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"Shoes and Squares": A computer-based probabilistic game for preschoolers

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Abstract

Children as early as 5 years old have been found to be able to manipulate basic concepts of probabilities. In the current study, 50 preschoolers participated in a between-subject developmentally appropriate computer task, named "Shoes and Squares" and were tested on whether they can estimate the most probable outcome in conditions of unequal likelihood of events. Participants were asked to make predictions and guess the most likely option in a random game composed by electronic items that represented cards with shoes and/or squares. Preschoolers were personally engaged, they made estimations and seemed to get affected by the structural changes among the sample space. Such findings raise educational implications concerning not only the teaching and constructing of probabilities in preschool education but also the role and use of technological means in the classroom.

Keywords: Preschool education; ICT; probabilistic thinking.

1. Introduction

Knowledge can become meaningful and purposeful if it gets related to and integrated into children's daily lives and experiences. Real-life data, contextualized tasks, the support of play and the use of everyday manipulative objects or technological tools provide opportunities that trigger the student's curiosity for learning and investigating. Learning occurs while children actively construct new knowledge and "*build something tangible … that is personally meaningful*" (Papert, 1990), under the constructivist approach.

Preschoolers learn and understand basic mathematical concepts and skills through explorative and interactive experiences with materials, peers and teachers (Charlesworth, 2005), among settings that encourage personal involvement and construction, as well as collaboration and the exchange of ideas. Besides, "*the most powerful mathematics for a preschooler is not usually acquired while sitting down in a group lesson, but is brought forth by the teacher from the child's own self – directed, intrinsically motivated activity*" (Clements, 2004).

Such activities get enriched by computers as they can be considered a significant tool that enhances learning (Clements & Nastasi, 1993). Through computer – based tasks children confront a simulation of the real-world, they

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make use of cognitive mechanisms and they gradually construct knowledge. Research has shown that even 3 year-olds who use computers with supportive activities within the context of objectives acquire greater developmental gains compared to children without computer experiences in similar classrooms (Haugland, 2000).

One of the mathematical areas investigated recently in preschool education is the notion of probability (Jones et al, 1997). Research has shown that children at the age of five to six possess a minimal understanding of randomness, as they recognize the likelihood of events (Schlottmann, 2001; Nikiforidou & Pange, 2007), they make causal inferences (Kushnir *et al.*, 2005) and they can make use of basic probability notions such as possible, impossible and sample space (Way, 2003).

The current study investigates whether preschoolers respond to the mathematical notion of most probable in a probabilistic game designed on the computer. This random-game, named “Shoes and Squares”, allowed children to get actively involved and infer the most probable outcome among different conditions with structural changes in the composition of the sample space. Children are tested on whether the gradual alterations in the analogies and distribution of the items in every condition affect their predictions.

2. Methodology

The between-subject study took place in two public kindergartens in Ioannina during 2009. Preschoolers (N=50), aged 5-6, participated in a computer-based game with probabilities. The game was named “Shoes and Squares” after the items that were used as visual input on the screen of the computer. The theme of the visual inputs was selected randomly and as shoes, squares and cats do not relate semantically, children’s personal preference towards one of them was eliminated.

The game “Shoes and Squares” was set up through Microsoft PowerPoint and every trial was consisted of 5 slides. Each slide represented the relative action that would take place if concrete items, real cards, would be used. The game was pre-tested on 10 children in order to evaluate whether it responded to their interests and the stimuli had the same size as if they were real (7x5cm). There was an effort to relate the visual input of 2 dimensions with the items of 3 dimensions.

The first slide provided all the available information; cards with shoes and/or squares depending on the Condition and a recorded voice that gave instructions about how to play the particular game. In the following slide participants would observe the cards getting turned around and mixed up. Subsequently children were asked to predict what they believed would be the most probable outcome when one card would be picked out randomly. In the third slide participants would see one card being selected. Before their final estimation and response, the initial sample space of the items would appear on the screen again on a fourth slide, next to the selected hidden card, so that memory deficits would be ruled out. At that time, participants would make their inferences by pressing on a keyboard button in order to find out whether they responded in accordance with the hidden item. There were both icons of a ‘shoe’, a ‘square’ and a ‘cat’ stuck on the responsive keyboard buttons: ‘a’, ‘l’ and ‘h’. At the same time the researcher who was seated next to the participants recorded their predictions on a sheet for further analysis. No matter what children responded, the computer would randomly reveal either a square or a shoe or a cat (only in the 3rd level).

There were 2 Conditions and 25 children participated in Condition 1 while the rest 25 participated in Condition 2 (Table 1). Participants were randomly allocated in either Condition.

Table 1. Name of the table

Levels - Distribution of sample space	Condition 1	Condition 2	Stimuli
3:1	3 shoes, 1 square	3 squares, 1 shoe	
5:1	5 shoes, 1 square	5 squares, 1 shoe	
4:1:1	4 shoes, 1 square, 1 cat	4 squares, 1 shoe, 1 cat	

In the 1st Condition the cards that represented shoes were more advantageous and in the 2nd Condition the cards that represented squares were more advantageous. In both conditions, there were 3 levels with a progressive enrichment in the distribution of the sample space and the amount of given information. In all trials the sample space did not exceed 6 and in the first two levels 2 items were used whereas in the 3rd level of both Conditions, an additional neutral card was used, a cat. Thus, the levels did not have a progressive difficulty in probabilistic terms, but in terms of the arithmetic structure of the sample space. Each trial was repeated 3 times and the levels did not run in the same sequence every time.

Children participated in the game in pairs but one at a time would interact with the computer. They were seated in front of a screen at a distance of 70 cm and were given supplementary instructions when needed by the researcher. Participants were presented with the stimuli and then they were asked to get personally involved in the task by pressing the button they believed was 'correct'.

For the purposes of the current analysis we categorized as 'correct' (=1) the responses that related to the most probable outcome, as 'incorrect' (=0) the responses that related to the most unlikely outcome and as 'missing' (=-1) the responses that were not recorded at all. The procedure lasted around 15 minutes and in the end each child would get a candy for participating. For example, in Condition 1 – level 1, shoe would be 'correct' and square 'incorrect', in Condition 2 – level 3, shoe would be 'incorrect', square would be 'correct' and cat would be 'incorrect'.

3. Results

Overall in 450 trials, preschoolers (N=50) gave 255 correct predictions, 172 incorrect predictions and 23 errors, st dev=0,59.

The variance in the distribution of the sample space tended to affect children's predictions in both Conditions 1 and 2, no matter whether shoes or socks were more numerous (Figure 1).

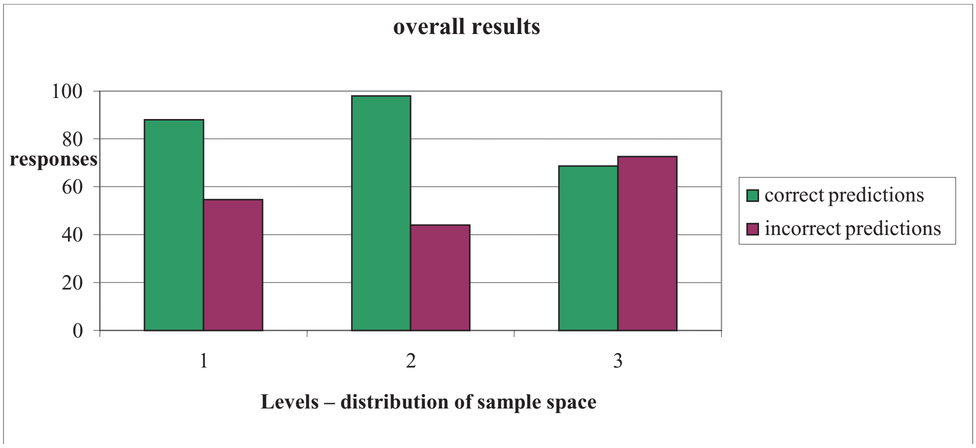

Figure 1. Graph of overall results

It can be seen that the greatest difference in preschooler's predictions was given in the 2nd level, where the probability of gaining the advantageous item was higher compared to the other levels. In this level, children scored 98 correct vs 44 incorrect responses. In the 1st level, where the distribution of sample space was 3:1, children again made more correct inferences (88) vs incorrect ones (55). In the 3rd level, where the distribution of sample space was more complex, 4:1:1, children reported more incorrect predictions. Based on the Pearson correlation coefficient, $r = -.99$, $p = .025 < .05$, there is significant negative correlation which means that as the levels vary correct responses decrease significantly. As more information is given and the most possible outcome is less evident, preschoolers show difficulty in making 'correct' predictions.

Concerning the repetition of the trials there is a statistically significant effect $p=.04<.05$. In the 1st trial of both Conditions children gave 56.6% correct predictions, in the 2nd trial they gave 52.6% and in the 3rd trial 59.3% correct answers. This implies that there seems to be a learning effect.

4. Discussion

Children were found to be able to participate actively and make correct judgments in this probabilistic computer task. Their personal engagement and the use of the computer as a tool affected their estimations positively. Such findings support the importance of developmentally appropriate computer games in preschool education (Haugland, 2000; Clements and Samara, 2003).

The role of technology in the teaching learning procedure is an aspect of important pedagogical implications and computer activities tend to be integrated nowadays in kindergarten classrooms. Computers provide situational and visual cues that allow children to think, elaborate, interact, collaborate, create and learn. Virtual manipulatives seem advantageous as they offer opportunities for explicit representations (Moyer et al, 2005) and contribute to more effective thinking, problem solving and learning (Papert, 1990). Under these lines, Haugland (2000) supports teachers' implementation of technology in classrooms with young children in order to accomplish learning objectives that provide opportunities for experimentation and exploration.

Such opportunities are underlined by the constructivist point of view. Constructivism, as a theory of learning or meaning making, encourages individuals to create personal new understandings while interacting with what they already know and believe (DeVries, 2002) and learn from a variety of instruction and methods (Richardson, 2003). Students should be provided with stimulating learning situations and opportunities that trigger their own thinking and engagement through the exploration of materials and interactions. Thus, technology can change the way children think, what they learn, and how they interact with peers and adults (Clements, 2004).

Another important aspect to be stressed out by the current results relates to the fact that participants showed a minimal understanding of the probabilistic thinking and made correct predictions no matter if the socks or the squares as stimuli were more advantageous. Even at the early age of 5, before formal elementary learning, children demonstrate basic notions of statistical thinking contrary to traditional theorists. Precisely, recent research has shown that young children have the cognitive and intellectual capacities to handle and analyze data (Watson & Moritz, 2000), to make inferences about the most/least likely outcomes (Way, 2003; Schlottmann, 2001), to estimate the likelihood of events (Nikiforidou & Pange, 2007), to understand the probability of an event, probability comparisons and conditional probability (Jones et al, 1997).

Additionally, preschoolers showed a better understanding of what is the most probable outcome in the 2nd level, where the given information was more apparent and the probability of the advantageous item was 5/6. As information became more complicated and the structure of the sample space altered, 3:1 and then 4:1:1 respectively, children showed more difficulty in estimating the most probable outcome. This provides support in the field of designing probabilistic tasks for preschoolers, as two components opposed to three are more manageable for children at this age (Nikiforidou & Pange, 2009). Thus, the overall results provide evidence that preschoolers can be actively involved in probabilistic tasks set up on a computer with simulations.

By taking into account the limited sample, further research should focus on more participants and more conditions. Would diverse stimuli or different distributions within the sample space provide different responses? How could the repetition of each trial 3 times and the learning effect be used within a didactic constructivist setting? When do preschoolers reveal characteristics and approach probabilistic thinking and other mathematical notions, with tangible material, computer simulations or both? In more general, which is the cognitively appropriate role of ICTs in preschool education?

Such methodological and theoretical implications should be taken into consideration. Computers provide new avenues and perspectives in preschool education and enhance children's learning when used in developmentally appropriate and meaningful ways. As computer-based manipulatives allow the transition from hands-on experiences to abstract learning (Papert, 1990), technological tools should be integrated in the preschool classroom in order to supplement and enrich the educational procedure.

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