Inspiring Computational Thinking: a Science Fair Activity

Mats Daniels
Dept of Information Technology
University of Uppsala
Uppsala, Sweden
orcid.org/0000-0002-8465-7629

Arnold Pears
Dept of Learning in Engineering Sciences
KTH Royal Institute of Technology
Stockholm, Sweden
orcid.org/0000-0002-5184-4743

Aletta Nylén
Dept of Information Technology
Uppsala University
Uppsala, Sweden
orcid.org/0000-0003-0513-9338

***Abstract*—This Research Full Paper introduces a model for structuring playful, challenge-based learning activities drawing on a process of decontextualisation of a challenge to access its Computational Thinking intellectual and conceptual components and subsequent computationalisation of these components into computational artifacts that are recontextualised to render them attractive and accessible to school pupils. The case study follows a thick description approach to evaluating the engagement potential of the instructional design, as well as the didactic choices made during implementation. We conclude that Bebras cards and Dash robots provide considerable support for a playful engagement with computational concepts and engaging children with different scientific backgrounds in Computational Thinking. In particular, flexibility in how they are used and easy adaptation of challenge level make them useful in contexts with broad participation. Additionally we find that using robots to provide a link between the theoretical presentation of CT in the Bebras card and a physical representation and programming challenge is engaging and helps participants to focus on algorithmic concepts.**

***Index Terms*—computational thinking, science fair, school education**

I. Introduction

This paper presents the analysis of a case study activity held at a large Science Fair. The activity was designed to inspire pupils in the age range 11-13 to engage in Computational Thinking. However, during the case study we had the opportunity to use the activity also with a series of special learning needs students up to the age of 16. The intention of the research was to evaluate how a combination of Bebras [1] cards and Dash robots [2] could be used to motivate pupils, and scaffold scientific reasoning in the form of Computational Thinking [3], [4] in a collaborative setting. Of particular interest was the accessability and motivational power of the activity in a context with broad variety in science capital [5] among the participants.

The definition of Computational Thinking (CT) has been under considerable discussion since the term was first coined by Wing in her 2006 position paper on the topic [6]. Wing's definition was both sweeping, and imprecise, but argues that there is a specific type of thinking associated with formulating solutions in terms of computational components for subsequent automation. The definition of CT concepts has recently been the subject of a discussion of their utility by Pears [7] and both the definition of what CT might be and the implications this has for teaching are discussed at length by Tedre and Denning [8], [9]. However, despite the limitations of existing definitions, which focus almost exclusively on computation from a third generation imperative programming language perspective, in this study we adopt the definition of CT as consisting of skill-sets in: data analysis and representation, computing artefacts, decomposition of problems, abstraction, algorithms, communication and collaboration, computing and society and evaluation of solutions proposed by Dagiene et al. [10], page 273, table 3.

The case study utilised the activity design in the context of a School Science Fair, and the research data collection consisted of a structured documentation of the activity and detailed observations of the participants behavior.

The theoretical framing of our activity draws on the This work illustrates the application of a conceptual framework, as shown in Figure 1, developed by Barendsen [11], in combination with a repository of activities to construct and develop an activity. We explore how the combination of these theoretical and concrete resources provides support for contextualising Computational Thinking concepts scaffolding relevance and engagement in pupils. The study was conducted in the context of a larger EU project promoting science capital approaches to engaging pupils in compulsory schooling with fun-based and playful learning.

II. Theory and Method

To help to structure our investigation into computational thinking we adopt a theoretical model based on the work of Barendsen [11], [12].

The didactic model is presented in Figure 1. The left-hand side of the figure concerns the design of learning activities. In the case of this study these aspects of the model are connected to the design of the activities used, in particular the Bebras card designs, and the didactic choice to physically represent one of the situations depicted on the card (a computational artefact) as a robotic programming exercise (a re-contextualised application): in summary four phases are explored through explicit

This work funded under the aegis of the European Union Horizon 2020 programme H2020-EU.5.d., Grant agreement ID: 787476

instruction, instructional design exercises, classroom practical evaluation and reflection. The final stage of pedagogical insights may be coupled to assessment approaches, if required. In our case, no assessment was conducted, purely observations of engagement and the impact of societal context and relevance of the activity.

Data in the form of observations regarding how the participants approached the activity, including how they interacted, type of interaction needed from facilitators, sophistication level of Computational Thinking demonstrated, and potential impact of assumed level of science capital were collected by the three researchers, also serving as facilitators. The researchers recorded observations regarding the participants' mood, activity, interaction and engagement during sessions of the activity. Each session was followed up with a reflection session with all three researchers discussing their observations. The data collected consist of the researchers' individual notes as well as notes from the reflection sessions.

The combination of observations and active participation in the activities by the researchers provide a rich data set for a qualitative analysis in the form of a reflective narrative surrounding the activity and its implications. This data, which for our analysis constitute the key observations, are both analysed and presented here in a manner intended to be relevant to the transfer of this practice to other contexts.

The analysis draws on the "thick description" technique (See Ponterotto [13] and Geertz [14] for additional explanation of the method), which is suitable for this relatively small qualitative case study. The "thick description" technique is commonly used in qualitative research to situate the research and to provide as many contextual details as possible to the reader. The intention is to spur further questions and provide some insights regarding the activities as they were performed in the study context.

To collect relevant information about the practices we adopted an approach to observation that results in a reflective narrative surrounding the activity and its implications in regard to the primary research objectives. The reflective narrative approach consists of three parts:

- An observation of the practice under investigation following the guidelines as given in Ponterotto [13].
- A reflection relating aspects of practice to the intentions of the activity.
- An executive summary of the analysis indicating the key observations which are considered relevant to the transfer of that practice to other contexts.

III. Resources

Bebras cards and Dash robots were the two main resources used in this case study.

Bebras [1] is an international initiative aiming to promote informatics, computing and Computational Thinking among school students at all ages. The cards used in the activity each contain a Bebras task, an easily understandable task representing informatics concepts that can be solved within 3 minutes. An aim is that the tasks should be interesting and funny. The Bebras tasks concentrate on smaller learning items. The focus of the tasks is intended to be the understanding of principles, ideas and concepts that are involved in informatics systems.

The Dash robot [2] was designed to be used by children aged 6-12 years to learn programming in a playful setting. It can be programmed or remotely controlled in apps that are available for iOS and Android devices. For younger children, the programming is done in a graphical environment without any text where different actions are represented with graphics. The next programming environment is a block-based environment using Blockly [15], a graphical programming environment similar to Scratch [16]. For older students and adults, a programming API is available for Python and other text-based programming languages.

To sense the surroundings, the robot is equipped with proximity sensors at the front and rear, and a microphone. It has high-precision motors for movement and head movement, a speaker and some lamps. Connectors for peripherals can extend the robot's ability, especially with the Lego connector that supports adding Lego constructions to the robot. Built-in are some pre-programmed sound clips, but it is also possible to record and upload sound clips to the robot.

These robots were chosen since they are relatively inexpensive and easy to control.

The activity in question consisted of two parts. Both were using Bebras [1] cards as a source of Computational Thinking conceptual content. In one part the cards were used, in accordance with the intention of the developer, to solve a a question/task in a small group promoting discussion and reflection in relation to a computational or informatics concept.

The second part of the activity used two Dash robots [2] to navigate a structured playing field (a maze-like construction) in order to concretise a solution to a Bebras card question (see Figure 2 in the physical domain, where explicit programming of robot motion in pseudo-synchronicity provides the contextualisation of the abstract computational artefact that the card represents into the lived context of the pupil. This is illustrated by the process blocks on the right hand side of the model in figure 1.

IV. The Case Study

The study was conducted in the informal setting at a science fair organised by a research intensive European University. The main purpose of the fair is to inspire interest in science and science education, rather than achieve specific learning objectives, targeting both school classes (formal education) and the general public. In 2020, the fair had more than 6800 visitors of which approximately 4100 were visiting school classes. This study investigates one of the many activities offered at the fair. An activity that was offered only to school classes that had to sign up in advance.

A. The Activity

The learning activity under study was of 30 minutes duration, and consisted of two parts: 1) the participants solved

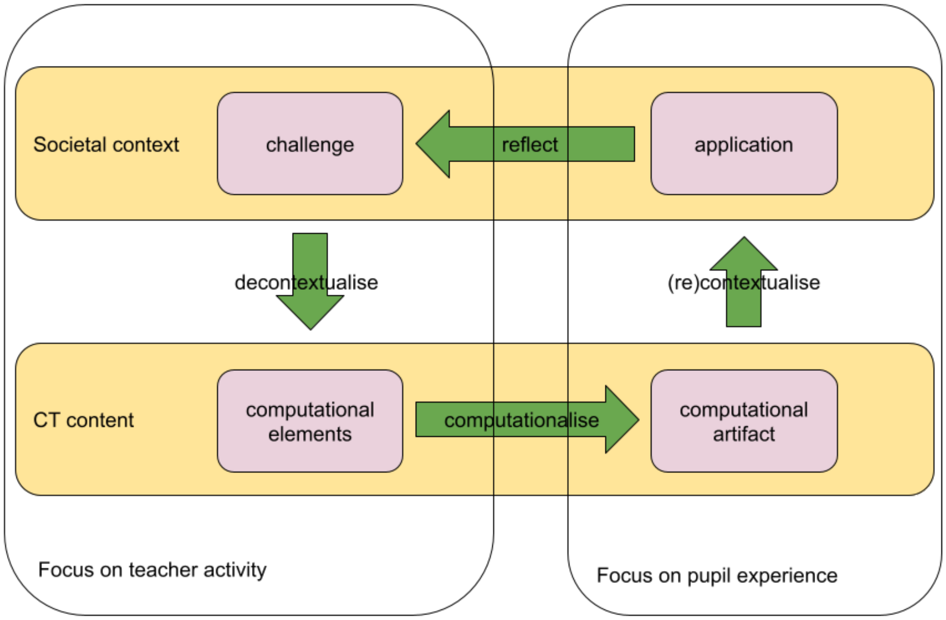

Fig. 1. Didactic Model Adapted from Barendsen

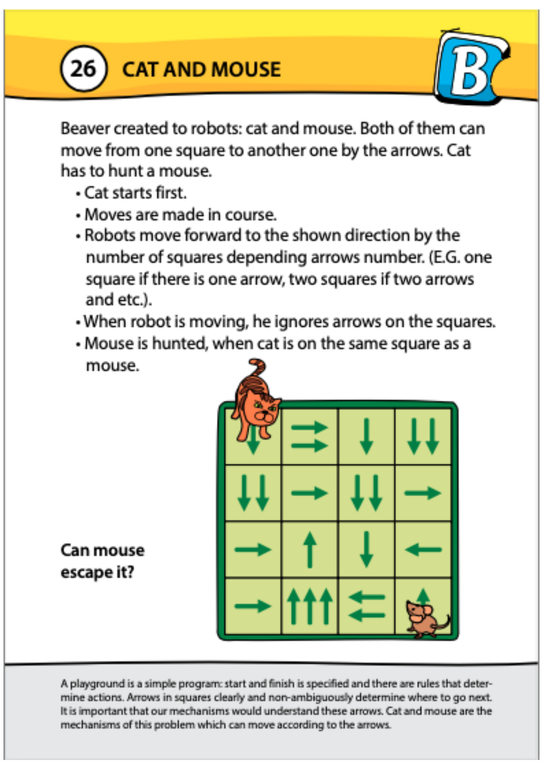

Fig. 2. Cat Hunting Mouse Bebras Card

problems from a selected number of Bebras cards, and 2) the participants solved a problem from a Bebras card and implemented their solution using Blockly to program Dash robots. During the activity the participants worked in groups of four, sitting on chairs gathered around the activity. In part 1, the participants sat around a table, and in part 2, they sat around a playing-field taped on the floor, see Figure 3. The activity was conducted in the Local Language of the European country involved.

B. Participants and Facilitators

In this qualitative study, we had 140 participating students from eight different schools divided into 10 sessions. Three researchers, two male and one female, were present and functioned as facilitators for the two activities. In some cases teachers were also present, but did not take an active part in the activity.

Participants were selected through a sign-up process, in which all school classes attending the Science fair were offered the opportunity to attend one of the sessions offered by the facilitators. Almost all available time slots during the two-

Fig. 3. A group around a 4 by 4 maze.

day event were booked in advance. That is, the researchers had no real influence over the selection other than in how the activity was described. However, the attendees covered a broad demographic, from well equipped schools attended by students of families of greater economic and educational means, to schools with students from immigrant and less affluent socio-economic segments of the population. Overall we judge the activity to have attracted participants who might be expected from prior research to demonstrate a wide range of personal science capital. The students were between 10 and 13 years, except a group of 8 special needs students that were older, i.e. 16-17. The gender distribution was roughly 50/50 in most groups. One group consisted of only male students and one group had mainly female students.

TABLE I
DISTRIBUTION OF PARTICIPANTS OVER SESSIONS.

Session	School	Students
T1	A, B	16 (8 female)
T2	A, B	16 (8 female)
T3	A	16 (7 female)
T4	B	16 (7 female)
T5	C	16 (7 female)
T6	C	16 (8 female)
F1	D, E	16 (12 female)
F2	F	8 (4 female)
F3	D	16 (6 female)
F4	G	4 (all male)

The participating students were from schools in the Local region and had a reasonably homogeneous background given the region. That is, on average roughly a third of the pupils had a background as a recent immigrant, but the ratio differed between schools. Being signed up by their schools, the students can be assumed to have heterogeneous interests and backgrounds. However, their teachers can be assumed to value this kind of activity, which may have a homogenising effect on the participants.

Socio-economic differences in the local city region were reflected in the participants, some of which were possible to observe. The even gender distribution contributed to an environment where all students were free to expose their strengths. It was however observed that the sub-groups of four tended to be less evenly distributed. Table I shows the distribution of genders and schools in the different sessions of the activity.

The facilitators were university teachers in computer science engaged in computing education research, and all have extensive experience with qualitative methods. One of the facilitators had some teacher training and experience from teaching children the age of the participants and all had children of their own. All of the facilitators had more than 20 years of teaching experience.

C. Procedure

The study was conducted over two days of the Science Fair. Ten sessions of the activity were conducted in the same manner. In each session, 4 groups of at most 4 students participated. No student participated in more than one session. Two of the groups started with part 1 of the activity (Bebras cards) and the other two started with part 2 (Dash robots).

Each part consisted of a short introduction, typically less than five minutes before the pupils started with the activity. At the end the facilitators gave a short summary, less than five minutes, related to what the pupils had done in the activity. This was combined with interventions during the activities when a facilitator found that there were some misunderstandings.

Both activities were set up to encourage collaboration and active participation from all participants. Part 1 was introduced as a think - pair - share activity, but then left open for the participants to decide how to work. The facilitators needed in some cases interact with the group to ensure either collaboration (rarely) or to encourage all to participate (more common). There were no specific roles assigned to the pupils.

The setting was that one of the facilitators integrated with either the two Bebras card groups or the two Dash robot groups. The short introduction and summary were given to the two sets of groups simultaneously. The interaction was intended to be minimal, but leading questions were asked when the facilitator felt that the group had either got stuck or did not manage to engage everyone in solving the problems. The setting was such that all participants could have eye contact and be close enough for all to hear what someone said.

The Bebras cards were used to inspire discussions around problem solving and computational thinking. The researchers had prior to the event selected a small set of cards. Some of the cards presented problems that allowed for different solutions. This encouraged a discussion focused on argumentation and motivation rather than just stating answers. The cards were also chosen to provide a progression of reasoning required to discuss each card. The researchers had selected more cards than needed for a typical session. This allowed for adjusting the level of difficulty to the current participants.

In part 2, the Dash robots were used to reason around a Bebras card that presented a challenge related to the outcome of two autonomous agents (a cat and mouse) navigated the field synchronously. Could the cat catch and eat the mouse? about what could happen in a maze when two robots were navigating the maze. The sixteen individual squares were only roughly of the same size. Additional navigational information was given on the Bebras challenge card, which the pupils needed to translate into programs for the two robots (see Figure 2).

The participants started by trying to program one Dash robot to follow a pattern according to the playing field depicted on the card. The intention with this part was to familiarize the participants with writing a program for the robots and to reason about unexpected outcomes. Unexpected outcomes were, for instance, that the individual squares were not all identical in size, and that the real robot didn't navigate in strict accordance with the manner in which it was programmed, for instance due to wheel slippage due to loss of traction on the polished linoleum flooring. The second step was to reason about outcomes related to interactions between the two Dash robots (representing a Cat and a Mouse) moving on the playing field starting from different access points. The full scenario is described on the card.

V. Observations

A. Engagement/activity

Most of the students were very much engaged in both activities of the session. However, it was clear that towards the end of the day students became less engaged in problem solving using Bebras cards. This did not occur to the same extent in the robotics activity. In one late session, classmates that did not participate in the activity were a distraction for those participating. We observed no difference in engagement between male and female students.

Engagement and enjoyment of participants was palpable, demonstrably so. For instance, slightly more than half the groups stayed on after their slot to pursue the challenge to completion. In addition several keen students returned with their teachers later in the day and over lunch to demonstrate their approach, and discuss the robotics challenge and potential alternative solutions with us.

B. Interaction/collaboration

The activities were set up to encourage interaction and discussion. An observation was that in general female students were more inclined to collaborate throughout the problem solving process, while male students preferred to think on their own first and discuss after they had reached a solution. Most students discussed their solutions with their peers without prompt from the facilitator after the first problem. Some, but not all, groups organised their collaboration as a competition while others preferred a collaborative construction organisation.

C. Diverse experiences from school

It was obvious that students' previous experience of problem solving differed between schools, and possibly even between classes in the same school. In one session, the participating students were already familiar with the Bebras cards since they had been used in their math class. In another session, the participants wished that maths would be taught in similar ways in school.

The level of problem solving ability in the different student groups varied. In one session, the level needed to be lowered significantly and in another the students solved more than twice as many problems as the average. Note that this was not the students that had previously been exposed to Bebras cards. This difference can only partly be explained by age differences.

D. Diverse conditions

In one of the sessions, the number of non-native participants was significantly higher than in the others. Some of the participants had difficulties in reading and comprehending the problems and needed the help of other students to translate for them. Once they understood the problems their problem solving skills were good, but the language barrier causes an unnecessary obstruction to their participation in science contexts, e.g., by impairing their ability to perform at their actual level in tests.

We also had a session with special needs students, since the participants were from a school specialising in students with special needs. To cater to the needs of these students, their teachers supported the facilitators. Challenges encountered were for example that the context for interpretation of problems could not be assumed to the "normal" extent. Working with these students also required the facilitator to be open to different modes of communication, e.g., through images rather than words. In this session, it was also not possible to rely on students spontaneously communicating with each other. To engage these students in the robot activity, all students were using the iPad. An observation is that the challenges encountered when working with these students were present even in the other sessions, although to a lesser extent. Facing these challenges tests the activity's ability to cater for broad diversity in participants.

E. Impact on society

The science fair SciFest constitutes a meeting point for research, industry and community. In 2020 it had 6836 visitors of which 4097 were visiting school classes. By inviting schools broadly, it has potential to reach children of all socio-economic backgrounds, genders, etc. Participation, however, depends on teachers' values and interests and the activity may therefore not reach the students with the lowest science capital. It still reaches a number of students that would not normally visit science activities and that do not have personal connections to researchers, i.e., children with low science capital.

One of the aims of the activity under study was to introduce affordable materials to teachers. In particular the Bebras cards attracted much interest. Teachers were less confident that they could get funding for purchasing robots.

F. How well did the materials work?

Both activities engaged and motivated the students. In particular, the robots could engage even tired students. Two of the teachers commented on robots as useful for creating engagement, even in otherwise silent students. In the activity, control of the iPad was successfully used as a means to engage silent or passive students.

The activities could easily be adapted to different levels of difficulty. The robots could either be used to program the robot to follow a given path or extended to a cat and mouse game. For the Bebras cards, the selection of cards defined the level of challenge.

Some of the Bebras cards assumed familiarity with computer science for interpretation of the problem. For some cards, solving the problem did not depend on understanding but could easily be done by pattern matching. Therefore, the value of these particular cards for learning can be questioned.

G. The role of the facilitator

The facilitators needed in some cases interact with the group to ensure either collaboration (rarely) or to encourage all to participate (more common). The interaction was intended to be minimal, but leading questions were asked when the facilitator felt that the group had either got stuck or didn't manage to engage everyone in solving the problems. The facilitators occasionally interacted to engage the shy pupils in a roughly equal opportunity manner. In Activity 1 the facilitator sometimes intervened to ensure that discussions were focused on seeing different perspectives without valuing them, to embrace diversity. This was combined with interventions during the activities when a facilitator found that there were some misunderstandings.

VI. Lessons Learned

A. In general

The participants could in general participate well in the activities, but we propose that this was due to the presence of experienced facilitators. Several of the teachers that came with the pupils showed interest and could in our opinion use the activities themselves later in their classes.

B. Implications (for practice, research or theory)

For activities targeting broad participation, it is important that the activity is flexible in order to cater to different interests and styles, and that it is possible to adapt it to different levels of prior knowledge and skill. Manipulation of physical objects, e.g. robots, help participants to stay focused on the task.

Not all Bebras cards lend themselves to discussions related to computational thinking. It is important that tasks are constructed in a way that promotes scientific reasoning and that experienced facilitators note and intervene if participants fail to reason in a scientific manner and resort to other means to solve the task, like for instance pattern matching.

C. Limitations

The science fair was offered on a voluntary basis and the researchers could not control which schools signed up for the activity. It is thus likely that the participants had teachers that are more interested in science than the average.

VII. The Case Study as seen through a Didactic Model

The case study and the results presented so far are related to the structure chosen for the large European project. In this section we present our findings through the didactic model of figure 1 lens. We start in the lower right hand corner to capture what we saw in the case study and end up in the lower left hand corner pointing out changes from the teacher/facilitator perspective.

A. The computational artifact phase

In our observations of the cohorts we noted that some of the Bebras cards lent themselves to pattern matching rather than computational thinking. These cards should not be used for an activity like our case study. We also noted that there were some cards that were too hard for some cohorts with regard to their experience with IT.

We noted that not having squares of identical size in the maze and wheels sometimes losing traction caused navigation problems. Using an iPad to control the robots worked well.

B. The application phase

There were some difficulties, as mentioned above, regarding the competences in a cohort. For instance, some cohorts had difficulties with the level och computational thinking required. This was, in our case study, amended by the facilitators giving hints. Other solutions to this issue could be considered.

The squares in the maze were not identical, which led to problems with the navigation of the robots. This, and the loss of traction, could be seen as a problem or a feature. In some cohorts we noted a reluctance to hand over the iPad to another pupil.

C. The challenge phase

The challenge as such is not changed, but insights regarding the societal context were gained though the case study. For instance the importance of being flexible regarding differences in communication and language competences as well as in problem solving abilities. That the previous experience with IT in a cohort was also noted as a factor that should be taken into account.

The implications of having identical squares in the maze or not should be explicitly considered. The non-identical squares could provide an interesting problem to deal with, but it is important that the facilitators are aware of this learning opportunity.

D. The computational elements phase

The selection of cards should be more careful. The selection should for instance take what we observed regarding pattern matching approaches in the case study into account.

If non-identical squares should remain as a feature of the activity this would need to be explicitly addressed and explained in terms of its connection to computational thinking in terms of planning robot navigation.

VIII. Conclusions

This paper analysed a playful and challenge-driven approach to engaging pupils in the age range 11-13 with CT concepts. The two activities we designed are framed within the didactic model of Barendsen in terms of both design for engagement and also contextualisation for pupil societal relevance. Our observations of both activities confirm high levels of pupil engagement and motivation. Pupils from schools from areas with less advantageous socioeconomic background required more scaffolding to stimulate engagement, but, once engaged were clearly active and enjoyed the activities.

The importance of competent facilitators cannot be overemphasised, adaptability and mastery of CT concepts is crucial in order to cope with the differences between the cohorts. In most cases the standard selection of Bebras challenges functioned well, but there were cohorts that certainly needed an adjustment to the activities in order for them to interact meaningfully around it.

We recommend the documentation format used to capture this activity as a tool for future research in similar settings. We note that the didactic approach requires that the team setting up such an activity has a good understanding of the computational thinking conceptual ecology. Knowledge about Bebras card and robots are not as critical, and many other resources are available that can be leveraged in conjunction with the Barendsen model to create suitable challenges, e.g. csunplugged.org.

Applying the Barendsen didactic framework has proved valuable as a means to analyse why and where an activity was useful, providing new perspectives on what happened and what might be changed for the better. The model also provides support for design of new activities helping to extract and contextualise the required CT concepts and explaining what types of learning outcomes they can be expected to achieve.

IX. Future Work

The design of our study was affected by the onset of the Covid-19 pandemic, which precluded focus group follow-up interviews with pupils and teachers, and collecting science capital surveys for the school classes who participated. This phase of data collection remains to be completed, and we have plans to complete this data collection phase in the near future.

In addition we have no data on long term effects on interest in computational thinking associated with the activities and the Science Fair. The implications of pupil's standing in terms of science capital was only studied superficially using school and county demographic data. We intend to use surveys and additional interviews with teachers to explore this avenue further. Anyone pursuing similar initiatives should consider collecting Science Capital data prior to the school classes engaging in the activity. Followup surveys can then be used to track any long-term affect these activities might have on development of Science Capital in young people.

References

[1] "Bebras International Challenge on Informatics and Computational Thinking," http://bebras.org, accessed 2021-05-17.

[2] Wonder Workshop, "Dash," https://www.makewonder.com/robots/dash, accessed 2021-05-17.

[3] V. Dagiene and G. Stupuriene, "Bebras- A sustainable community building model for the concept based learning of informatics and computational thinking," *Informatics in Education*, vol. 15, no. 1, p. 25, 2016.

[4] A. Pears, V. Dagiene, and E. Jasute, "Baltic and nordic K-12 teacher perspectives on computational thinking and computing," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2017.

[5] L. Archer, E. Dawson, J. DeWitt, A. Seakins, and B. Wong, ""Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts," *Journal of research in science teaching*, vol. 52, no. 7, pp. 922–948, 2015.

[6] J. M. Wing, "Computational thinking," *Communications of the ACM*, vol. 49, no. 3, pp. 33–35, 2006.

[7] A. Neville Pears, "Developing Computational Thinking," Fad" or" Fundamental"?" *Constructivist Foundations*, vol. 14, no. 3, 2019.

[8] M. Tedre and P. J. Denning, "The long quest for computational thinking," in *Proceedings of the 16th Koli Calling International Conference on Computing Education Research*, ser. Koli Calling '16. Koli, Finland: Association for Computing Machinery, Nov. 2016, pp. 120–129. [Online]. Available: https://doi.org/10.1145/2999541.2999542

[9] P. J. Denning and M. Tedre, *Computational Thinking*. Cambridge, Massachusetts: The MIT Press, May 2019.

[10] A. Juškevičienė and V. DagienĖ, "Computational thinking relationship with digital competence," *Informatics in Education*, vol. 17, no. 2, pp. 265–284, 2018.

[11] E. Barendsen and M. Bruggink, "Het volle potentieel van de computer leren benutten: over informatica en computational thinking," *Van Twaalf tot Achttien*, vol. 29, no. 10, pp. 16–19, Dec. 2019, publisher: Uitgeverij School bv. [Online]. Available: https://research.ou.nl/en/publications/het-volle-potentieel-van-de-computer-leren-benutten-over-informat

[12] M. Kallia, S. P. van Borkulo, P. Drijvers, E. Barendsen, and J. Tolboom, "Characterising computational thinking in mathematics education: a literature-informed Delphi study," *Research in Mathematics Education*, pp. 1–29, Jan. 2021. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/14794802.2020.1852104

[13] J. G. Ponterotto, "Brief note on the origins, evolution, and meaning of the qualitative research concept thick description," *The qualitative report*, vol. 11, no. 3, pp. 538–549, 2006.

[14] C. Geertz *et al.*, "Thick description: Toward an interpretive theory of culture," *Turning points in qualitative research: Tying knots in a handkerchief*, vol. 3, pp. 143–168, 1973.

[15] Google Developers, "Blockly," https://developers.google.com/blockly, accessed 2021-05-17.

[16] The Scratch Foundation, "Scratch," https://scratch.mit.edu/, accessed 2021-05-17.