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Children's digital skills acquisition in non-formal educational contexts: pedagogical practices, learning, and inclusion opportunities in coding and robotics workshops

L'educazione alle competenze digitali in contesti educativi non-formali: pratiche pedagogiche, apprendimenti e inclusività nei workshop di coding e robotica

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Abstract
Coding and robotics education has drawn a lot of interest in recent years to get children ready for the future labour market and advance their digital skills. This paper focuses on coding and robotics workshops in non-formal educational settings in Belgium, Denmark, and Italy. Building on data from a comparative/cross-national study, part of the broader ySKILLS project, we will present findings from 16 observations of such workshops followed by 11 interviews with the organisers and moderators with the purpose of investigating their pedagogical practices, learning and inclusion opportunities. Findings of this study suggest that while digital skills workshops in non-formal learning contexts are designed and implemented with the goal of encouraging children's collaboration and active participation, the structure of the learning activities, the organization of the learning environment, and the choices made by children themselves may promote individualistic practices. Furthermore, despite attempts to encourage diversity and inclusion, such as choosing a "free" and "open-door" approach, these workshops may fail to attract participants from diverse backgrounds. We argue that an active dialogue between organisers and moderators, researchers, parents, and, of course, children from various backgrounds is required to promote child-centered approaches that move beyond individualistic accounts of learning and toward the creation of more collaborative and inclusive digital skill activities through a systemic and holistic approach.

Keywords: non-formal education; coding; robotics; digital skills; inclusion.

Riassunto
L'educazione al coding e alla robotica ha suscitato un grande interesse negli ultimi anni come strumento per preparare i bambini al futuro mercato del lavoro e per migliorare le loro competenze digitali. Questo articolo si concentra sui laboratori di coding e robotica in contesti educativi non formali in Belgio, Danimarca e Italia. Basandoci sui dati di uno studio comparativo/internazionale, parte del più vasto progetto di ricerca ySKILLS, presenteremo i risultati di 16 osservazioni di tali laboratori seguite da 11 interviste con i rispettivi organizzatori e moderatori allo scopo di indagare le loro pratiche pedagogiche, le opportunità di apprendimento e di inclusione che da tali esperienze derivano. I risultati suggeriscono che, sebbene i laboratori di competenze digitali in contesti di apprendimento non formale siano progettati e realizzati con l'obiettivo di incoraggiare la collaborazione e la partecipazione attiva dei bambini, la strutturazione delle attività, l'organizzazione degli ambienti di apprendimento e le scelte fatte dai bambini stessi possono promuovere pratiche individualistiche. Inoltre, nonostante i tentativi di incoraggiare la diversità e l'inclusione, offrendo percorsi gratuiti e aperti a tutti, questi laboratori rischiano di non attrarre partecipanti provenienti da contesti differenziati. Su queste basi, reputiamo necessario un dialogo attivo tra organizzatori e moderatori, ricercatori, genitori e, naturalmente, bambini di differente background, per promuovere approcci centrati sui partecipanti basati su attività più collaborative e inclusive attraverso un approccio sistemico e olistico.

Parole chiave: educazione non-formale; coding; robotica; competenze digitali; inclusività

Credit author statement: This paper and the research behind it is based on the collaborative efforts of all the authors. With respect to the research process: Giovanna Mascheroni and Davide Cino prepared the research protocol and materials to be used by the different national teams and collected the Italian data; Bieke Zaman and Silke Brandsen collected the Belgium data; Eva Eriksson and Natahalie Bressa collected the Danish data. All the authors contributed to the refinement of the research protocol and materials and to the data analysis. With respect to the paper: Davide Cino wrote the introduction (paragraph 1), paragraph 2 (2.1 and 2.2), paragraph 3, paragraphs 4, 4.3, 4.4, paragraph 5 (5.1, 5.2, 5.3) and parts of paragraphs 4.1 and 4.2; Silke Brandsen wrote parts of paragraphs 4.1, 4.2 and paragraph 6 and contributed to paragraph 5; Nathalie Bressa contributed to paragraph 4.4. and paragraph 5. Giovanna Mascheroni, Eva Eriksson, and Bieke Zaman revised the whole manuscript, provided adjustments and feedback, and contributed to the different paragraphs.

1. Introduction

Coding and robotics education has gained significant attention in recent years to prepare children for the future workforce and promote their digital skills, from preschool to secondary education (Livingstone & Blum-Ross, 2020; Merkouris et al., 2017; Turan & Aydo du, 2020). Informed by an utilitarian idea of education centred on the social and pedagogical need to construct the "digitally competent" child as a means of preparing young people for the labour market and fostering economic competitiveness (Mehta et al., 2020), many educational initiatives have been promoted at the formal, non-formal, and informal level. Examples of these are school curricula focused on strengthening children's learning of STEM disciplines (Science, Technology, Engineering, and Mathematics) (English, 2017; Kennedy & Odell, 2014), non-formal workshops held by profit and non-profit organizations to teach children skills related to activities such as coding and robotics (Sheridan et al., 2016), as well as a broader social discourse promoting and reinforcing the idea that in order for a child to be digitally competent in today's society such skills need to be mastered (Chesky & Wolfmeyer, 2015). However, not only can the emphasis on economic utility lead to a narrow focus on STEM fields as a means of generating economic growth and innovation, but certain educational opportunities may fail to be democratic and inclusive for a diverse range of children, with the risk of perpetuating inequalities (Baber, 2015). As such, research exploring how certain experiences are carried out is warranted.

In this paper we will focus on coding and robotics education in non-formal learning contexts in Belgium, Denmark, and Italy. Building on data from a comparative/cross-national research project on children's digital skills acquisition, we will present findings from a study involving 16 observations of coding and robotics workshops in non-formal contexts complemented by 11 interviews with organisers and moderators of such workshops with the aim of investigating their pedagogical practices, learning, and inclusion opportunities.

After introducing relevant theoretical concepts to frame our work, such as educational polycentrism and non-formal education, we will present the design of the study and its goals, moving to our findings that will be organised into three main thematic units to better get a grasp of these initiatives with respect to the dimensions of teaching, learning, and inclusion.

2. Background literature

2.1 Educational Polycentrism and Non-formal Education

In framing education as an epistemic object, «formal» education - that is, activities occurring in institutionalized learning contexts like pre-schools and schools – has frequently been used as a major lens of reference to understand and investigate how people, in general, and children, in particular, learn (Tramma, 2009). Schools, however, are not the only educational loci that children have experience of. Notwithstanding, until the 1970s a school-centric approach to education that positioned professional educators as institutional agents tasked with passing on information, skills, and values to future generations had led to the recognition of schools as the society's major and privileged educational agencies (Giovannini, 1987). Even though this perspective would acknowledge additional educational opportunities people could encounter outside of formal contexts (primarily the family and the church), it wasn't until the 1980s that educationalists began to conceptualize the idea of an educational polycentrism, which led to the recognition and formal development of polycentric educational experiences that would acknowledge the educational potentiality of many actors, contexts, and experiences outside of the school (Giovannini, 1987). In this respect, Reischmann (1986) coined the phrase «lifewide learning», emphasizing that education occurs not only throughout an individual's entire lifespan (lifelong learning), but also across many and differentiated contexts, which may also increase opportunities for people to acquire knowledge and skills that are not sufficiently promoted (if at all) within the traditional educational system (Jackson, 2012). To account for the complexity and pervasiveness of education and learning, the framework on formal, non-formal, and informal learning environments proves useful (Tramma, 2009). For this paper, to properly contextualize the many educational opportunities and circumstances that children may encounter, we rely on the defi-

nition proposed by the OECD and Tisza and colleagues (2019), based on The Council of Europe (COE) and Eshach's (2007) conceptualization.

According to this framework, formal education normally takes place in a classroom setting, is structured, pre-planned, and sequential. Formal learning is guided by a teacher, who assesses the learning objectives and provides feedback that officially evaluates the efforts of the pupils, relying mostly (but not completely) on their extrinsic motivation. Non-formal education takes place outside of traditional educational settings but inside some sort of organizational framework (e.g., amateur choir, sports clubs, etc.). With the activity being directed, but not totally predetermined, by a moderator, it is mostly supporting and nonsequential. Since most of learners' involvement is voluntary, the learning outcome is generally not formally evaluated, and students are frequently motivated for intrinsic reasons. Informal learning encompasses all of a person's relational and communicative experiences, and it occurs everywhere and at any time. Through informal learning, people can acquire reference frames, skills, belief systems, and the like, both unintentionally and on purpose (Tramma, 2009). Unintentional informal learning can happen when talking to someone, playing with friends, and other similar situations, whereas intentional informal learning can be stimulated, for instance, by the explicit explanations that parents give to their children as part of their childrearing cultures.

By examining this triple conceptual framework, we can see that, in contrast to informal experiences, the main distinctive factor of both formal and non-formal education and learning is that they are always intentional. In other words, intentionality, as a pedagogical category signifying that what is done is not casual, is what makes a difference. Formal and non-formal education are always purposeful, never neutral, although informal education can happen both inadvertently and intentionally (Bertolini, 1988). Intentionality calls into play axiology, or what education works for in terms of ideals to transmit, objectives to attain, and ultimately the kind of people we want to inhabit the social world (Besozzi, 2006; Biesta, 2015).

2.2 Not-school Activities, Digital skills Acquisition, and Social Inclusion

The emphasis of this paper is on non-formal educational initiatives that support children's acquisition of digital skills, specifically through coding and robotics workshops. It enables us to investigate the possibilities and resources employed outside of the national and standardized educational curriculum, putting a greater emphasis on local and context-specific activities in Belgium, Denmark, and Italy.

Our notion of non-formal learning is in line with Sefton-Green's (2012) conceptualization of «not-school» activities as a component of «an overall ecology of learning opportunities for young people» (p. 5), acknowledging that schools are by no means the only educational institutions that people rely on to learn. Non-formal learning may also be interpreted through the lenses of the Connected Learning model (Ito et al., 2020). This sort of learning takes place in a variety of contexts outside of official schooling, such as after-school programs, community centres, online communities, and so on. Connected learning is supported by theories that highlight how social relationships and cultural contexts are essential to learning and growth. The Connected Learning framework emphasizes the role of peers and tutors to scaffold the process of learning new information and acknowledges the significance of grounding learning in learners' interests. Connected Learning's main concern, however, is that thinking of educational opportunities outside of the school context raises questions about accessibility and social inclusion, namely the extent to which these learning opportunities are accessible to diverse young people so that they will not contribute to escalating social inequalities. This is in line with Sefton-Green's considerations on "not-school" learning experiences (2012). Without a continued focus on equity of access, any educational opportunity runs the risk of becoming «another way to reinforce the advantage that privileged individuals already have,» according to Ito and colleagues (2020, p.6). Such an assumption holds true even though non-formal learning enables us to move beyond conventional understandings of learning environments specifically tied to schools.

Based on the idea that digitally skilled citizens are needed to inhabit the ever more digitalised societies of the Global North, and that promoting digital skills acquisition will fight digital exclusion, many activities and initiatives have been promoted to start teaching digital skills from a young age (English, 2017; Kennedy & Odell, 2014; Sheridan et al., 2016). Coding and robotics activities for children, which are the

focus of this contribution, are a tangible example of that, for they have gained ever more attention and popularity (Livingstone & Blum-Ross, 2020). Research on the topic has pointed to various reasons for educating children to robotics and coding, such as learning critical thinking, scientific reasoning, and problem-solving abilities (Bybee, 2013; Chesloff, 2013; Turan & Aydoğdu, 2020). However, a strong focus on coding and robotics may also lead to neglect that certain educational activities instead of fighting inequalities may exacerbate them (Baber, 2015), as children from disadvantaged backgrounds may have less access to these resources and opportunities.

3. The Present Study

In this paper, we investigated non-formal education initiatives aimed at teaching children coding and robotics skills in Belgium, Denmark, and Italy. Within the broader ySKILLS project this study is part of, these countries were chosen keeping in mind their level of digitalisation as measured by the Digital Economy and Society Index (European Commission, 2018), according to which Denmark got top scoring, Belgium high, and Italy low. This different background allowed us to explore different contexts and should be kept in mind when reading our findings focused on patterns of similarities and differences between countries.

Theoretically informed by Ito and colleagues' (2020) conceptualizations concerning the role of learners, educators, and equity in access, we sought to address several research questions investigating three main areas to be understood as broader thematic units: teaching, learning, and inclusion.

Concerning our first thematic unit on teaching, we investigated how the axiology guiding the digital skills workshops led by moderators and organisers have an impact on the organization of the workshops in terms of their selected activities, pedagogical approaches, teaching styles, imaginaries, and values. In fact, we contend that these issues shouldn't be ignored since they can be part of a hidden curriculum (Gordon, 1982) and are likely to have an influence on how children and young people acquire and use digital skills. Therefore, we formulated the following research questions:

- RQ1a: What ideas, values, imaginaries do inform moderators' and organisers' practices?
- RQ1b: How are these values and ideas embedded in the workshop activities and teaching style?
- RQ1c: How do these imaginaries, values, and approaches shape opportunities for children's digital skills practices?

In relation to learning, although we did not measure learning outcomes, we examined how children participated in the workshops in relation to the goal of learning something new or consolidating existing knowledge, and whether and how the organization of the workshop would support learning practices:

- RQ2a: How do children participate in the workshop?
- RQ2b: How does the structure and moderation of the workshop influence children's digital skills learning practices?

With respect to inclusion, we sought to understand who attends digital skills workshops and who does not, as well as the reasons behind that, questioning potential sociocultural or material barriers that might be affecting the distribution and democratisation of these learning opportunities. As such, we posed the following research question:

- RQ3: What could be the opportunities and barriers for low socioeconomic (SES) children's participation in non-formal digital skills workshops)?

4. Method

This study integrates the findings obtained through two methods, including 1) observations of coding and robotics workshops; and 2) interviews with organisers and moderators of such workshops. As such, it is important to emphasize that any inference that will be made is based either on researchers' observations or on the interviewee's words, as experts of the initiatives we investigated.

4.1 Observations

First, we designed a shared observation protocol, which was organized in three areas and six dimensions. Specifically, our protocol included specific dimension to look for, guiding reflexive questions that the observants could ask themselves to better orient the observation, and a space for any annotation. The six dimensions we focused on were: space and tools (i.e., how the space was organised and what tools were available); children (i.e., exploring how children approached the tasks, their working style, etc.); moderators (i.e., exploring how moderators would interact with children, the teaching styles they adopted, whether and how they paid particular attention equally to all children or someone in particular); procedure (i.e., the structure of the activity, their sequential order if applicable, the presence of sub-activities, and the like); children's participation (in terms of their involvement in decisions concerning the tasks, or possibility to critically reflect on them, their responsibility within the group, etc.); observed skills and outcomes (i.e., whether children would approach the task without asking for help showing some sort of previous knowledge, or if they were learning something new, as well as tangible outcomes deriving from the activities, such as the construction of a specific tool, and the like). For each national team, at least one member of the research team was present during the observation phase. To consult our observation protocol, please see the Methodological Appendix.

In all the participating countries, we turned to organisations such as CoderDojo, that organise and conduct workshops either in public libraries, youth centres, museums, or afterschool programmes in schools or, in the Danish case, in high schools or on the Aarhus University campus. All 16 observed workshops (BE=4, DK=9, IT=3) were free of cost, and with all resources freely available for all. An overview of the observations can be found in Table 1.

Country	ID	Target	No. of children	No. of moderators	Technology	Venue
BE	BE1	Children 7-18	12	2	Scratch, Micro:bit, Lego Spike & Education	Building owned by the city
	BE2	Children 7-18	15	2	Scratch, Python, Lego Boost, Arduino	Science and technology museum
	BE3	Children 7-18	16	4	Scratch	Public library
	BE4	Children 7-18	4	3	Scratch, VR	Building owned by the city
DK	DK1	Girls 9-11	9	2	Lego Spike	X-lab at Aarhus University
	DK1	Girls 9-11	9	2	Lego Spike	X-lab at Aarhus University
	DK1	Girls 9-11	9	2	Lego Spike	X-lab at Aarhus University
	DK1	Girls 9-11	6	1	Lego Spike	X-lab at Aarhus University
	DK1	Girls 9-11	9	2	Lego Spike	X-lab at Aarhus University
	DK2	Girls 16-21	26	11	Lego Spike	Aarhus University
	DK3	Girls 16-21	28	11	Greenfoot	Aarhus University
	DK4	Children 16-18	29	1	HTML & CSS	High school
	DK4	Children 16-18	12	1	HTML & CSS	High school

IT	IT1	Children 6-17	13	4	Scratch, Python	Public library
	IT2	Children 7-12	10	4	Scratch, micro:bit	Business school
	IT3	Children aged 7-13	6	4	Lego WeDo 2.0	Youth club

Table 1: List of observed workshops

Parents and children were informed about the presence of the researchers during the workshop by the organisers, who shared an invitation letter and the informed consent form to all registered children. The invitation letter explained the aims of the study, informed parents of the scope and nature of the observations and provided the contact of researchers for further information. Additional information was provided directly by researchers before the workshop, when parents accompanied their children. Informed consent forms were either returned in a digital copy through organisers or signed on a paper copy by parents before the workshop.

During the observation, the researchers collected field notes without interacting with participants. Researchers filled in the observation grid for each dimension presented above as relevant, adopting a descriptive/interpretive approach (Denzin & Lincoln, 2000). Occasionally, researchers would interact with the workshops' moderators in quiet moments if some clarification was needed or to get some information about children's background (as it was the case in Belgium and Italy), without disrupting the activity.

4.2 Interviews

We designed a qualitative interview guide that could complement the field notes drawn during the observations which were kept during the interviews to ask for explanations about the activities, if needed. Our interview protocol was semi-structured, in the sense that it was based on 28 shared questions for each national team, but each interviewer could ask additional complementary questions on things observed. Through our interviews we investigated five areas: the role of the actor in the context of the workshop and the goals/philosophy behind the activity/ies; questions about children's background, to the best of the interviewee's knowledge, to better contextualized our findings and have an understanding of who would attend these workshops and who would not; questions about children's participation and digital skills; questions about the choice of activities and the space organization; clarifying questions on what had been observed. To consult our interview protocol, please see the Methodological Appendix.

The interviews were conducted by at least one member of each research team either online, using different tools for videoconferences (such as Microsoft Teams, Zoom or Skype), or face to face, after the workshop, and lasted between 15 and 100 minutes. They were audio-recorded and transcribed for analysis. The participants provided their informed consent. Table 2 provides a list of the interviews.

Country	ID	Interviewees' role	Interview mode
Belgium	BE1	Organiser	Online
	BE2	Organiser	Online
	BE3	Organiser	Online
	BE4	Volunteer	Face-to-face
Denmark	DK1, DK2	Moderator	Face-to-face
	DK4	Organiser and moderator	Online
Italy	IT1	Organiser	Online
	IT1	Moderator	Online
	IT2	Organiser and moderator	Online
	IT2	Moderator	Online
	IT3	Organiser and moderator	Online

Table 2: List of interviews

4.3 Data analysis

The field notes and transcriptions of the interviews were analysed thematically by each national team using two shared coding schemes: one for the observations, and one for the interviews. The final coding templates were constructed collaboratively and iteratively through various meetings, using a combination of inductive and theoretical thematic analysis (Fereday & Muir-Cochrane, 2006). The initial thematic coding was theoretically informed by the concepts discussed in the literature and included in both the observation grid and the interview guidelines (i.e., participation, teaching style, space organisation, etc.), and how they related to the three dimensions of teaching, learning, and inclusion. The coding schemes were iteratively adjusted as needed, in line with a mixed deductive-inductive approach (Saldaña, 2009). Specifically, additional codes and adjustments to already existing codes (including re-labelling certain codes or grouping different codes) were jointly discussed after each round of coding was performed independently by each national team. The coding took place on a shared Excel file, creating a sheet for each coding team, one for the observations and the other for the interviews.

With respect to the observation, we put in columns the five dimensions of space and tools, children, moderators, procedure, participation, and observed skills and outcomes, and in the rows we included the observation's notes. Each dimension, treated as a variable, could be coded with respect to more values that were identified through a number. To explore in details our observation coding grid, see the Methodological Appendix.

The same approach was followed for the interview coding scheme, where the relevant dimensions to be coded where the moderators and the organization's pedagogical approach, children's background, children's participation and digital skills, space and tools. Here as well, each dimension, treated as a variable, could be coded with respect to more values, that can be explored in detail through our methodological appendix.

In our analysis we triangulated data from the observations and interviews, especially with respect to shared dimensions between the coding schemes (such as activities, space and tools, children and moderators' roles, and the like.

4.4 Activities and Participants

The activities provided in the workshops were similar, including programming robots using Micro:bit or Lego robotic kits or Scratch, Python, or Unity.

In Belgium the four local CoderDojo divisions centred their activities mostly around the use of Scratch, a free programming language for children. Two local divisions also provided Lego Boost, Arduino and Python for those who were more advanced in their programming skills. Organisers of these workshops agreed that Scratch is a good program for children to familiarise themselves with coding before moving to more complex programs.

The activities observed in Denmark focused on programming, ranging from physical computing to game development and web development. In the DK1 workshops, participants used Lego Spike Prime to create a mini version of MGP (Melody Grand Prix), a Danish song contest for children. In the DK2 workshop, part of an IT camp for girls, participants built a Lego robot with a pen that could drive to draw on a piece of paper to create a piece of art. In DK3, also part of the IT camp for girls, participants used the educational IDE (Integrated Development Environment) GreenFoot to design a Pac-Man game. Participants used pre-existing code, which included a user interface that needed to be finished for the game to function. In the DK4 workshops, organised by Co-Coders, an organization that offers programming classes, the basics of HTML and CSS were taught to high school students to create a website in Visual Studio Code.

In Italy the observed activities were focused on coding and robotics. In details, coding has been a major feature of the IT1 workshop, with children using apps like Scratch and Python. The workshop was divided into three main activities that took place in the same library space but were organized into three micro-spaces: Scratch for beginners (in this case, young children, but more generally newbies who are not familiar with Scratch); Advanced Scratch users (for those who are already familiar and have used it at least once);

and Python (for children with higher skills). Python was used to construct a game called «Whac-a-mole,» while Scratch was used to generate interactive tales and animations. IT2's session focused on exercises using robots and coding. Children could work on their own Scratch projects, such as creating a tale about witches and unicorns, while the two older and more knowledgeable guys used microbits to program a little robot called micro Maqeen. The activity conducted by IT3 focused on the use of Lego Education WeDo 2.0, an educational robotic set that enables players to engage in coding activities to build objects using the classic Lego bricks and have them perform various tasks using a computer-based program, in this case Scratch plus a special Scratch extension designed for Lego WeDo 2.0. Building the Lego Robot, sometimes known as «Milo,» and using Bluetooth to link him to a computer to control him were the two objectives of the exercise.

In terms of participants, with respect to Belgium, the number of children who took part in the CoderDojo workshop varied for each session: 12 at BE1 (aged about 8-13 years old, 8 boys, 4 girls), 14 at BE2 (aged about 9-13 years, 11 boys, 3 girls), 16 at BE3 (aged about 10-15, 10 boys, 6 girls) and 4 at BE4 (aged 11-12, all girls). Eleven children (boys and girls) enrolled for the BE4 workshop, but only four girls showed up.

In Denmark the number of participants who took part in each activity ranged from 6 to 29. The workshops (DK1 workshop series, DK2, DK3, DK4) were all targeted towards girls. Although the DK4 seminars were marketed as being for girls, they were available to everyone, and the moderator reported that the gender balance in those courses was generally equal.

In Italy a total of 29 children participated in the three workshops, including 13 at IT1 (aged 7 to 15; 11 males, 2 girls), 10 at IT2 (aged 7 to 12; 8 girls, 2 boys), and 6 for the Lego We Do Activity led by IT3 (aged 7-13, 4 boys, 2 girls). The session hosted by IT2 was the only one where more females were present, which surprised one of the moderators, but otherwise the gender ratio was skewed in favour of guys.

For further details with respect to moderators participating in the workshops and interviewees, see tables 1 and 2.

With this information in mind, we now move to our three thematic pillars, reporting combined findings from both observations and interviews in the three countries.

5. Findings and Discussions

In this section we organise our findings across our three thematic units of teaching, learning, and inclusion.

5.1 Teaching

Data gathered from both the observations and the interviews made it clear that the pedagogical approach enacted in these coding and robotics workshops was intentionally different from schools and, in general, formal education contexts. At the time of data collection, the space organization in some workshops was dependent on COVID-19 restrictions. The organisers and moderators confirmed that the material space is used to promote children's collaboration in small and larger groups, put together according to one's personal interests and level of digital skills, trying to promote a constructivist approach where more expert ones could act as more knowledgeable others in a peer education process (Vygotsky, 1980). The desire to propose something different from schools was also evident in the way moderators would interact with children, with a more symmetric and approachable attitude compared to those of school teachers, also remarking the free choice of children to be there. The following two excerpts are an example of that:

> We don't want to seem too hard like school. It has to be enjoyable. Getting together with other peers, with other like-minded souls. Coding is also often, if you do it at home, often alone anyway. Here we come together in group. (BE2, organiser)

> I think they should feel like this is a nice place to be […] if they don't want to do the coding, I don't want to point any fingers at them, because they're there because they choose to be there. So, they

> decide what they want to get out of it. So, I think it's important to create a nice atmosphere. That's the most important thing compared to what they learn. Also, because the goal is just to make them curious. And if they go home and think, that was really boring, or not that interesting, they will not look into it again. (DK1, moderator)

Stimulating and respecting children's intrinsic motivation was seen as a goal by these moderators, also ensuring that participants could enjoy the experience and being there, as in the words of an Italian workshop organiser, claiming that "the point is to make sure that you have fun, because if you have fun you come back" (IT1, organiser).

In general, the declared mission of the workshops was to promote children's collaboration and active participation, to stimulate independent and creative thinking through a problem-solving and "get-your-hands-dirty" approach, with occasional scaffolding from moderators when needed. In this regard, both Italian and Danish interviewees emphasised the importance for children to copy from each other, an approach certainly different from those promoted in schools, but specifically aimed at stimulating collaboration and passing on the idea that there is not a wrong way to learn something new. A Danish moderator, in this regard, claimed that copying is in line with children's play culture and as such should not be sanctioned:

> Normally in their play culture, they [...] go out into the playground and then they copy and remix what the other kids are doing» which got eliminated in school: "they really do it as a normal thing in being together when you are three, four, five years old and when you come to school you are not allowed to do that. (DK1&2, moderator).

In the DK4 workshops, the moderator talked about teaching copying as a professional practice, also called expert strategies (copying, adopting and repurposing others' software) (Kafai et al., 2010). Such approaches to software designs might provide a promising training ground for later professional practice.

Along the same lines, but with a stronger attitude towards the topic, an Italian moderator harshly criticised school's repression of copying from others:

> School ruins them. I know it's a strong statement. But you realise that when you tell them that they can copy here, and they look at you as an alien. If you then tell them «you can make mistakes here» they don't believe you, because they grow up with the idea that every mistake you make is a failure, that collaborating with others is not good, there is an exasperated individualism, and therefore you have to compete with others and not collaborate. You can see that in most cases they don't spend much of their time in an environment that promotes collaboration. In fact, we are happy when someone lacks a computer and works in pairs with another partner. So we explain to them that the computer is just a tool and you work with your head, and it's nicer if you have two heads [working together]. (IT2, moderator)

In the words of this moderator, the value of making mistakes to learn and grow, is another element that contributes to construct a specific teaching philosophy that is far from formal education contexts. This state of affairs reflects a condition of misalignment between different educational contexts with respect to values and teaching strategies, as already found by Livingstone and Sefton-Green (2016).

While moderators may differ in their practical approaches, these seemed to be core values shared across activities and countries. Creating a welcoming space so that participants could get to know each other was an important goal beyond the specific focus of the workshops:

> It is about taking a bunch of students and make an activity that is relevant in the field of programming and technology, but also to make them do something that brings them together, to get to know each other. (DK1&2, moderator)

In general, the moderators of all workshops seemed to interact with all children in an almost equal manner, being present when needed, and keeping an involved and enthusiastic attitude to offer children a positive experience. Overall, similar educational strategies were used by moderators across all nations to

encourage children's autonomy, reflexivity, play, and creative thinking. With the occasional scaffolding from the moderators, independent and innovative thinking was encouraged. Beginners received extra attention from moderators, who sat next to them and assisted them as needed.

5.2 Learning

Our results are consistent with the idea that workshop design affects children's involvement and task-related motivation (Wigfield et al., 1998). The workshops differed in formality, with children generally being told to do tasks while following a thorough step-by-step instruction manual and other times being free to pursue their own objectives.

Despite their declared intention, both our observations and the interviewees suggest that collaboration was not always an actual outcome, with many children working on their own. In some workshops, the way learning activities were structured, the opportunities provided by the digital learning environment, and the choices made by the children themselves encouraged individualistic behaviours, in which each child worked independently to accomplish their own set of objectives. However, we also observed children peering at their neighbours' laptops and cooperating by pointing out codes and chatting about the assignment. Also, there were times when children sat next to a more mature or experienced child so they could ask questions. Still, it was common to see that participants' cooperation remained somehow restricted and that children continued to focus on their own projects, which is indicative of a more general and commonly accepted individualistic approach to learning (Johnson & Johnson, 1987). This ambivalence was also recognised by the organisers and moderators we interviewed, as reported in the following excerpts:

> They usually work alone and with their parents who often sit next to them. But sometimes it's also... There are a few children who I think deliberately put themselves next to older children, and you also notice that if something doesn't work out, they ask a neighbour. (BE3, organiser)

> They interact a bit with each other and help each other, but each student has their own computer. [...] my experience is that everybody has their own computer and they of course help each other and sometimes they are also doing the same things, but they are […] typing the code. (DK4, moderator and organiser).

An exception were the DK1 and DK2 workshops in Denmark where the participants worked together in groups on their projects. The facilitator orchestrated the activities and layout of the room with the goal of creating common spaces so that people could sit together and see other groups' work. The projects that the participants worked on were collaborative and involved an exhibition or performance at the end to share the outcomes of the activity.

Even though the workshops were founded on a clear philosophy that does differentiate them from school and formal educational contexts, and although children's creativity and autonomous thinking was clearly promoted, the activities tended to follow a pre-established structure to some extent in terms of what to do and how. This should not surprise for non-formal education is always characterised by intentionality, so at least to some extent the asymmetrical relationship between children (as the recipients of the interventions) and adults (as coordinators) remains. In this respect, we could not explore what children might have desired to accomplish beyond what was previously presented to them and the possibilities from which they could pick. This was also confirmed in the word of an Italian moderator, who stated:

> I have to be honest, children are not very involved in the design. Involvement may be 'deciding what to focus on in the game', but not the overall organisation of the workshop. (IT3, moderator)

Our findings suggest that although animated by best intentions in terms of fostering collaboration and promoting a constructivist approach, in certain cases learning in these workshops may end up being an individualistic endeavour, unless collaboration is actively promoted (as in the DK1 and DK2 workshops). Furthermore, children may have little room to actively decide what to learn, soliciting reflections

in terms of how the structure and management of the activities may promote certain learning outcomes over others.

5.3 Inclusion

Promoting inclusion in terms of access was a specific goal of these workshops. Several strategies were identified to promote children's participation and inclusion: being free of cost, targeting activities at a particular group, usually under-represented (as it was the case in Denmark with girls), opting for workshop open to everybody despite age or gender, providing equipment in case participants did not have it.

In spite of these efforts, however, based on our interviews with organisers and moderators, these coding and robotics workshops may risk not engaging a diverse range of children. Interview data, indeed, suggest that quite often children tend to be mainly medium-high SES and boys. Differences in terms of age, gender social class, and family background were in fact all relevant in making these workshops quite elitarian and reproducing traditional inequalities according to what we gathered from the interviews. In this sense, our findings suggest that the «open doors» or «one size fits all» approach does not always work to include a wide spectrum of children. Despite the workshops' non-formal, adaptable structure, which included a variety of possible activities for beginners and advanced programmers as well as for elementary school students and high school students, CoderDojo moderators and organisers reported that most children only tend to participate when they are young and tend to leave as they grow up:

> In terms of age, they are mostly young kids now. Well, young in the sense of 9, 10, 11 I think they are. Because it is actually from 10 to 18 years, but in terms of older [kids] there is only one who is 15. (BE3, organiser)

Our findings, however, do not allow us to draw any conclusions on whether older children are no longer engaged in learning or whether the learning activities are not tailored to the older age group.

Sometimes reasons for not participating would intersect, as it was the case for age and gender, as reported by two Italian moderators claiming that girls were more likely to abandon than boys as they grew into adolescence:

> It is unlikely that girls over 12 will join, they tend to decrease in number and almost disappear [as they grow]. It is easier for them to come if there is at least one girl friend who comes with them, because they expect to be in a male-dominated environment. But we fail to solicit their interest enough. It is not a question of competence, of course. [...] I'll give you that gender difference for sure because statistically we see this tendency in Coder Dojos worldwide. (IT2, moderator).

> Let's say that in terms of gender, we noticed a big difference when kids move from primary to secondary school, not to mention upper secondary school. In the sense that if they are at primary school the gender difference between participants is not that high, we are around 50%, whereas from secondary school onwards there starts to be a big difference. We are quite in line with international statistics, in the sense that we have seen that we don't have more than 20-25% of girls anyway (IT1, moderator).

With a few notable exceptions, boys were predominately the attendees of the CoderDojo workshops in Belgium and Italy, which is consistent with a general under-representation of girls in STEM-related activities (Wang & Degol, 2017; Tisza et al., 2020), and may be the result of a gendered-biased socialization process taking place in the home (Eccles, 2015), as in the words of this moderator:

> […] Another thing I noticed about gender is that sometimes if there is a choice to be made by families, even at a very unconscious level, if in the family there are a boy and a girl, parents tend to encourage the boy more. I mean, they let them both participate, but there is a maybe involuntary encouragement for the boy which is quite evident. (IT1, moderator)

However, this was not the case for the observed activities in Denmark, where the activities targeted girls mainly. This was considered and communicated in both promotion, workshop title, and theme of

the workshops. The DK4 workshops were branded as "Code Like a Girl" in High Schools but were open to boys and girls and the DK2 and DK3 workshops were part of an IT camp for girls that aimed to get girls interested in studying IT and computing related subjects at university. For choosing a theme for the workshops, the DK1&2 organizer emphasized the importance of enabling self-expression to motivate participants and keep them interested:

> I think you can make them program, if it has a purpose and [...] they end up with something that expresses themselves, within that purpose. (DK1&2, moderator).

The objective and nature of the activities themselves provide still another explanation for the gender differences. Previous European research has demonstrated that participants' gender matters for who is engaged in informal and non-formal science learning contexts, with girls being more likely to be drawn to topic-related activities like the arts, biology, chemistry, and physics and boys more likely to be drawn to skill-related activities like those aimed at enhancing computer science skills (Tisza et al., 2019). The following excerpt support this claim:

> Gender-wise, we have always managed to have around 25-30% of girls. This means that we also pay more attention to how we construct our proposals. Because if we do a workshop in which you have to create an animated story using Scratch, the characters, the story and its development must also be able to accommodate the differences, so we leave more freedom to choose characters and settings, which is usually welcomed by the girls participating, who often achieve better results than the boys. But you need to pay attention not to make the initial proposal too rigid. (IT3, moderator).

These results imply that the learning activities' content as well as the discourses that surround them might affect the young people who are being reached and who ultimately engage in these workshops.

In terms of socioeconomic factors, all workshops put in place strategies to foster inclusivity and guarantee that workshops were free of charge and that participants could rely on the provision of extra laptops and equipment if necessary. Still, except for the BE4 CoderDojo4All workshop, some interviews suggest participants seem to share the same middle- or upper-middle-class socioeconomic background:

> Children who come here have a high standard of living, I don't know it for sure, but when I see them and talk to some of the parents, I get that impression. I say this with regret, because usually vulnerable groups lack these experiences the most. We are completely open, in the sense that you don't pay anything, enrolment is open, but given the target group of children a lot has to do with parents, who are generally people working in informatics and the like." (IT2, moderator)

Overall, another barrier to participation identified by interviewees is that for many young people the digital skills practices taught in these programs are distant from their real experiences and interests; at the same time, children who were already familiar with coding and robotics, or whose parents shared this same interest were more likely to attend:

> Sometimes it's a bit like preaching to the choir, in the sense that a lot of children who come to CoderDojo are already triggered. Of course, the intention is also to let children who are not so familiar with it find their way (BE1, organiser)

> I've heard several students say that their mom or their dad did some coding and they thought it looked fun and they would like to try it out themselves, so I think that has an impact on the students. (DK4, moderator)

> I know that [...] a lot of parents are computer scientists, I know them. So, they are either computer scientists or engineers. (DK1&2, moderator)

6. Concluding remarks

This study aimed at gaining knowledge on how to better promote children's inclusion and participation in non-formal digital education experiences. Our findings showed that although digital skills workshops in non-formal learning context are designed and run with the mission of promoting children's collaboration and active participation, the structure of the learning activities, the organization of the learning environment, and the choices of children themselves, may promote individualistic practices, where each child worked on their own to achieve their own personal goals. The DK1 and DK2 workshops were exceptions in this matter. We contend that while instructing children to achieve a certain coding task that is not related to their own interests may fail to keep them engaged, a child-centered teaching style could be far more engaging and more likely to keep them motivated in the long run. This is in line with previous European research that also showed that keeping young children interested and engaged is the most frequently best practice mentioned by experts in informal and non-formal science learning activities (Tisza et al., 2020). Our study further challenges the myth of the digital native, showing that children need appropriate and meaningful external support, individual effort, and motivation to become digitally skilled. Additionally, the spatial organisation of the workshops including the features of the technologies and tools can both hinder or facilitate collaboration and learning practices. It is important to align these to the intention and orchestration of moderators so that the room, the physical materials, and the technologies contribute to the overall goals.

No major economic barriers to the accessibility and inclusivity of the programming workshops could be identified: all the workshops we observed were free, some provided extra laptops or tablets, offered snacks and drinks for the break, and were generally held in inclusive spaces (libraries, schools, youth clubs). Despite these efforts to promote diversity and inclusion, participants in these workshops seemingly had a rather homogenous socioeconomic and cultural background, based on the interviews. This shows that a "free" and "open door" approach to the organisation of digital skills workshops does not necessarily mean that it is inclusive. The main incentives to participate seem to stem from the child's genuine interest in programming, and/or because of their parents valuing programming as beneficial for their future academic and professional achievements. In this regard, we wonder whether what makes current coding and robotics workshops less attractive for vulnerable children is that they rest on a narrow definition of digital skills as an individual achievement that is future-oriented (and related to better school- and professional performances), as it is usually represented in social discourses on the matter (Livingstone & Blum-Ross, 2020). Such a narrow perspective does not necessarily link to children's own future aspirations. Therefore, more inclusive understandings of digital skills informing policy interventions as well as programming workshops, along with diverse and inclusive child-centered teaching styles, could compensate for the lack of diversity and inclusivity observed in our fieldwork. To foster inclusivity, our findings suggest that workshops should allow a certain degree of open-endedness and freedom, so that children can adjust and embed the projects into their own lived experiences and future-oriented imaginaries. This also means adapting the educational proposals to suit the interests, needs and competences of a wide variety of children with different backgrounds and aspirations.

Although our work offered us a glance into these workshops, future research could implement and triangulate our findings by analyzing official statistics, where present, to have a better estimate of who attend these workshops and who doesn't (beyond information gathered from interviewing organisers and moderators), and also including children in the research process, to investigate and learn about their aspiration, goals, and needs behind the decision to take part or not in these activities.

We advance that an active dialogue between policymakers, organisers and moderators, researchers, parents, and, of course, children themselves from different backgrounds is needed to promote child-centered approaches that move beyond individualistic accounts of learning, towards the creation of more collaborative, and more inclusive digital skill activities through a systemic and holistic approach.

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Conflict of interests

The authors declare no conflict of interest.

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Methodological Appendix

In this methodological appendix we report, in the following order: the observation protocol; the interview protocol; the observation coding grid; the interview coding grid.

OBSERVATION PROTOCOL

Activity (Date, Time, Place)
Description of the Activity:

What to look for	**Guiding questions**	**Notes**
Space and tools	How is the space organized? What kind of equipment are children provided with? Does the space allow for children to cooperate? Are there barriers and/or facilitators to children's participation?	
Children	How do children approach the tasks? Do they work autonomously or in group? Is there a team leader? Do children take on a specific role? Do children look involved in the tasks? Do children look like they are having fun? Do children ask for teachers' support and help?	
Moderators	How do moderators interact with children? What teaching style do they adopt? (e.g. cooperative, traditional, practical etc.) Do moderators interact equally with all children or more with someone in particular, and if so why does this seem to be the case? (E.g. so not to leave a specific child behind, etc.) Do moderators look like they're enjoying the task?	
Procedure	How is the activity structured? What's the order of activities? How long do they take? What are the different sub-activities? How many children and how many teachers are there?	
Children's participation	Who makes decisions? Why? Do power differences exist between participants? Have the power differences been deliberately negotiated? Does it seem like all participants understand reasons for decisions? Are there occasions for all participants for critical reflection on the process and the outcomes? Are there occasions for evaluation for all participants, on both individual level as well as on group level? What kind of responsibility children have / do not have? Why? Who defines the goals for the activity? Are children allowed to take part in defining the goals? Why/ why not? Do all participants understand the goals? Do children have all information they need? How can they get it? Does everybody get a chance to contribute?	
Observed skills and outcomes	Does it look like children learn something? Does this learning build on top of previous knowledge/competences? Does the work process support children to initiate future projects by themselves? Does the project result in tangible outcomes?	
Other	Anything else	

INTERVIEW PROTOCOL WITH ACTIVITIES' FACILITATORS

Needed materials:
- Audio recorder
- Informed consent
- Notes from the observation
- Pen and paper/computer

Course of interviews:

Subject	Questions
Introduction	Introduce yourself and other researchers (if any). Thank the participant for their time. Ask them if they have any questions.
Start of the interview	Is it okay if I turn on the audio recorder?
Role of the actor in the context and goals/philosophy of the activity/ies	Ask questions about what the role of the interviewee in the context of this specific educational activity is, e.g.: • How would you define your role? • What types of activities do you generally carry out with children? • What target do you want to reach and why? • Why do you believe these activities are relevant? What are you trying to accomplish? • Are there other areas you think should be covered when teaching children digital skills? If so, what, and why? • Other
Questions about children's background	Ask questions to gather information about children who generally attended these courses: • Can you tell me about the gender and age balance of children participating in these activities? • Do you have any idea about their socio-economic background? • How involved are parents in their children's participation to these activities? • Do parents report particular reasons for having their children participate to these activities and do they have particular expectations? • Other
Questions about children's participation and digital skills	• How would you describe children's participation to the activities? • Do they tend to work mostly on their own or to ask for their peers' support? • Are these children familiar with technology in general? • And are they familiar with the type of activities you propose? • How good do you feel children are at using technology? • How often are you asked for help and what kind of requests do children have? • Do you see any improvement or change in their technology use or confidence after your activities? • Have you ever noticed any difference between children according to their age or gender? • Have you ever noticed any difference between children who appear to be more digitally skilled than others?
Activities and space	• How, if at all, do you organize the space where the activity takes place? • Is there a rationale behind space organization? If so, what? • What about the objects used during the activities? How do you choose what to use and why? • What kind of practical implications do you believe these activities may have for children in their daily life and in the future? • Do unexpected events ever take place that makes you adjust the activities? If so, could you provide some examples? • Are children ever involved in the choice of activities or in the direction to take?
Questions on things observed	Ask situational questions based on what you observed during the activity. These questions may also be asked at the beginning of the interview to break the ice. You can also use occurrences you observed to provide examples or back questions during the previous (or following) phases of the interview.
Anything else?	• Is there anything else you'd like to give your opinion on or that I forgot to ask a question about?
Concluding the interview	Thank the participant. Emphasize the confidentiality of the information given. Clarify that the participant may also contact the researcher afterwards in case of further questions.

OBSERVATION CODING GRID

Name of the organization:
Workshop observed:
Date:

Observation notes	Space and tools	Children	Moderators	Procedure	Participation	Observed skills and outcomes
Copy and paste notes here	*Indicate the code/codes here*					

Variables and codes

Space and tools:
1. equipment hardware
2. equipment software
3. classroom materials
4. space affordances (incl. material facilitators/barriers)
5. space organization
6. covid restrictions
7. technical issues

Children:
1. Demographics (age, gender)
2. child-moderator interactions
3. children's engagement in the task (level of attention and focus on the task)
4. familiarity with technology/task
5. peer cooperation
6. individual involvement (as opposed to cooperation=children completing the task individually)
7. differences in skills and pace (observed)
8. digital self-confidence (child showing off, bragging)
9. emotions
10. creative and independent solution to the task

Moderators:
1. number of moderators
2. profile of moderators
3. teaching philosophy
4. fostering creativity and autonomous thinking
5. cooperation over competition
6. feedback on the achievement of the task (e.g., reinforcement at group or individual level)
7. moderators' support (or lack of)
8. practical approach
9. differences from school
10. technological imaginaries

Activity:
1. description and goal of the activity
2. step-by-step instructions provided by the moderator(s) (vs. open stimuli)
3. Incremental challenges (the activity is structured along a gradual progression from basic to advanced tasks)
4. playful and spontaneous activities during the workshop (=the assigned task)
5. spontaneous activities during the break
6. time constraints
7. break up in smaller groups

Competence:
1. tangible outcomes of the activity
2. skills learned
3. enhancement of creativity and autonomous thinking
4. enhancement of children's reflexivity

INTERVIEW CODING GRID

Name of the organization the interviewee is part of:
Workshop of reference:
Date of the interview:
Length of the interview:

Interview's quote	Moderators and organization's pedagogical approach	Children's background	Children's participation and digital skills	Space and tools
Copy and paste quotes here	*Indicate the code/codes here*			

Variables and values

Moderators' pedagogical approach and imaginaries:
1. teaching style
2. type of activities
3. perceived outcomes of the activities
4. imagined target
5. technological imaginaries
6. expected outcomes (daily life, future)
7. degree of pre-planning of the activity

Children's background:
1. Demographics (age, gender, SES)
2. Parent involvement
3. Parents' expectations

Children's participation and digital skills:
1. Children's familiarity with activities and tools
2. children's engagement in the task
3. child-moderator interaction
4. children's working style (autonomous/collaborative, focused, etc.)
5. children's learning/improvement (digital skills, tangible outcomes, etc.)
6. children's resistance and negotiation
7. co-decisions of the goal of the activity

Space and tools:
1. hardware/software equipment
2. classroom materials
3. space organization and affordances (incl. material facilitators/barriers)
4. covid restrictions