Kindergarten Children's Perceptions of "Anthropomorphic Artifacts" with Adaptive Behaviour

David Mioduser
Tel Aviv University
miodu@post.tau.ac.il

Assi Kuperman
Tel Aviv University
asikuper@post.tau.ac.il

Abstract

In recent years, children from a kindergarten in central Israel have been exposed to learning experiences in technology as part of the implementation of a curriculum based on technological thinking, including topics related to behaving-adaptive-artifacts (e.g., robots). This study aims to unveil children's stance towards behaving artifacts: whether they perceive these as psychological or engineering entities. Hence, their explanations were analyzed looking for their use of anthropomorphic or technological language. In contrast with previous findings, which reported on kindergarten-age children's tendency to adopt animistic and psychological perspectives, we have observed that the engagement in constructing the "anthropomorphic artifacts" behaviour promoted the use of technological language and indicated the early development of a technological stance. The implications of the findings for the development of technology-related learning tasks in the kindergarten is discussed.

Keywords: technological thinking, adaptive artifacts, anthropomorphic language, kindergarten, control technology

Introduction

In recent years, children from a kindergarten in central Israel have been exposed to learning experiences in technology as part of the implementation of a curriculum on technological thinking. The curriculum has been developed upon the idea that technological thinking integrated into the kindergarten's culture will stimulate the children's curiosity and will support, and even demand, the use of higher-order thinking, analytic capabilities, abstraction and problem solving, laying out the road to knowledge building processes and learning. The demand for such technological-thinking related skills is not usually part of the curriculum in Israeli kindergartens. One of the key strands of the implemented curriculum deals with the issue of smart artifacts - computer controlled adaptive systems. Children are exposed nowadays from a very young age to controlled technological systems. A visit to the nearest shopping centre introduces them to automatic doors, escalators, anti-theft security equipment or automated control gates in parking lots. Many toys they play with are programmable, and at home they interact with complex tools and devices, e.g. remote-controlled appliances, mobile phones and computers. Children are born into a technological world comprising a wide range of smart artifacts, hence it is only natural that the kindergarten's learning environment embraces these advanced technologies as well.

The rationale of this study addresses the fact that while smart artifacts and robotic systems are being increasingly adopted as educational resources in many kindergartens, key questions deserve still to be examined: What do we know about children's understanding of artificial-adaptive behaviour? What developmental affordances and constraints support or restrain children understandings? What understandings and skills does the interaction with the robotic

Proceedings of the Chais conference on instructional technologies research 2012: Learning in the technological era
Y. Eshet-Alkalai, A. Caspi, S. Eden, N. Geri, Y. Yair, Y. Kalman (Eds.), Raanana: The Open University of Israel

systems promote? How systematic knowledge about children's understandings and capabilities might help for planning mindful integration of robotic systems as educational tools?

Background

The ambiguous status of computational objects among artifacts was studied in a series of works (e.g., van Duuren & Scaife, 1996; Francis & Mishra, 2008). In van Duuren & Scaife's study artifacts with different anthropomorphic features, i.e., interactive and adaptive behaviours that can be interpreted by children as psychological reality,) and a person, were used to elicit children's associations as regards to issues such as: mental acts of dreaming; motor acts of walking; sensory acts and feelings; and even the very question as to whether the objects have a brain. While children's ideas about a doll, book and person did not show any developmental differences, the "clever artifacts" -a robot and a computer- showed developmental differences. By the age of 7 years, children construe such intelligent machines as cognitive objects.

Along similar lines, Francis and Mishra (2008) asked children (aged 3 to 8) to interact with "anthropomorphic toys" of three types -a stuffed dog, a mechanical cat and a robotic dog- varying in level of complexity of their observable functioning. They requested children to tell if these are "real", and to interact with them. They report on differences between the children's verbal descriptions, mostly acknowledging the ontological reality that these are not real, and their behaviours, indicating confusion concerning the reality of the robotic dog - the most sophisticated toy. As well, they report on extensive use of anthropomorphic language as opposed to non-anthropomorphic language.

Ackermann (1991), in describing children and adults' understanding of controlled systems or self-regulating devices, proposes two perspectives: psychological and engineering. The psychological point-of-view conceives intelligent artifacts as living creatures, attributed with intentions, awareness, personalities and volition. The engineering point-of-view is typically used when building and programming a system.

However, in most previous studies the participants were requested to observe and/or to interact with behaving artifacts - and were not involved in constructing their behaviour. As well, the focus has been on the use of anthropomorphic language, and less attention has been put on the nature of non-anthropomorphic descriptions generated by the children, i.e., descriptions indicative of children's "intuitive engineering" (Pinker, 1997).

In previous studies (Levi & Mioduser, 2008; Mioduser & Levi, 2010) we have already reported about the contribution of the involvement in constructing an artifact's behaviour to children's development of a technological (i.e., engineering) perspective. In this study we refined the focus addressing children's explanations of "behaving" (thus potentially anthropomorphic) artifacts **as a function** of their involvement in programming the artifact's behaviour. We focus on two questions:

Question 1: What is kindergarten children's stance towards programmable adaptive artifacts as reflected in the language used in their explanations?

Question 2: Does children use of anthropomorphic language vary as a function of the **complexity of the task** and their **involvement in programming** the artifact?

Method

For this study we adopted a qualitative approach (Guba & Lincoln, 1998). Participants were 10 children, 5 boys and 5 girls, arbitrarily chosen from a group of 25 attending a kindergarten of average socio-economic status in the central region in Israel, defined for the last five years as experimental kindergarten implementing a technological thinking curriculum. Children's age ranged from 5:4 years to 6:3 years - average 5:9 years.

A key research instrument was the robotic learning environment, specially developed for young children ("Robogan" - Mioduser, Levi & Talis, 2009). The environment comprises a physical robot built from Lego pieces, a dedicated Iconic interface, and a progression of tasks of increasing complexity (Figure 1). The iconic interface allows the definition of control rules in simple and intuitive fashion. The subjects in our study participated in description and construction tasks. In a description task, the child narrates and explains a demonstrated robot behaviour. In a construction task the child programs the robot's control rules to achieve a specific behaviour. Example a: The robot has to walk around a "black" island without falling into the "white" Water surrounding it.

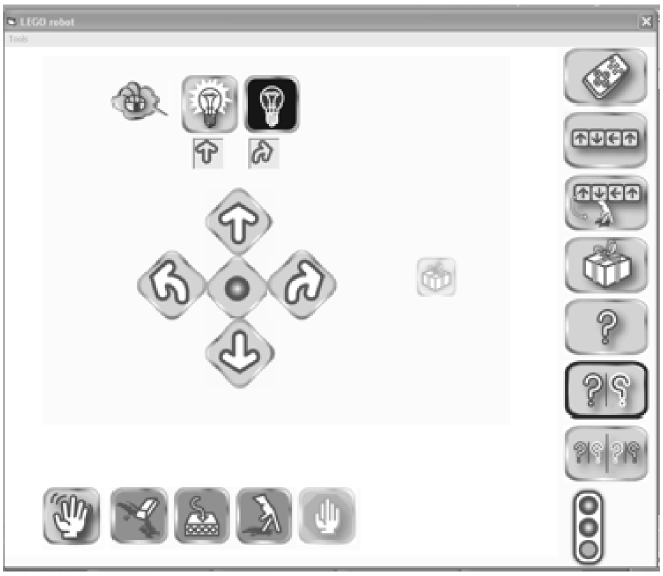

Figure 1: "Robogan" – the robotics behaviour-construction interface and robotics working area in the kindergarten

The tasks were sequenced in increasing difficulty by the configurations of rules required. The operational definition of rule-configuration is the number of pairs of condition/action couples. The tasks spanned from the use of one rule (one condition/action couple), the joint use of a rule and a routine (a reusable sequence of instructions), to the use of two interrelated rules (two pairs of condition/action couples).

Data collection lasted two months. All sessions and interviews took place in the kindergarten's robotics corner and were videotaped.

Results

Question 1: What is kindergarten children's stance towards programmable adaptive artifacts as reflected in the language used in their explanations?

To address the first question we assessed children's stance towards smart artifacts as reflected in their explanations and the kind of language used. We defined the use of anthropomorphic language as indicative of a psychological or animistic perspective, while the use of technological language characterizes an engineering perspective. The different types of explanations are exemplified in Table 1.

Table 1: types of explanations using different languages

Explanations	Definition	Examples of children's explanations
Use of anthropomorphic language	Robot's behaviour is explained in terms of intentions, volition, feelings and human-like actions	"*… He sees that it is the sea and decides to turn…*" "*... If he sees a person then he has to tell him…*"
Use of technological language	Robot's behaviour is explained in terms of its components' functions, mechanisms, and formal decision-making rules	"*… we simply wrote [programmed], when he gets to the black area he stops and when in the white area turns back…*" "*... and if one [sensor] sees white and the other sees black then [turn] left…*"

A total of 844 statements were generated by the children, of which 684 were found relevant to our analyses (the remaining statements were not related to the children's perception of the robot's behaviour). 107 statements (16%) were articulated using anthropomorphic language, and 577 statements (84%) using technological language. This finding is particularly interesting against the expectations based on previous literature about children's perceptions of "ambiguous" creatures like robots. In the vast majority of the situations faced by the children, they approached the robot's behaviour mostly from a technological/engineering perspective rather than from a psychological perspective.

A more refined analysis of the statements showed nuances characterized by the use of anthropomorphisms. In some cases children's phrasings indicate conceptions that are typical to this age level, e.g., "*He's walking only on the white area because it feels warm ... he wears a hat and he knows that he is wearing the hat*". Many other statements indicate children's identification with the robot and describe its functioning in terms of volition and emotions.

However in many other cases, the use of a similar language evidenced a **functional** rather than an anthropomorphic perspective: within the context of the "story" of the task, and in a colloquial dialogue, children felt more natural to use human-like terms for describing things even if they explicitly acknowledged that they are talking about an artifact's behaviour. An example: "*I have left the maze*" [talking about the robot's success in the task] - when further inquired by the interviewer the child added: "*because I've directed him*" [referring to the program he has constructed].

In sum, children's explanations show that they perceive the robot mainly as an artifact able to show adaptive functioning. They use mainly technological language to explain its functioning (obviously within the constraints of their technological knowledge), and the use of anthropomorphisms is due to functional purposes rather than to a psychological stance towards the robot.

Question 2: Do children explanations (and the use of anthropomorphic language) vary as a function of the **complexity of the task** and their **involvement in programming** the artifact's behaviour?

A breakdown of the analysis of children's statements by the kind of task performed (i.e., explaining observed behaviour vs. constructing the robot's behaviour), and its complexity, is shown in Tables 2, 3 and 4 (N-statements=684).

A first glance on the data unveils several facts:

- The number of statements **increased** with the complexity of the tasks (Table 2).
- For all tasks, about two thirds of the statements were phrased using **technological** language (Table 2). However. Most of these statements were generated by the "constructors" (Table 4).
- "Constructors" generated **five times** more statements than "observers" (Table 3).
- For all tasks, the percentage of observers' statements comprising anthropomorphic or technological language was similar (~50%), while **two thirds** of the constructors' statements were phrased using technological language (Tables 3 and 4).
- With the increase in tasks' complexity, the use of **anthropomorphic** language by the observers increased and by the constructors decreased. At the same time the use of **technological** language by the constructors remain at similar level - about two thirds of the statements (Table 4).

Table 2: explanations' language by complexity level of the tasks

Task	Anthropomorphic language	Technological language
One rule - N=197	76 (39%)	121 (61%)
One rule + routine - N=204	79 (39%)	125 (61%)
Two rules - N=283	93 (33%)	190 (67%)

Table 3: explanations' language by children's activity in the tasks

Activity	Anthropomorphic language	Technological language
Observation - N=107	54 (50%)	53 (50%)
Construction - N=577	194 (34%)	383 (66%)

Table 4: explanations' language by task level and children's activity

Task	Activity	Anthropomorphic language	Technological language
One rule	Observation - N=44	21 (48%)	23 (52%)
	Construction - N=153	55 (36%)	98 (64%)
One rule + routine	Observation - N=41	19 (46%)	22 (54%)
	Construction - N=163	60 (37%)	103 (63%)
Two rules	Observation - N=22	14 (64%)	8 (36%)
	Construction - N=261	79 (30%)	182 (70%)

It results clear that the involvement in constructing the robots' behaviours affects the richness of children's explanations (reflected in the number of statements), and their content - directing their focus to the technological features of the artifacts' functioning and adaptive behaviour.

In contrast with previous findings, which reported on kindergarten-age children's tendency to adopt animistic and psychological perspectives, we have observed that the engagement in constructing the "anthropomorphic artifacts" behaviour promoted the use of technological language and indicated the early development of the engineering stance.

It seems that technological language is needed for addressing tasks of increasing complexity, both for understanding and explaining the artifacts behaviour **and** more evidently for programming it.

Implications of the study

The study has several implications at both the theoretical and practical/pedagogical levels.

We have expanded our understanding of how children's involvement in tasks affording activities both symbolic (i.e., reflecting on the artifact's behaviour; working with the iconic interface) and physical (i.e., manipulating and observing the behaviour of a real artifact) supports their thinking and acting beyond the anticipated in the literature for this age level. The results encourage the further development of technology-related learning tasks for kindergarten children along these lines.

As well, we have observed that while approaching the "breed" of behaving and adaptive artifacts children very rapidly adopt appropriate (even if not accurate or correct) language and explanatory approach. The new technological landscape in which they are immersed (quite different from landscapes within which previous research on children's perceptions was conducted) seems to challenge their curiosity and affects the quality and content of their understandings and explanations. The insights obtained about children's understandings should guide the devise of authentic, situated and challenging learning tasks incorporating the new sophisticated landscape.

Finally, the learning environment -computer interface and learning tasks- has proven to be a powerful tool supporting children's construction of knowledge. Nowadays, the pedagogical approach and sets of tasks developed according to it are being implemented in increasing number of kindergartens in Israel.

References

Ackermann, E., (1991). The agency model of transactions: Towards an understanding of of children's theory of control. In J. Montangero and A. Tryphon (Eds.). *Psychologie genetique et sciences cognitives*.

Diesendruck, G., Hammer, R., & Catz, O. (2003). Mapping the similarity space of children’s and adults’ artifact categories. *Cognitive Development, 18*, 217-231.

Fleer, M. (1999). The science of technology: young children working technologically. *International Journal of Technology and Design Education, 9*(3), 269-291.

Francis, A., & Mishra, P. (2008). Differences in Children’s Verbal Responses and Behavioural Interactions with Anthropomorphic Artifacts. Paper presented in the AERA 08 Annual Meeting, New York, NY.

Guba, E.G. & Lincoln, Y.S (1998). Competing paradigms in qualitative research. In N.K Denzin & Y.S. Lincoln (Eds) *The Landscape of* Qualitative *Research (pp 195-220).* London: Sage Publications.

Kemler Nelson, D.G. & 11 Swarthmore College Students (1995). Principle-based inferences in young children's categorization: Revisiting the impact of function on the naming of artifacts. *Cognitive development, 10*, 347-380

Levy, S., & Mioduser, D. (2008). Does it ''want'' or ''was it programmed to...''? Kindergarten children's explanations of an autonomous robot's adaptive functioning. *International Journal of Technology and Design Education, 18*(3), 337–359.

Matan, A., & Carey, S. (2001). Developmental changes within the core of artifact concept. *Cognition, 78*, 1-26.

Mioduser, D., Levy, S.T., & Talis, V. (2009). Episodes to Scripts to Rules: Concrete-abstractions in kindergarten children's construction of robotic control rules. *International Journal of Technology and Design Education, 19*(1), 15-36.

Mioduser, D. & Levy, S. T. (2010). Making sense by building sense: Kindergarten children's construction and understanding of adaptive robot behaviors. *International Journal of Computers in Mathematical Learning, 15*(2), 99-127, 2010.

Pinker, S. (1997). *How the mind works*. New York, NY: W. W. Norton & Co.

Qualifications and Curriculum Authority. *Design and technology in the National Curriculum* (2000). London: HMSO.

Turkle, S. (1984). *The Second Self: Computers and the Human Spirit*. New-York: Simon and Schuster.

van Duuren, M., & Scaife, M. (1996). Because a robot's brain hasn't got a brain, it just controls itself: Children's attribution of brain related behavior to intelligent artifacts. *European Journal of Psychology of Education, 11*(4), 365-376.

Acknowledgments

This work has been partially funded by the Israeli Science Foundation (ISF) - grant No. 850/08