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Developing a knowledge economy through technology and engineering education

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Welcome to PATT 37 Msida, Malta

Developing a knowledge economy through technology and engineering education.

Technology is pervasive in modern life and the economies of countries usually depend on how this is understood, developed, used and critiqued. With the advent of technologies which might disrupt the way we operate, becoming technologically literate and developing technological habits of mind is increasingly important for societies that value human capital.

Design and Technology education can be seen to have multidimensional roles. Research stimulates debate about important concepts and helps to answer questions such as the following:

1. Is design and technology education only for developers or producers of technology, or is it suitable for all citizens?
2. What knowledge and skills within design and technology education are transferable to future contexts within the workplace or for life?
3. How can we democratize technological knowledge and skills through design and technology education?
4. Specialised technological knowledge versus generalised technological knowledge: which is more suited for developing a knowledge economy based on human capital?
5. How can design and technology education contribute to generating future workplaces based on creativity and innovation?
6. What pedagogies are most suited to design and technology education?
7. How can design and technology education prove useful for everyday life?
8. How can design and technology education help to develop cultural capital?
9. What are the expectations for learning outcomes from different educational levels of design and technology education, ranging from primary, secondary, post-secondary and tertiary education?

PATT conference 2019 is open to the research topics which inform on the topics above as well as others relevant to the area of technology education, such as: a) curriculum content, b) STEAM philosophy, c) classroom practices, d) technological vocational education, e) project based learning and assessment for technology education, f) design knowledge and processes etc.

PATT is an international community of technology education colleagues (researchers, teacher educators, teachers, etc.) who are interested in educational research as a support to developments in technology teaching. PATT is open to all. There is no membership. Proceedings of previous conferences can be found at the ITEEA website (https://www.iteea.org/Activities/Conference/PATT/PATTConferences.aspx).

PATT 37 is a historical milestone for Maltese education in Design, Technology and Engineering in Malta since it is the first international conference focused on the teaching of technology from the primary level of schooling, to secondary, post-secondary and tertiary. We believe that this conference will make an interesting, valuable and significant contribution to the scholarly discourses of Technology education. We are convinced that the introduction of an international perspective into technology education will act to inspire Maltese stakeholders to become more participant within the international community of researchers and we hope that Technology education will continue to grow and mature through scholarly analysis and communication.

Sarah Pulé and Carmel Navarro
University of Malta
Conference conveners
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Programming as a New Content in Swedish Preschool: What Is It and How Is It Done?

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ABSTRACT

In 2017, the Swedish government decided on a new national strategy for digitalisation of the school system. The strategy resulted in a revision of the curricula for Swedish preschool in order to strengthen digitalisation. Although programming is not explicitly mentioned in the curriculum, programming and robots have become a more common feature of preschool teaching. There are intervention studies showing that children can develop programming skills and conceptions. However, studies of programming from a technology education perspective are rare, and there is a need for further research. This study aims to investigate how programming in a preschool context and what the teachers and children do. This study focuses on the interaction between children, teachers and technology. The programming activities in preschool are not a separate activity, but part of a wider context, hence we adapt a sociocultural perspective. The empirical data consist of two group interviews with preschool teachers and one video-recorded programming activity with children aged 4-5 years and their teachers. The data material was analysed using a thematic content analysis to inductively search for patterns in the actions and methods used by teachers and children. This study shows that four aspects of programming were communicated: *instructions*, *sequences*, *bugs*, and *language*. Moreover, the relationship between humans and the technological artefacts was characterized in three different ways: technology as I) *anthropomorphic*, II) *gender coded*, and III) *autonomous or non-autonomous*. Thus, the programming activities and robot were incorporated in a wider context. Technology (the robot) became a tool to achieve several learning objectives. The technology was not the main focus; the overall message constructed in this teaching setting is that the human controls and uses the technology to achieve specific purposes.

Keywords: preschool, programming, technology education

Introduction

In 2017, the Swedish government, decided on a new national strategy for digitalisation in the school system. Digital competence for all and equal access and use of digital tools are two of the prioritized goals (Ministry of Education, 2017). The strategy has resulted in a revision of the curricula for Swedish preschool in order to strengthen digitalisation. Additionally, in recent years there has been a trend of including more digital tools and programming or coding content in schools and preschools. According to the Swedish Curriculum for the Preschool (Swedish National Agency for Education, 2018): "Education should […] give children the opportunity to develop adequate digital skills by enabling them to develop an understanding of the digitalisation they encounter in everyday life." (p.10). However, even though programming is not explicitly mentioned in the curriculum, programming and robots are becoming more common in preschool teaching (Kjällander, Åkerfeldt & Petersen, 2016). In this paper we use the term "programming", as the overall problem-solving process that implies exploratory learning since it is the official term used in the English version of the Swedish curriculum for the compulsory school.

Since programming in preschool is still a new topic, there is little research. However, there are some intervention studies showing that children can develop programming skills and conceptions (e.g., Bers et al. 2014; Sullivan & Bers, 2016). There is research claiming that sequencing is an important component of early mathematics and literacy learning and consequently for the preschool ages. Researchers argue that it is possible to develop these skills by using robotics and programming (Kazakoff, Sullivan & Bers, 2013). Furthermore, Janka (2008) explains how Bee-Bot®, a programmable small robot, has been used in role-play activities in preschool. Her conclusion is that the children are not very interested in the Bee-Bot® itself and how it works. However, when the Bee-Bot® was a part of an open-ended story created by the children, some of the children showed understanding of how to control the Bee-Bot's movements, while others showed a lack of self-confidence. Janka also suggests working in very small groups of no more the five children. It is also important that the teacher takes active role in encouraging the participation of all children (Janka, 2008).

In Sweden, there has been a request for research on programming in schools and preschools (Kjällander, Åkerfeldt & Petersen, 2016). Building on the premise that learning is mediated by social interaction and cultural artefacts as language and computers, this study is based on sociocultural perspective (Vygotsky, 1962; 1978) and we focus on the interaction between children, teachers and technology.

Two contrasting perspectives between humans and technology have been suggested: technology lives its own "life", independent of human actions (determinism) or technology is a result of human activities, hence humans rule technology (Ellul, 1964; Winner, 1977). On the other hand, Pannabecker (1991) claims that alternative perspectives are needed in technology education to understand the complex relationship between humans and technology. Ascribing human attributes to animals or technological artefacts is common in children's literature and movies (Axell, 2015). Anthropomorphism is suggested as a way to bridge the barrier between humans and the complex technology and build emotional bond between them (Axell, 2015; Waytz, 2014).

This study investigates programming in a preschool context and the actions and methods of teachers and children. We use the term *programming activities* for activities that are defined by the preschool teachers as programming activities. In doing so, we want to show how preschool teachers, together with the children, construct new content in a preschool setting.

1. How are programming activities conducted in a preschool setting?

2. What is the relationship between participants (teachers and preschool children) and technological artefacts?

Methodology

This study was conducted in a small municipal preschool (children 3-5 years old) in a middle-sized Swedish city. The preschool director had prioritized working with digital tools. In this study, four preschool teachers participated (all women).

The empirical data consist of two group interviews and one video-recorded programming activity. Four preschool teachers participated in the first group interview, where they discussed the programming project and their forthcoming projects. A second interview was conducted approximately six weeks after the first with three preschool teachers participating. The teachers discussed the programming project activities so far and showed pictures from the activities with the children. Furthermore, they discussed their plans for the upcoming teaching section.

The group interviews were audio-recorded and later transcribed. The first interview lasted for about one hour and the second interview was 25 minutes long.

In total, two groups of children participated in the programming project. The “yellow” group comprising three-year-old children and the “blue” group with children between 4-5 years old. In the teaching activity that was video-recorded as part of this study, four children from the blue group participated (one boy and three girls). All children had their caregivers consent to partake in the study. The study followed Swedish Research Council’s (2017) ethics considerations and guidelines. Pseudonyms were used in this study. The teaching activity lasted approximately 45 minutes and was recorded by three stationary cameras and one hand-held digital video camera.

The recordings were transcribed using a multimodal approach in which talk, as well as activities, gestures and positions in the room were noted if important for constructing meaning in the specific situation.

Data analysis

The analysis comprised three stages, the first being descriptive and the second and third an analysis. Firstly, the preschool activities were described. Secondly, the empirical data material were analysed by using a thematic content analysis to inductively search for patterns (Braun & Clarke, 2006). This first analysis revealed four themes that came to describe programming in a preschool setting. Thirdly, the second analysis found three different themes that showed the relationship between the participants and the technological artefacts. Hence, the first and second step correspond to the first research question, while the third answers the second research question.

Results

To answer the first research question about how programming in a preschool setting, two perspectives are presented. The first is the description of the activities constituting the teaching sequence of programming. This is followed by four different themes that characterised what programming became in a preschool setting. Each theme is illustrated with excerpts from the empirical data.

Putting programming content into context

The preschool teachers and children had chosen the well-known tale of *The Three Little Pigs* as for the basis of their programming theme. Just after the first interview, the teachers introduced the storybook to the children. They read the book aloud, showed the pictures and used soft toys as props when they read and talked about the book. Moreover, the children used different materials to build the three houses. Yarn and wallpaper glue were used to build the straw house; the stick house was built from sticks that the children had collected in the woods. However, they struggled to get the sticks to hold together and so they attached them to a cardboard box. The third house, which in the story is built of bricks, was made by the children using red Lego bricks.

Before the teaching activity that was video-recorded, the preschool teachers had prepared printed and laminated copies of the pictures from the book. During the teaching activity, the children placed the pictures in the correct order to be able to retell the story of the book. Then, the teachers got the three houses and the children placed them on the floor. They positioned the soft toy pigs in the houses and retold the story together. After that, the children placed arrows on the floor to provide the wolf with directions to each house (figure 1). Next, the Blue-Bot® was introduced. The children tested how it worked and programmed it to walk from one side of the room, turn around, and return. However, at this moment the children had begun to lose their focus. The teachers encouraged the children to talk about what role the robot could play next time, but were unable to gain a consensus.

Figure 1. The children put arrows on the floor from the straw house (right corner) to the stick house (between the two children that sit on the floor) to indicate the route for the wolf.

What is programming in a preschool setting?

In the following sections, four different themes are presented that characterize what programming became in a preschool setting. These themes are built on what the teachers and children did and said.

Instructions

The preschool teachers discussed how programming includes the ability to express and follow *instructions*. The teachers' message was that the instructions must be precise, given in a correct order and clear to the receiver.

During the teaching activity, one of the preschool teachers, Sarah, asked the children to put all the pictures from the storybook in the same direction. She implicitly meant that the pictures should be facing the children (Figure 2a). However, the children interpreted the intention from the preschool teacher's view as depicted in figure 2b. One of the other preschool teachers,

Becca, noticed the misunderstanding between the teacher and the children and she said: “Now you weren’t clear enough”. She communicated the importance of giving accurate instructions.

Figure 2a. The teachers’ intended direction of the pictures.

Figure 2b. The children’s interpreted direction of the pictures.

This theme was rather prominent, both in the interviews, and in the teaching activity.

Sequence

In the teaching activity, one of the tasks was to place a sequence of pictures from the storybook in the correct order. The message that was communicated is that a sequence has a clear beginning, middle and ending, and follows a logical order. In the teaching activity, the sequence was illustrated by the order of the pictures from the storybook. The preschool teachers asked the children with which picture the story should begin and where on the floor it should be placed. The task was for the children to place the pictures in the correct order and thereby recreate the story (Figure 3).

Figure 3. The children put the pictures of the storybook in a sequence.

The sequence was clearly seen in the teaching activities but was not explicitly mentioned by the teachers during the interviews.

Bugs

The preschool teachers equated errors with bugs. In both interviews, the teachers talked about the bug as a typical programming concept that they want to include in the teaching activity. However, the concept appeared rather vague. For example, in the group interview, one of the teachers talked about a bug in terms of a rock in the way of the wolf trying to reach the three houses.

However, even though the teachers often mentioned bugs during the interviews, when teaching, they did not use the word bug. For example, the teacher Becca talked about doing a small trick, removing two pictures from the sequence the children had placed on the floor.

> *Becca:* *Yes, but I want to do a small trick if you are going to read the story. Then I will take away… [leans forward and removes two of the pictures]. Now you can try to read the story.*
>
> *Andy:* *No! It will never work!*

Becca challenged the children to think about the consequences of the missing pictures. This was a way for her to try to introduce the concept *bug* without using the term with the children.

Language

The preschool teachers talked about programming as a language. The language worked as the interface between the human and the machine. During the second group interview the teachers discussed how they introduced it to the children:

> *Becca:* *Aah, when Sarah pushes that button, she talks with the projector. We have started to introduce that as well.*

During the teaching activity the teachers used the same way to talk about the buttons on the Blue-Bot®, as in the following sequence (figure 4):

> *Becca:* *This robot only talks one special language. It is the language of when we push on it [the buttons]. Then it knows what to do.*

Furthermore, the teachers named this way of interacting with the robot as *programming*.

Figure 4. The children push the buttons on the Blue-Bot to make it follow the arrows.

Relation between human and technology

Targeting the second research question, the following themes aim to capture the relationship between human and technological artefact that was communicated through the teaching activities and the talk about programming. These themes could in some senses overlap with previous themes.

Anthropomorphism

The technological artefacts, the robot and the projector, acted as human (or animal) agents with human attributes. They could listen or did not understand a certain language. In the

following example, one of the children pushed the robot over the floor. However, this could damage the engines. Becca explained:

> *Becca:* *You know, you should never push… you always must lift him up. Otherwise he will hurt his wheels.*

This way of talking about the technology in terms of human attributes was only seen in dialogue with the children.

Artefacts as gender coded

The technological artefacts were gender coded. In the example above, Becca talked of the robot in terms of "he", even if it would be more appropriate in Swedish to entitle the robot as the gender-neutral pronoun "it". Later, during the teaching sequence they discussed what name they should give the robot.

Technology as autonomous and as non-autonomous

When the teachers and children used the Blue-Bot®, it suddenly did not do what they thought that they had programmed it to do. When technology lives its own life, it is depicted as autonomous.

> *Becca:* *Follow that arrow. Which one [button] should you push?*
>
> *Elsie:* *{Pushes the correct button, and then the start button, but the robot does not move}*
>
> *Andy:* *Noo…*
>
> *Becca:* *Has it gone to bed now?*

In the example, Andy was devasted when the robot did not move. Becca tried to talk of it in terms of being tired. The malfunction was also explained in terms of low battery level. So even if the technology seems to live its own life sometimes, the overall message constructed in this teaching sequence was that the human is in control of the technology, since there were always logical explanations to why the robot did not work as intended.

Conclusions

Programming in the preschool in this study was situated within the context of a story book, *The Three Little Pigs*. Through the teaching activity, children were introduced to four different aspects of programming:

1. Programming involves the ability to express and follow *instructions*. Consequently, the instructions must be precise.
2. Coding is equivalent to a *sequence* that has a clear beginning, middle and ending, i.e., it follows a logical order.
3. All kinds of errors that occur are labelled as *bug*. However, the teachers do not use the word explicitly during the teaching activity.
4. Programming is communicated as a language that is in the interface between the human and the machine.

The relationship between humans and the technological artefacts was characterized in three different ways:

1. *Anthropomorphism*: the technological artefacts were endowed with human traits and behaviour, i.e. the projector can listen, or the robot does not understand a certain language.
2. *Artefacts as gender coded*: the technological artefact (the robot), was depicted as a male.
3. *Technology as autonomous and non-autonomous*: technological artefacts sometimes make their own "decisions" however humans generally control the technology.

In summary, in the preschool in this study, the programming activities and the robot were part of a wider context. The children were involved in language activities, collaboration, technological constructions, digital resources, story reading and narrating from a thematic approach. Consequently, the technology became a tool to achieve several learning objectives and the technology itself was not the main focus. We believe that the overall message of this teaching setting is that humans control and use technology to achieve specific purposes.

References

Axell, C. (2015). *Barnlitteraturens tekniklandskap – En didaktisk vandring från Nils Holgersson till Pettson och Findus*. [Technological landscapes in children's literature – a didactic journey from Nils Holgersson to Pettson and Findus]. Doctoral Dissertation, Linköping University.

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education 72*: 145-157.

Braun, V. & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology, 3* (2). pp. 77-101.

Ellul, J. (1964). *The technological society*. New York: Vintage Books.

Janka, P. (2008). Using a programmable toy at preschool age: Why and how? *Workshop Proceedings of SIMPAR 2008,* International Conference on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS. Venice (Italy) 2008, November 3rd-4th.

Kazakoff, E. R., Sullivan, A., & Bers, M. U. (2013). The Effect of a Classroom-Based Intensive Robotics and Programming Workshop on Sequencing Ability in Early Childhood. *Early Childhood Education Journal*. 41(4): 245-255.

Kjällander, S., Åkerfeldt, A., & Petersen, P. (2016). Översikt avseende forskning och erfarenheter kring programmering i förskola och grundskola [Overview of research and experience of programming i preschool and compulsory school]. Swedish National Agency for Education. https://natverk.dfs.se/system/files/oversikt_programmering_i_skolan.pdf

Ministry of Education. (2017). Nationell digitaliseringsstrategi för skolväsendet [National strategy for digitalisation of the school system]. https://www.regeringen.se/4a9d9a/contentassets/00b3d9118b0144f6bb95302f3e08d11c/nationell-digitaliseringsstrategi-for-skolvasendet.pdf

Pannabecker, J. R. (1991). Technological impacts and determinism in technology education: Alternate metaphors from social constructivism. *Journal of Technology Education 3*(1).

Sullivan, A. & Bers, M. U. (2016). Robotics in the early childhood classroom: learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade. *International Journal of Technology & Design Education 26*: 3-20.

Swedish National Agency for Education. (2018). *Curriculum for the Preschool, Lpfö 18*. Stockholm: Norstedts Juridik kundservice.

Swedish Research Council. (2017). *Good Research Practice.* Stockholm: Swedish Research Council.

Vygotsky, L.S. (1962). *Thought and Language*. United States of America: MIT Press.

Vygotsky, L.S. (1978). *Mind in Society: the development of Higher Psychological Processes*. United stated of America: Harvard University Press.

Waytz, A. (2014). The mind in the machine: Anthropomorphism increases trust in an autonomous vehicle. *Journal of Experimental Social Psychology 52*(3): 113-117.

Winner, L. (1977). *Autonomous Technology: Technics-out-of-control as a Theme in Political Thought*. Cambridge, Mass.: MIT Press.