development [3, 11, 31]. Supplementary, knowledge growth is recognized as important in the creation of professional roles and professional expertise. Contemporary scholars have begun reconsidering a range of methods related to creative practice to support learning and creativity of ideas and to generate reflections in response to those ideas [11]. For another example, see in Ref. [34], studies of students´ learning outcomes found growth in academic capability when implementing the 4C learning model. This model refers to students as creative, active, collaborative, and critical learning groups.

In addition, other corresponding forms of professionalism, such as space for independence in the performance of work, are important factors for the practitioner's possibility to be creative. To these, another aspect can be added, namely the individual's degrees of freedom in their professional role, access to resources, and opportunity for development [23, 25, 35]. The environment's acceptance of and contextual receptivity for change and different ideas are very important [26]. In social professions, there are strong points of contact between systematic humanizing support work and the search for creativity [2, 13, 17]. Psychosocial and social pedagogical social work can be seen as a kind of liberation from the oppressive mechanisms at work that limits both the professional caregiver and client. Creativity is, therefore, understood as shaped by individual, structural, and environmental factors as well as the position of the profession in terms of authority, occupational value, and positional strength.

3. Creative development example

There is no shortage of project ideas within the context of higher education. The outcomes of various project-related activities may be very different, but the logics of project work are build on development of new growth models and sources of inspiration, and create inputs for changes [12, 16, 31, 36]. Based on the previous development work and the discussion of creativity needed for the development of social, cultural, and support systems for the well-being of young populations in European countries in general [6, 12], a project was conducted called Social Professions for supporting Youth in a European Solidarity Context [37]. The goal of this work was the development of the art of education for students aiming to enter social professions. Hereunder, I look at how a project understood as creative process engages its members in a profoundly reflective, dialogical, creative, and functional relationship that creates a specific community of practice.

This study is partly influenced by qualitative methodology including data sampling and analyses on the descriptive level, and partly by participatory methodology. Given the specific focus on this study, a retrospective review of documentation from formal project meetings, interim reports, notes from international seminars, and memos from meetings with teachers, students, and field workers was conducted (n = 182). Each document was fully transcribed by a member chosen at the start of each meeting/assembly or voluntary secretary. Sampling of empirical data was completed purposively to allow analyses from different sources in order to ensure a mixture of perspectives. Basis for an organized and thematically sorted platform for the construction of meaning and data interpretation was generated using open coding methodology using the constant comparative method [38]. As reflexivity is a key component in qualitative research, two academic seminars and two critical friends not engaged in the project were further involved to stimulate reflections and discussions relating to the subject, deepening the analysis. This also generated an extending understanding and confirmation of trustworthiness [39, 40]. In this respect, the methodology of data interpretation has pointed out the importance of involving and co-producing understanding and knowledge development through participatory encounters and co-influencing the existing reality. The intersubjective understandings and interpretations were questioning data from the perspective of this broader question: How the ongoing collaborative processes mirror creativity and how the participants figure out its occurrence or shape?

According to these elements, on general level, the analysis identified three interrelated, overarching, and intertwined creativity frameworks: an integrative creativity, functionalist instrumental creativity, and adaptive developmental creativity.

3.1 Integrative creativity

An integrative course of action initiated the start of project work. It was important to create a common picture of the current state of knowledge encompassing the client population concerned, as well as the needs of various social services, and to relate this to an international context. There were many conflicts to clarify current cooperation and, not least, manage contradictions between the planning process, the project's goals, and a shortage of resources. In this perspective, it was important to focus on the needs of client, development of educational and pedagogical practice, and building up knowledge about the existing professional realities.

Another appeared creativity process was one to connect and integrate project team members. This entire creative process developed through actions such as local and international meetings, discussions, exchange of experiences, studying format documentation, making knowledge overviews, etc. This development creativity process occurred both in groups and individually. When sharing one's own and other's ideas about the subject and their working methods, in collaboration, ideas for future implementations developed. In joint work, participants both supported each other and challenged each other to go a step beyond their usual way of thinking. Creativity could take the form of both a group process and an individual, intuitive, and mental process [3]. The collaborative context is built on joint experimentation and on experiences from resources obtained in partners' contexts [6]. During such processes (e.g., exchange teaching practices course layout and contents exchange) the creative dimensions of both physical and distance meetings between team members were crucial. It was a process of cooperative and intuitive formulation where it was important to meet, listen, and reflect on the manifested issues.

Studies of the role of intuition in educational creativity contexts found intuition understood as specific way of knowing, one that does not really articulate the origin of how a specific situation or subject is perceived [3, 27, 31]. The integrative phase in this project was, in the beginning, dealing with some of the occurring problems more intuitively than cognitively, for example, viewing problems solution as hypotheses. The project team could react in an affective tone or sometimes exhibit more profound involvement, for example, deep engagement with a task force that later showed little importance for enhancing problem-solving formulations or activities. Despite certain circumstances being in place and different approaches of problem-solving, the project developed great results such as new didactics based on cross-border analysis of contemporary status of young people in partner countries (for example, see [37]. These results formed a base for the conceptualization and development of a new international course module from a socio-cultural, socio-ecological, and socio-political perspective related to the life needs of young people.

3.2 Functionalist instrumental creativity

Within the functionalist and instrumental rationalistic creativity logics, the focus was placed on creativity in economy management, teaching technology, and knowledge creation [4, 10, 41]. Each university contributed with its competence for curricula development and teaching methods. It was ascertained that the goals of the project were extremely overambitious and it was especially important to facilitate the distribution of tasks, as well as make decisions regarding recording and the responsibilities within the work process. In organizing learning, the project group focused on involving and taking advantage of the academic teachers' and students' ideas, needs, and views regarding the subject and teaching methods [34, 39]. It was important to mobilize several possible creative sources. Knowledge overview carried out by groups in participating institutions created the basis for curriculum development and the new course content. Urgent and actual topics, and concepts crucial for contemporary social professions related to the perspectives of young people, were broadly selected to inspire educators and students [4]. Further, a pilot study of the curriculum at each institution was conducted. The project groups developed a sharing of similar intentions between institutional approaches regarding the teaching and facilitating the students in acquiring skills needed for work with young people. A collaboratively developed handbook becomes an important tool in the direct teaching situation [10]. At this stage, creativity was intertwined in many of the projects both extensively intuitive and practical rational forms. This is in line with previous authors (e.g., [41]), examining broad tendencies in project management that suggested the changing development from dominated hard paradigm to tendencies for acceptance of the more soft paradigm. At this stage, the collaborative creativity was intertwined in many of both extensively intuitive and practical rational forms. Nevertheless, all creativity forms were primarily related to the interpretative dimensions within each university's structures of environmental and organizational logics [20, 25, 26]. The project team of attending academic teachers and students through concrete actions, discussions, and knowledge development while implementation of the pilot course deepened creativity of the curriculum. Given and structurally–developed course frameworks were open for creative changes. Students gave their views on which areas they perceived as most important for them to gain competence to meet with, treat, and create interventions for young vulnerable clients. The progression of functionalist creativity related to structural plans and schedules and measurements of factors indicating the progress and status of the work process. As also suggested in other studies [1, 15, 31], the sense of various relationships and elements of diverse situations were understood as more connected to analytical thinking than intuitive conceptualizing of occurring situations.

3.3 Adaptive creativity

Adaptive creativity meant a very intensive work phase for all partners. The shaped knowledge and previous experiences problematized and further processed more concretely in the direction of the goals that had been set in the ambitions of the project [2, 4]. For example, traditional education adopted more integrative curriculum development where each university contributed with specialist knowledge [10, 11]. The needs inventory and the research processed collaboratively by each institution showed that extensive investment in social implementations is needed to help young people in contemporary societal conditions [4]. The collaboratively created new course module, therefore, contained five sections of knowledge areas that students could master for professional social pedagogical work with young people: various aspects of general characteristics of youth problems, social exclusion vs. inclusive education, un-employment vs. wellbeing, then prejudice vs. tolerance, and risk vs. protective factors [10].

Within this process of creating collegial culture, development embraced increased interconnection of communication. The joint work highlighted issues connected with development and innovations and, most of all, positive meetings between people and the developmental conditions of the meetings, such as creative relations, exchange culture, and shared knowledge of social values [20, 21, 24]. The developed or occurring situations could be described as partly intuitive logic and partly ritualized social responsivity [42].

Everyday life, according to Goffman [43], is lived unconsciously (e.g., socially created rituals) and is very difficult to uncover. In the same way, the professional community created within the everyday framework of the project exhibited partially intuitive unconscious forms as well as logically planned cognitive ones. This important implication was reflected in how the project practice formed pattern of routines, behaviors, and rules constructing social order [18, 20, 28]. These structures could benefit the creativity forms of all participants individually and the group community of practice at each university.

The members´ individual opinions, experiences, and ideas were acknowledged seriously. Challenges were recognized and worked through [4, 10]. Icebreakers were processed away and techniques for future work were introduced, discussed, and carried out. The established interconnection between member institutions may make a positive contribution to the improvement of international change and new forms of creative pedagogical achievement. For example, most of the participating universities have updated their courses and educational programs. Among other things, it can be mentioned that Klaipeda University includes its international students in the program and Malmö University generated CIM (Certificate of International Merits) in the graduation degree of Swedish student participants.

4. Creativity paradigms combined

Within the framework of the project, through pedagogic research methods, a new international education module has been developed and implemented. The innovative process was an attempt to evoke the reality of the future with conscious intention in the universities' pedagogical approaches and through meaningful professional contexts [1, 11]. The notion of rituals in everyday life and the project's daily routines united and ritualized appearance of social creative responsiveness [2, 42, 43].

4.1 Collaborative creativity

Carrying out development through projects means being able to detach oneself from various existing organizational prefixed logics. The multiple sources and various multilayered aspects connected to collaboration within this project formed unique collaborative creativity in the educational context. This, implementation of the SP Young project [37], resulted in opportunities for curriculum development, adopted for use in international academic contexts and adjusted to university requirements within the European Union [44]. The working process builds a base for reciprocal creativity for improvement of learning goals and institutional appreciation. In addition, the collaborative creativity recognized the participating universities´ multiple educational abilities. Creativity and professional development were expressed in a search for various forms of knowledge as well as through deep interactions and inspirations, in accordance with created or existing circumstances for action [21].

The resulted outcome from this study showed integrative, functionalist, and adaptive creative logics that did not emerge in a linearly rational manner, but rather appeared situationally—formed in relation to certain issues in the project's practicum, with specific actors involved and related to particular contextual circumstances. Thus, as it is pointed out in the literature [15, 17, 24, 45], the cultivated collaborative forms of creativity in this project had its nourishment from a diverse set of contributing factors. Major indicators of creative development were the participants´ personal and professional competence; openness to change was a crucial condition of the developmental atmosphere both within institutions and cross-institutionally.

A major challenge for Western countries is to contextualize education and knowledge related to both local and global transformations and how they influence life conditions for young people. Cultivating awareness of important social and educational issues provided openness to facilitate the collaborative exploration of links between both social work practices in participating countries at the individual micro-level and societal globalized macro perspectives.

The risk of modern society lies in its fragmentation ensuring unstable networks [8]. Within social care and educational research, it is emphasized that an increased awareness must emerge about complex systems surrounding the individual [7]. Difficult life events and stress increase the risk of a number of problems, for example, physical and mental illness, social vulnerability, and lack of protective factors [9]. In general, the risk of adverse outcomes increases as the number of negative factors increases. Despite the fact that there is a great variation at the individual level in coping with negative life events, it is also no longer possible to make point-by-point measures for vulnerable people. It is the knowledge and need for collaborative creativity that makes demands from both educators and professionals working in the field.

In this chapter, not all aspects of creativity may have been considered due to the arrangement, content, process, and design of the project concerned. However, this study indicated three forms or logics of collaborative creativity: integrative creativity, functionalist instrumental creativity, and adaptive developmental creativity. Further, this study indicated that collaboratively developed stimulation between students´ creative self-concept and creativity in teachers' guiding strategies (e.g., group work, reflective learning discussions, situational case methodology [10, 11], etc.) was beneficial for students' learning situations. Nevertheless, it may not be possible for the project participants to take into account each available institutional resource during the process; hence, as much as possible, this could be supplemented by examples given during the international meetings, study visits, sharing of documents, etc. The creative mechanism and creative thinking affecting the whole growth process are understood through exploration of the creativity progression and as a tool for the application of the evolving project process.

After the implementation of the pilot course, students gave positive feedback about the module content and learning process. They were very much looking forward to the summer course, which ended the project, to physically meeting their colleagues from other participating universities. Furthermore, the curriculum design incorporated multiple themes regarding young people's vulnerability and contemporary life situations. This allowed students to approach the subject from different angles. Various situations integrated into curricular activities and students' creative thinking integrated into the subject curriculum may thereby inspire students´ future performance. Cross discussions, reflections, and sharing of experiences related to both local and global perspectives help students to achieve more holistic understanding of themselves and their future personal roles.

In project meetings, there are usually clear motives for encounter and story provided to, for example, fulfill specific objectives. Nevertheless, that narrative falls out in a certain way is far from obvious—there are always alternative ways to perceive a present story. In the same way, narratives from different institutional contexts could meet, intertwine, and form new approaches to practice. This was possible through development of the collaborative logics that intertwine integrative, functionalist, and adaptive creativity forms. For example, digitalization and Zoom meetings due to COVID-19 presented the project with major challenges. However, because the group was not locked into one mode of functioning, it was able to creatively deal with the situation, and thus the project was able to successfully achieve goals. However, today's situation shows what challenges await in the future and how certain stories and forms of work will be silenced. Regardless of societal development, it is difficult to imagine a society without human encounters where perspectives are exchanged, or to imagine organizations without development projects, where creativity is allowed to flourish.

5. Closing remarks

The conceptualization of collaborative creativity in capacity building was founded on three separate but interrelated and associated creativity logics: integrative creativity, functionalist creativity, and adaptive creativity. No matter what mark the developmental work has left on the participants, the odds are likely that the educational programs and participating institutions have been somewhat positively affected. It is assumed that this developmental work could take place due to the occurrence of the creativity forms. The practical outcome of the development work is more related to collaborative creativity ideas and the creativity potential within the created community of practice than to the flexible aspects of the project's formation itself.

Collaborative creativity is indicated to be a context-dependent process and shaped both as intuitive and structural development. This study showed that it flourishes when it shapes and encloses integrative, functionalist instrumental, and adaptive creativity growth. The *integrative creativity* forms bridges and conflicts and helps create new insights. It helps to connect and integrate task forces, people involved in the process, and existing knowledge, as well as crucial environmental factors. The *functionalist instrumental creativity* showed to be intertwined in both intuitive and rational collaborative forms related to interpretative dimensions of contextual structures and existing relational elements. The *adaptive creativity* meant mastering raised process characteristics. It builds up developmental conditions and diverse forms of ritualized social responsivity. These core structures promote approaching different reality angles and cultivate intersectional creative mechanisms.

In summary, the use of creativity concepts can provide a conceptual lens to illuminate a change process; it captures both internal and professional processes of development and shapes positions in the field of practice, both educational and the student's acquired professional knowledge. Creative potencies may be inserted by many events, both through coincidences and conscious actions. They can take the form of as well individual and collective expressions. In this way, this inquiry contributes to unique insights and understandings of creativity as a developmental phenomenon and as a core means in both individual, socio-cultural, and organizational human environments. This may imply an ongoing widening of the project management scope to include reconsiderations regarding more than hard rationalistic structures but also value deductive and interpretative soft meanings approaches to practice. However, it is important to notice that creativity shapes communication and experience in many different ways, forced by interaction embedded between political, societal, methodological, and personal considerations.

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Chapter 7

The Future of Education: Strengthening the Relevance of Lifelong Learning

Tone Vold

Abstract

This chapter explores educational practices to increase work relevance in lifelong learning education programmes. The outlet of the analysis is the development of skills for change, and to lay the grounds for innovativeness and entrepreneurial behaviour in future organizations. For the Higher Education Institutions (HEI's), there are different pathways to shape and improve on their relevance to education for the work life. We examine how higher education institutions can consolidate their position in the future by agile attention to the development of the necessary skills that promote innovative and entrepreneurial behaviour. The primary argument is a need for a dynamic co-evolving relationship between the work environment and the fine tuning of educational content and educational practices in order to bridge the gap from curriculum to work context, and the probability of a meaningful application of educational content at work. The qualitative data is collected through interviews with students and their colleagues and superiors within two different organizations in Norway. From the analysis, we suggest a conceptual model providing further details of these "relational interdependences" between educational and work factors and outline some basic underlying factors in the work environment that help shape the relevance of skills needed in work life.

Keywords: work relevance of education, lifelong learning, knowledge production, organizational change processes, knowledge economy

1. Introduction

In recent decades, the concept of relevance has attracted quite a bit of policy attention. The majority of the intellectual traditions studying "educational **relevance**" focus on the intrinsic factors and characteristics of the educational curricula within Higher Education Institutions (HEI). This chapter explores how work organizational factors also contribute to help shape the relevance of adult higher education, a topic we believe is vastly neglected in the extant literature.

In this chapter, we will derive ways of suggesting an enhancement of the relevance of higher education for a rapidly evolving work life.

Several key policy documents help to underscore the political significance of the work life relevance of higher education in general and, in particular, the need for effective higher education lifelong learning schemes. In the report, "Promoting the relevance of higher education" [1], commissioned by the European Commission, the authors formulated three main objectives for higher education used as a measure of relevance, adding *sustainable employment* and *personal development*, which is about individual, sustainable employment and active citizenship. In the white paper from 12th March 2021, the Norwegian government states that higher education needs to meet the needs of both present and future work life [2]. This white paper further states that this is about developing and utilizing new solutions that are sustainable, and also support the advancement of the scope and quality in lifelong learning. It is about what and how students should learn, and that this includes not only factual knowledge, but also generic skills, such as skills for a better collaboration in work life, for continuous self-learning and for managing the technological and managerial processes of change that are now the norm in organizational life due to the rapid digitalization of the societies. In addition, they point out that there is also a question about how and to what extent the HEIs support the students, both during and after their studies, by preparing them for their return as future employees/students for lifelong learning purposes.

This preparation is about enabling the students to assume a degree of relevance of their education.

In this book chapter, the focus is on the various types of the involvement of the students in curriculum activities, with an added focus firstly on their ability to tie new knowledge to their experiences from work life, and secondly to prepare for an understanding of how they may utilize new knowledge in their work life.

We therefore propose that in order to utilize the knowledge the students/employees draw from the more "generic" courses in adult HEI programmes, we need to not only focus on the university, but also to look more carefully and closely at the employing organization's characteristics, and to the factors leading to a "meaningful" utilization of certain types of new knowledge and skills. Hence, this discussion naturally leads to the following research question:

> *What are the factors that enable the facilitation of educational relevance in organizations?*

In order to help answer this, there is also a need to explore the theory and previous research on "educational relevance", on what constitutes relevance for the students and for the organizations. Likewise, how to teach a curriculum to make it relevant, and how to facilitate for the students to acquire this knowledge in such a way that they are able to utilize it, is what is required of the HEI, both now and in the future, as the number of adult students returning to campus is increasing [3].

2. Methodological approach

The empirical method applied is that of a comparative case study. Two different approaches to meeting the requirements of adult students' need for work-relevant education have been investigated, a Health Manager Education (bachelor's degree programme) and a Knowledge Management study programme (half year programme) both offered at the Inland Norway University of Applied Sciences, Norway. The reason we chose these two case studies is that it allows us to more carefully examine the impacts on the relevance of two educational approaches within the same country, the same county and the same higher education institution, but in two different work life settings, thus keeping constant some of the important factors that could have an effect on the findings from the two case studies.

Qualitative data has been collected through interviews using a semi-structured interview guide [4–6], with the respondents divided into three categories: the main respondents, which are the students/employees, the secondary respondents, which are their managers and the tertiary respondents, which are co-workers and/or subordinates. The interviews were recorded and transcribed. The data (the transcriptions) was analysed using NVIVO using a *hermeneutic* approach [7] (p. 45). The approach was in line with *content analysis* and *latent analysis* [8] (p. 9) rather than "manifest analysis" as we this time needed to go beneath the surface and interpret the meaning of the statements [8] (p. 9). We started out finding themes and from the data we labelled codes, and collected the codes in documents. The analysis and discussions will unveil a suggested model for enhanced work relevance for adult students. Lastly, we will present our conclusions and avenues for future research.

3. The new context of academia and its relevance

Academia is no longer an "ivory tower" (p. 313) [9], but instead an organic part of a system to support the development of innovation, entrepreneurship and sustainability in an ever-developing knowledge-based society and work life. The literature describes the relationships between the various systemic "partners", and while governmental white papers are providing guidelines as to how academia should adapt within this system and provide a relevant education for an ever-evolving work life, the literature describes the importance of the cooperation between work life and academia.

Etzkowitz and Leydesdorff [10] developed the triple helix model, depicting how the universities, with funding from the government, could provide education and research for the industry to produce goods for a profit. In traditional academic curricula at universities (and other higher education institutions), the organizations and students may influence the curriculum to a lesser extent, as the courses are to be more generic to suit several different organizations.

Carayannis and Campbell [11] developed what is called the "Mode 3" (p. 202) of knowledge production, and introduced both a quadruple and quintuple helix. The quadruple connects civil society into the helix, and by adding the natural environments of society and economy into the equation as socio-economic opportunities that bring in sustainable development and climate change issues. Within the helices, the political system influences the research and development system (R&D), the science and technology system (S&T), the economic system and the educational system. With the emergence of digitalization and digitalized work forms in organizations, the markets change rapidly, and what may have been a minor local market may now be a global market due to new ways of marketing, for instance, through social media [12]. Consequently, to even a greater extent than before, markets may impact on organizations. It is therefore important for academia/higher education to equip organizations to not only handle, but even create, most of the opportunities that arise. In the Nordic countries, academic adult education has contributed towards developing individual competencies and a high-quality education, as well as lifelong learning

[13]. This allows for the development of democratic processes, which together with an "investment in human capital" and "constant innovation in the public sector", contributes towards "sustainable entrepreneurship" [13] (p. 13). Regional Innovation Systems (RIS) rely on higher education regarding research and development, with the roles of higher education within these helices being to supply basic and applied research. Within the quadruple helix model, there is a strong focus on co-opetition, co-evolution and co-specialization [14]. This has been enhanced by the 4th Industrial Revolution (4IR), which blurred the lines among the physical, digital and biological spheres [15]. According to Schwab [15], there is also a responsibility that lies with the academic institutions (as one of several stakeholders) to take part in the work on understanding emergent trends in order to shape the future. Indeed, the future of education itself has had a major development due to the evolving technologies enabled by the 4IR, such as Massively Open Online Courses (MOOCs) and Learning Management Systems [16]. However, there are still some 4IR technologies that are not widely exploited by the educational sector, such as Augmented Reality, Virtual Reality and Mixed Reality [17, 18].

In Norway, the government has initiated support for the higher education institutions, such as universities, to enhance work relevance [2]. Nevertheless, the influence is not only *from* the political system, as the political system has received input from the organizations, the markets, the higher education systems and other stakeholders. When the markets, stakeholders and/or the technological development "require" innovations, this may put a pressure on the political system, which in turn will influence the R&D/S&T system and thus the higher education system. Indeed, our research shows the incremental and iterative development that is a result of a political system, employer organization and higher education institution cooperation and collaboration on developing an education that would cater to the changes initiated from the government [19]. The Mode 3 thinking with the systemic approach to learning and developing does recognize that the learning partners include customers, suppliers, competitors and other companies, in addition to the universities. Even public innovation within the service provision has documented innovation processes, like within the development of services and systems interaction, and in how they provide their services.

From being an institution of knowledge production and education, academic institutions have become academic entrepreneurs in a coalition with industry and other organizations. Academia has produced "academic spin-offs" (p. 7), such as firms that exploit scientific research results, newly developed technologies and other inventions [20]. These are noticeable within several different application areas, for instance, in biotechnology and industrial software. The trend of entrepreneurship education developing a more collaborative, student-centred approach to teaching and learning has spread into other disciplines [20]. Based on an entrepreneurial mind-set, Kolb's [21] theory on experiential learning and Dewey's [22] "learning by doing" and building on previous experience, the impact has spread to other study programmes.

However, Kaloudis et al. [20] point out the importance of combining both traditional and student-centred pedagogical approaches. This will support developing the reflective processes needed to "learn through an experimental approach, which is central to the development of an entrepreneurial mind-set" (p. 92). This mind-set is important for supporting lifelong learning [20]. This may imply an opportunity for returning students through their work life. Also, emerging trends within innovation research are features such as co-learning and co-production [20, 23], which imply that this needs to be introduced and practiced within the frames of a university.

Nonetheless, as the white paper [2] also states, there is not only the transfer of knowledge *from* the university *to* the industry/organization, as the employees are the experts in their own field who have insight into processes not accessible to the university. Some of the time, the industry/organizations need "learning partners who can help them find, digest and make use of relevant knowledge" and "who can help them come up with new ways of identifying and tackling challenges and opportunities" (p.103).

For example, The World Economic Forum claims that some organizations recognize the shift towards a more changing work life due to the digitalization and vast opportunities this has provided [24]. Some of the organizations interpret the rapid changes to mean less of a need for education, but a higher need for the particular generic skills necessary for the management of innovation and organizational change processes. Bolli and Renolds [25] argue that these are skills that are best taught at institutions of higher education and should hence strengthen the position of the universities.

4. The role of academia's contribution in the knowledge economy

Powell and Snellman [26] define the knowledge economy as "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technological and scientific advance, as well as equally rapid obsolescence" (p. 199). They further state that "the key component of a knowledge economy include a greater reliance on intellectual capabilities than on physical inputs or natural resources, combined with efforts to integrate improvements in every stage of the production process, from the R&D lab to the factory floor to the interface with customers" (p. 199). This implies an interest towards learning and knowledge development, distribution and management, and therefore an enhanced focus on how to support this.

Indeed, Keep and Mayhew [27] claim that solving problems and working in teams are just as important as theoretical knowledge and technical capabilities. Analytical thinking that supports analysing information to address work-related problems and issues, selecting and utilizing methods and procedures appropriate for learning and teaching within the organization, decision-making and creative and alternative thinking regarding developing novel solutions to work-related problems are becoming increasingly important.

According to Janssen [28], "innovative work behaviour"(p. 287) is about applying novel ideas in a work environment, as it is also about enhancing work performance and finding new ways of working, utilizing technology in new ways and adopting new technology and new skills [29].

In the Norwegian white paper "Education for Change" [2], it is suggested to have a tighter coupling between higher education and work life, in order to improve the understanding from work life as to what they may expect from students, and for higher education to comprehend not only the present and pressing needs of the work life, but also the future needs.

However, according to Bolli and Renold [25], it is of fundamental importance to ask where it is best to learn a specific skill, that is at work training or in an organized course setting at HEIs or other private providers. In their study, they investigated what types of skills HEIs have as an advantage in teaching, as opposed to learning them in a work training setting.

In the next section, we will address the literature that has investigated how and to what extent the opportunities for facilitating for innovative behaviour and support organizational changes are developed in higher education.

5. Academic adult education and the comparative advantage of higher education

Regarding work-based learning, Raelin [30] claims that a theory is needed regarding learning from practice. The learner may be introduced to theory after an experience "in order to question the assumptions of practice" (p. 564). He further states that: "The teacher's intentions and the students' understanding are best achieved through action" (p. 564). This implies that action is needed to help understand the implications of the theory. Raelin's critique of "conventional learning methodologies" is that the knowledge conveyed in the classroom is explicit, whereas some of the experiences they may face outside of school may provide the students with tacit knowledge.

Even so, Bolli and Renold [25] claim to have evidence for higher education institutions' advantage regarding teaching strategic management, innovation, human resources, organizational design and project management.

Raelin [31] points out the social context of learning. In organizations, one may form what Lave and Wenger termed "Communities of Practice", in which members of the organization work together, discussing and debating, to solve a "problem" [32, 33]. This social context will also represent situatedness within organizations. This situatedness is addressed in academia by case solving, role playing, gaming and the use of tools that enable a work life resemblance [34–38].

Dewey's "learning by doing" [22, 39] is also about practicing and experimenting, as students often find a discrepancy between what they have learned as theory, and how this appears in action. This may resemble what Argyris and Schön (1996) present as "espoused theory" and "theory in use", "espoused theory" being what the students bring from being taught a theory into putting it into action. Still, the action may bring different or modified versions of the theory; hence, the need to employ "theory in use". According to Raelin [30], these theories may be "aligned" through experimentation in the classroom (such as role play, simulation, exercises) or in real-life settings [40].

The support that academia can offer may reside within the areas of a willingness to learn [41–43] and learning to learn [44]. This corresponds with the OECD soft skill to "acquire new knowledge" [45, 46]. A "willingness to learn" may also be tied to self-efficacy [47] and intrinsic motivation [48]. Karatas et al. [49] have interpreted the definitions by Ryan and Deci [46] and Deci and Ryan [50] regarding intrinsic to be a "motivation that originates from within the individual and results in enjoyment of the process of increasing one's competency in regard to particular academic tasks" (p. 162). Learning also requires reflection processes [51, 52]. In HEIs, reflection is generally a part of the educational process [53]. *Reflection* is therefore something that we can include as a part of the training at HEIs. In fact, training for reflection and preparing for the students becoming *reflective practitioners* [54, 55] may support utilizing reflection back on the organization. Raelin [30] claims that organizations rarely have time, nor prioritize spending time on reflections for learning in organizations. Knowing how important reflection is for the learning process [21, 56, 57]; making reflection a part of routines may also support the development processes back into the organizations and aid in the process of becoming *learning organizations.*

Universities have yet another advantage in their pedagogical instruments that provide them with a comparative edge, as opposed to at-work learning. The utilization of pedagogical tools such as "e-learning, solving case studies and reflecting on work experience in school" aids in the development of the desired skill needed in one's work life [25]. Bolli and Renold also claim that factors like being able to be "presenting case studies of the workplace in school, presenting a survey in the workplace at school, making a learning contract and documenting the learning process in the workplace" enhance the universities' positions regarding the development of soft skills. This suggests a closer contact with the workplace and encourages the students to utilize the work experiences in their school situation, such as using examples and cases based on experiences from the organization, and also utilizing the new knowledge acquired at the university back into the organizations.

6. Organizational characteristics benefitting from learning in higher education

As our research has been on middle managers, both within the health sector and a private enterprise, we have sought towards other research done on educating middle management. Ballo and Dahl (2018) assert that an efficient pedagogical method should aspire to creating an association between the learning context and the work context, and investigate structures and processes within the organization that seem to forge this association. The structures in question are group structures and learning structures (such as learning methods). According to Ballo and Dahl [58], they "contribute towards developing the relationship between different learning and work-structures in the organization" (p. 12). This presupposes a focus on different processes and connections between phases concerning learning, and they propose the example of the transition from reflection and analysis to action [58]. They emphasize the fundamental importance of establishing learning and leadership as an integrated perspective for knowledge management at all organizational levels. The processes are management activities, knowledge management processes, work processes and learning processes at different levels within the organizations.

Ballo and Dahl [58] present two perspectives: 1) "managers participating in management development programmes take part in one or more learning processes" (p. 19) and 2) "management of work processes in organizations that offer [public] services also need to be understood as management of learning processes" (p. 19). Management that involves learning embraces both the organizational development and the employee dimension, meaning that combining the learning context with the work context is about adapting the work context in such a way that the learning processes for managers and their staff are a part of the work processes.

We can find an example of the association between the learning context and the work environment in our own empirical material. One of the case studies scrutinizes the Health Middle Manager Educational Programme at the Inland University of Applied Sciences, where it is deliberately required from the adult students (also health personnel) to apply examples from their own management experiences as illustrations for their learning in the adult education programme [59]. This pragmatic approach, and the specific work with their own real-life experiences and dilemmas, ultimately led to a more reflective professional practice, as well as to specific changes at the workplace that were possible to trace back to the experiences and discussions from the educational programme [19]. The important point here is that the organizational factors enabled changes and can be described as an *articulated and conscious acceptance of the need to experiment, to test new methods and to change and develop the new practices and routines in the organization*.

Another example of coupling a learning context with a work context is shown in a research project investigating how a previous student who was training in a responsible manner was able to utilize their own workplace for practicing and implementing changes derived from the learning context [59]. This research also implies that a managerial position may be a factor that *enables bridging the learning context and the work context*. As a result, the organizations benefit from the soft skills taught and developed in this collaborative exchange, as the learner (employee) is able to actively convert the learning into organizational development processes.

An important additional argument here is that the learning does need to be perceived as relevant, not only in a work context, but also personally at the individual level [59, 60]. When, for example, a gap analysis within any organization recognizes the need for a particular kind of competency or knowledge in order to innovate and grow/change, the employee affirms this need and views the possibilities and opportunities for his/her career advancement and job satisfaction by acquiring the "missing" skill in an adult higher education setting; the chances for more targeted learning and its application within the organization are then clearly greater. In this way, the learning (of the individual) and the practicing (in the organization) become organically relevant to the organization, as they contribute to filling the needs for change and innovation, in the sense that Nonaka [61] describes innovation as: "a process in which the organization creates and defines problems, and then actively develops new knowledge to solve them" (p. 14).

The figure below exhibits a model depicting how the relevance of an educational activity at the individual student/worker level is shaped by distinct organizational structures and processes, as exposed in the argument above (**Figure 1**).

What the figure above indicates is that the person/employee/student is *a part of the organization* and thus may be a part of analysing and recognizing the competency gap that they will be contributing to filling in order to contribute towards innovativeness. In previous research, this interaction was actually observed and identified as an important factor for enhancing the degree of work relevance of adult higher education trajectories [19, 59]. This research illustrates that as active members of the organization, the employees contribute to shared cognitive realities of organizational needs and gaps, in which they see *themselves* as potential contributors/employees/managers. In turn, this provides the Personal Association [60] that develops into a "personal identification", that is one's own genuine interest in the educational field the employee pictures as important for the organization. In other words, the degree of employee autonomy and participation in the decision-making, and a shared view of the priorities, threats and opportunities in their organizations, is a key factor in shaping the relevance of adult education back into an organizational context.

It is also pointed out the importance for the organizations to commit to utilizing their employees' skills and abilities [62–64]. This will contribute towards a higher level of self-efficacy [64, 65], which helps to reduce the chances of having educated an employee who is less motivated [66] due to a low utilization of skills and abilities, and thus contribute to a turnover [62, 63].

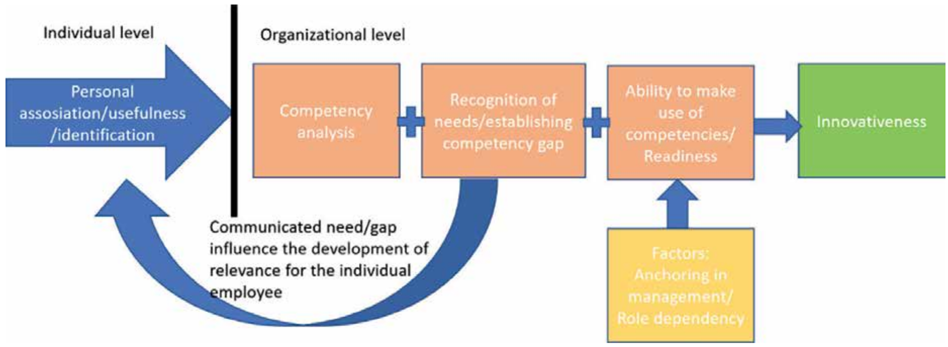

Figure 1.
The interaction between personal relevance and organizational relevance.

The students at the health care education found that *studying together* in the same educational cohort created synergies that they felt would benefit the organization [19]. Learning in teams and sharing the same educational experiences and theoretical concepts seem to support organizational learning [67], which again enables innovative behaviour. Arie P. de Geus [68] claimed that one learns faster when in a team. He explained that this was a matter of mobility, innovation and social propagation, insofar as being able to shift in a market, being able to innovate to survive and to need one another to perform, also claiming that skills should be preferred over "irreplaceable individuals", as this would demolish the community. At the same time, it is important to develop the individuals to their "full potential", since this enhances the innovative potential of a firm [68]. Though depending on its individuals' skills, team learning is a collective discipline that depends on the ability of discussing and maintaining a dialogue.

The case study on the student who graduated from the knowledge management programme at the Inland University of Applied Sciences, even though being on a close study of one individual alone and his reflections on the education programme he graduated from, the data shows that the way he worked within the organization resembles that of a team builder; he engaged his colleagues in the development for changes. In this case study, our main respondent included and engaged his co-workers for developing an on-boarding programme in order to reduce turnover and the time for training [59].

Our data also displayed a discrepancy in the middle managers' own perceptions versus the manager and the subordinates of one of students/employees. The student/employee interviewed reported—as did the other main respondents—on a high level of learning outcome, and also about having implemented changes. Yet, the managers and the subordinates only reported on minor changes. Digging deeper into the data, we notice that although the organizational position is described as "middle manager", the opportunities for major changes may be marginal due to several issues. On the personal level, the personal traits of the middle manager may influence the outcome of the desired induced changes. Resistance to change in an organization [69] may be due to communication (too much or too little), capacity within the organization and ability to empower the subordinates in order for them to execute any changes. Additionally, as mentioned by the manager, who is also the manager of one of the other main respondents, the ones who were able to induce major changes may be viewed as "over achievers" with exceptional talent for empowering their subordinates. This displays an interesting difference among the main respondents that should be investigated further, for example regarding previous background and education, personal characteristics, career and personal motivation.

The education should thus facilitate for reflection and develop an understanding for the problem areas in order to develop solutions, while also developing capabilities for empowering subordinates to cooperate and collaborate in developing the solutions for the recognized issues. This implies utilizing real-life cases from their work life. Therefore, the workplace and their managers need to approve and support the process of recognizing potential improvement areas in the organization, as well as monitoring and supporting the process of implementing any change processes.

The figure below displays the interaction and exchange between the HEIs and the organizations. Within the organization the learner is an employee, while within the HEI the learner becomes a student. The HEI facilitates for learning about the different organizational learning issues (such as, for instance: knowledge management, empowering leadership, organizational change processes, innovation and organizational development processes). The lecturing emphasizes tying the learning to the students' workplaces, and encourages and supports recognizing issues from organizations. Hence, there is a requirement from the HEI that the assignments are issues unveiled at the students' workplace. The development from understanding the curriculum, through connecting it to one's own experiences and observations, also includes seeking to implement any changes suggested by the students based on the theory in the curriculum. The whole process involves reflection processes, both prior to the work back in the organization, during the work on the change processes and also after in the form of an evaluation process. Students who are employees are active members of the work environment and possess a role [63] that provides them with a varying degree of opportunity and flexibility to influence the organization (**Figure 2**).

The model thus shows the dynamic intertwining of the learning context with the work context [58]. What the model does not depict as another important factor is *the learner's position within the organization*.

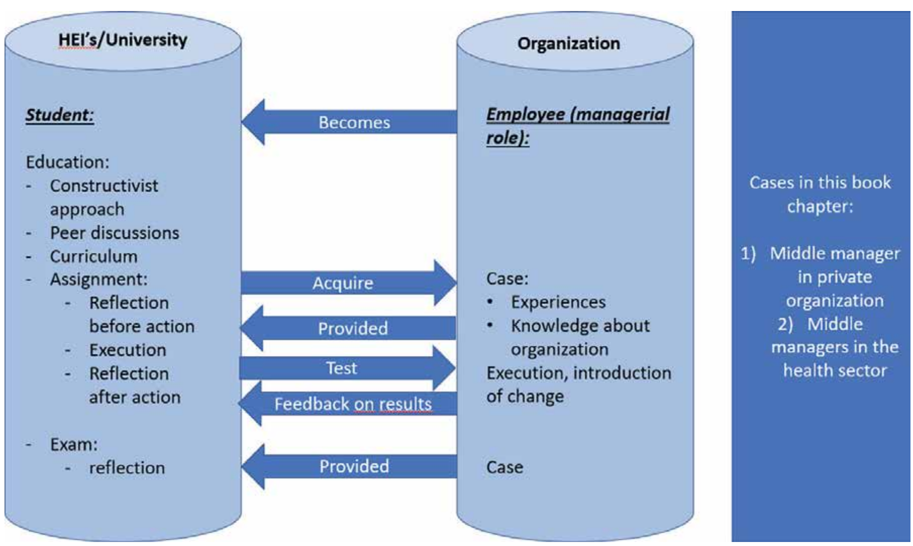

Figure 2.
The interaction and exchange between HEIs and the organizations: Utilizing the students'/employees' own work situation as a basis for education and (possible) organizational change.

7. Discussion

The argument so far, and the model above, underscores the following key findings and conceptual developments of this paper: The concept of "educational relevance" is "relational" in the sense that there must be some basic underlying factors in the work environment that provide "meaning" and "action content" to the acquired skills. We may go even further and claim that the acquired skills are able to play their role when there is a harmony among individual inclinations and talents, newly acquired educational soft skills and work tasks, as well as work organization and expectations in the receiving organization. This implies that there needs to be facilitation within the work context that secures the further development of soft skills. According to Raelin [30], there is generally less focus on the reflection and learning from reflection in the everyday work life within organizations, as their primary focus is on the production of services or products. The reflection processes are an important feature of developing analytical thinking, and at the HEIs this is an integral part of the education, while in an organization there needs to be a culture and focus on reflective processes in order for this development to be achieved [69]. Reflections should ideally be carried out with peers, preferably within the same organization [19], as this team learning [67] may contribute to a more sustainable implementation of the learning outcome within the organization.

Hence, there should be a *dynamic co-evolving relationship* between the work environment and the fine tuning of educational content and educational practices. We argue that this dynamic co-evolution will increase the probability of meaningful applications of various items and modules of educational content at work. For example, universities could offer more targeted university degrees designed for—and sponsored by different organizations, in which the educational content is determined by what the organizations need regarding knowledge development and research development [20]. This does not contrast the fact that universities are learning arenas that provide relevant and sustainable learning outcomes without a direct coupling to work [70]. Indeed, through entrepreneurship education, universities may also facilitate for new organizations to form based on what has been cultivated through education [20].

These points above accentuate the need to systematically develop arenas, in which in-depth discussions about the actual competence needs, strategical challenges and future possible technological and market trajectories in the business and public sectors should and could shape the content and form of the supply of (adult) higher education soft skills to the broader labour market. The managerial position in organizations is that they are expecting learning to be converted into action. In vocational education and training, there is a clear expectation of an implementation of the learning in a work setting [71]. Likewise, when the particular study programme is developed through the triple, quadruple or quintuple helix system [13, 72, 73], there is an expectation of some return on investment [19], not only from the organization, but also from the individual learner.

Yet, this systematic development cannot be achieved at a general educational level. There must be a systematic and specific feedback from the students and their work environment at the level of the educational programme, even at the level of individual courses within the educational programme as a means to co-develop and shape in common the meaning of the "relevance" as a concept. For the HEIs study programmes that are not yet co-developed with industry, this implies a focus on a more granular level to persuade students utilizing student-active methods of their relevance. Herein lies the importance of understanding the impact of involving students that make them build their knowledge on existing knowledge [22], preferably in a social setting

[32, 33]. Being able to discuss and reflect with peers, in order to understand the connections between their background/own work context and the curriculum, aid in the establishment of the personal relevance [60, 74–76].

8. Conclusion

The skills needed for innovation and entrepreneurial behaviours can be developed at both adult higher education and at the workplace. However, the higher education has an advantage in that it has the ability to support the students with the necessary innovation soft skills, such as a "willingness to learn" and "analytical thinking", in addition to contributing to the organizations' ability to utilize new knowledge and skills.

We have identified factors in the organization that are possible to induce by adapting and organizing the learning activities in higher education in such a way that the organizations are gradually involved and attentive to take an interest in their employees' career and competence development. As a result, bridging the gap between the learning context and the work context is an important systemic policy issue. Team learning seems to be important in both the HEIs learning context and a work context. By having more than one employee from the same organization studying the same courses may facilitate for enhanced learning not only for students, but also for organizational learning.

Nevertheless, if the student/employee is able to utilize his/her colleagues as a learning team (without them being students), it is still possible to facilitate for a collaborative learning process.

The main respondents in this study have been middle managers, which by position may enable them to execute any changes recognized, and implement solutions. However, this may also be dependent on their personal traits, organizational issues and internal resistance within the organization, among other issues.

9. Future research

As there are ever-increasing demands of change due to, for example, digitalization, emerging and disruptive technologies and environmental challenges, we recommend a continued research into how universities can collaborate and cooperate to provide a relevant education for the future work life. The ever-evolving market for lifelong learning may therefore provide a basis for doing research into discovering more factors that enable the universities to stay relevant in the future.

The particular issues of organizational resistance to change, and factors hindering the facilitation and execution of change processes as a part of the educational programme, should also be further investigated. What are the mechanisms that need to be "unlocked" in order to facilitate for a recognized and desired (?) change process during the course of the education? This may further support, and put a focus on the collaborative process of lifelong learning, between HEIs and organizations.

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The chapters in this book explore the methods by which the many aspects of creative pedagogy might be implemented in the context of teaching and learning. One chapter proposes a creative approach to studying local history, while another suggests a pedagogical framework for coding education that has the potential to foster the development of creative thinking abilities and equip individuals to actively participate in global affairs. The utilization of case studies in the field of Citizen Science demonstrates the implementation of a comprehensive and innovative learning framework that incorporates several sensory modalities. Another chapter demonstrates the potential of maker spaces in fostering active and creative learning as well as enhancing student engagement among underrepresented and minority populations. One chapter explores the emergence of flow in STEAM activities as a means to promote heightened levels of comprehension and active engagement in science education. The book concludes with the presentation of two scholarly studies on the implementation of creative pedagogy within the context of Higher Education. The first study explores the advantages of collaborative creativity within the bachelor of social work programs. The second delves into the pursuit of an innovative design that effectively connects the curriculum with the work environment, resulting in the integration of valuable educational content inside professional settings.

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