The construction of spatial awareness in early childhood: the effect of an educational scenario-based programming environment

ANASTASIA MISIRLI, VASSILIS KOMIS, KONSTANTINOS RAVANIS

Department of Educational Sciences
and Early Childhood Education
University of Patras
Greece
amisirli@upatras.gr
komis@upatras.gr
ravanis@upatras.gr

Abstract

A teaching intervention – educational scenario – was implemented by educators to 306 pre-schoolers in 17 classrooms. It was designed to foster children's spatial awareness so as to help them construct a model of spatial concepts with reference to a mobile object around the space, the programmable toy Bee-Bot. The educational scenario encompasses instruments designed for gathering data of the pre and post children's representations about direction and orientation concepts, the teaching activities conceived to deliver these concepts by using the programmable toy and finally instruments designed for evaluation. The evaluation took place after three weeks implementation and the results indicated statistically significant difference in children's pre and post-test intervention representations and consequently construction of spatial knowledge not only to a functional context but moreover to a more symbolic one.

Keywords

Spatial awareness, direction, orientation, programmable toy Bee-Bot, educational scenario, preschool children's representations

Résumé

Dans ce travail nous étudions l'application d'un scénario éducatif effectuée par les enseignants de 17 classes avec 306 enfants d'âge préscolaire. Il a été conçu *dans le but de renforcer les concepts de la latérisation et d'aider les enfants à construire les notions de direction et d'orientation ayant comme référence un robot qui se déplace sur le sol, le jouet programmable Bee-Bot. Ce scénario éducatif comprend également des instruments construits pour collecter des données sur les représentations des enfants concernant les notions visées. Dans le cadre du scenario ces notions-ci ont été enseignées à travers des activités appropriées et ces instruments les ont évaluées. Le scénario a duré trois semaines et son évaluation a été réalisée à la fin. Les résultats indicent qui il y a des différences significatives entre les représentations initiales et les représentations finales des enfants sur les notions de latéralisation. Ces représentations, après la réalisation du scenario, sont plus complètes, dépassent le niveau fonctionnel et montrent une avancée cognitive des enfants au niveau symbolique.*

Mots-Clés
Concepts spatiale, latéralisation, jouet programmable Bee-Bot, scénarisation éducative, représentations d'enfants d'âge préscolaire

Introduction

The term "Educational Robotics" refers to the teaching practice during which the students use the robots to construct knowledge with the help of or for the robots themselves. The term appeared in the 1960s through the educational approach of the Logo programming language. It concerns an approach which allows the learner to familiarize himself with the Information and Communication Technologies and use them to define a plan, to organize and find a specific solution to the given problem exchanging his opinion with those of others (Denis & Baron, 1994; Leroux, Nonnon, & Ginestié, 2005). Within this context educational robotics consists of an educational approach which recruits programmable devices to improve the learning process through project-based learning. It is defined by the use of Information and Communication Technologies (ICT) in its own affordances for observation, analysis, modelling and control of various physical procedures (Depover, Karsenti, & Komis, 2007).

A distinct category of educational robotics is the Logo-like programmable toys which are appropriate in early childhood and primary education. These programmable toys are programmable robots which are controlled by the user for the respective movement or path they are ordered to execute. In some cases the connection with the computing environment may be used. The child conceives and defines the commands which are introduced into the robot following the principles of the Logo programming language. Educational robotics in early childhood education uses appropriate cognitive tools, emphasizing on tangible use. The use of such tools which is the case of programmable toys is a factor of motivation infusing the interest in children and their actions towards learning. Those tools are developmentally appropriate as they are based on playing and consisting of meaningful action and reaction (Highfield, 2010; Mulligan & Highfield, 2008). As educators are responsible and aware to motivate children's learning, they should continually look for techniques and methods that are conductive to a positive learning environment. Within this context the present study proposes an educational process where pre-schoolers are engaged to problem-solving situations concerning spatial concepts by using the programmable toy Bee-Bot.

Theoretical framework

As Kilia, Zacharos and Ravanis (2015, p. 166) claim, children construct their interpretation of space by developing two different but related types of spatial knowledge: the first category has as its reference their own body (bodies-self-based) and the second has several reference systems which are exterior to their own body (external-based systems). In this second category of spatial knowledge that appears later than the first (Clements & Sarama 2009) the child is able to identify locations by evoking distances and directions of external points of reference, for example, using the frame of the sides of a room to find a toy (Bishop 1980; Clements & Sarama 2009; Germanos, Oikonomou, & Tzekaki, 1997; Zacharos, Kilia, & Ravanis, 2014).

As young children begin to discover the space, in a developmental perspective they come into mental contact with iconic representations of real space, such as maps and models. In the framework of the early childhood education various forms of spatial representations are used. Consequently, the interest of these representations is highlighted in a series of studies that study the development of children's ability to understand and use forms of external representations (Blades & Spencer, 1987; Blades et al., 1998; DeLoache 2000; Huttenlocher Newcombe, & Vasilyeva, 1999; Liben & Downs, 1993; Piaget & Inhelder 1956). One of the important issues of the mental construction of space in thinking of young children is the issues of oriented movement.

Piaget (1952) suggested that young children face difficulties to understand the relation aspects of spatial concepts such as front-back, left-right and up-down and it is near the age of eleven, the stage of formal operational stage as he called it, that such understanding may occurs. Although Piaget indicated that there are definite stages in the development of intellectual thought, understanding may occur earlier than these stages originally propose.

In her study Harris (1972) individually tested 27 pre-schoolers and 12 children in 2nd grade, on their knowledge of several spatial concepts. As it is indicated from the results half the pre-schoolers performed successfully on left-right tasks and answered the additional discrimination questions. The same behaviour was recorded for the 2nd

graders where only half of them made passing scores on left-right relationship questions.

Furthermore Lockavitch (1975) propose that lateral awareness, the ability to relate objects according to one's own left-right orientation, is found in the ground of skills required to develop more complex skills.

Germanos et al. (1997) conducted an experiment where 112 pre-schoolers aged 5 years old participated in a pre and post-test, in order to evaluate the results of their proposed educational approach. The selected spatial concepts studied were *in front of-behind*, *left-right* and although from a mathematical point of view are equivalent their psychological and psycho-sociological aspects 'alter their initial character of equivalence'. Children accomplished learning tasks related to the presence of a reference system focused on the child's body and the transfer of this system outside the child's body. The results showed progress in the learning process of primary mathematical concepts of space from the children.

The use of technology such as programmable toys, interactive whiteboards and dynamic interactive educational software facilitate children's early mathematical development (Highfield & Goodwin, 2008). Some researchers suggest that learning through interaction with a programmable toy, the construction of more abstract cognitive structures and the development of social skills is reinforced (Bers & Horn, 2010; Yelland, 2007).

This robotics subcategory is inscribed in the psychopedagogical approach of the Logo language, supporting the development of the metacognitive ability, with which the children reflect on the cognitive process adopted, improving the ability of problem-solving and promoting the ability of spatial orientation (Clements & Nastasi, 1999; Clements & Sarama, 2002).

Similar conclusions are drawn by Keller and Shannahan (1983) where pre-schoolers used the programmable toy Big Trak to approach concepts of directionality. They also found that this tool facilitated the learning process of pre-schoolers and help them to construct concepts of directionality which were related to successful learning in first grade.

The results of the study Carlson and White (1998) indicate that the kindergarten students who were exposed to a particular computer program significantly increased their scores on the post-test which measured their understanding of the concepts of left and right.

Greff (2001) supported that the programmable toy Roamer is an essential educational tool for children to construct, among other mathematical concepts, directionality and orientation. Its affordance lays on that it offers to children an immediate medium to validate their proposed solution.

João-Monteiro et al. (2003) report the results of their teaching intervention within the context of the ICEI program in preschool settings in Portugal by using the programmable toy floor-robot Roamer. This robotic tool was used to support teachers in using the ICT as a cognitive tool. The added value of this particular robot lies in its potential to develop mathematical concepts in children in early childhood.

Similar outcomes have also been stated by Highfield, Mulligan and Hedberg (2008) with the programmable toy Bee-Bot. They described various instances where early childhood and primary school children interacted with the Bee-Bot for the development of mathematical concepts. Among others children were observed to demonstrate "understanding of directionality through articulating their planned execution of the program" (p. 173).

In the study conducted by Highfield (2010) thirty three children of early childhood and their teachers chose the Bee-Bots and Pro-Bots from a range of robotic toys. Through a learning process of a combination of robotic toys and engaging tasks mathematical thinking and sustained engagement was promoted. A special unit of the learning tasks referred to directionality examining concepts such as *forward-backward*, *rotate, left-righ*t and positional language.

Pekarova (2008) studied the development of effective teaching practices and attractive activities for children through digital technologies in early childhood education. Her results show the need of an organised context for teaching programming concepts with the use of the Bee-Bot. However, since this procedure is not sufficient enough for activating childrens' inner motives, the formation and the organization of appropriate problem-solving tasks as well as the development of teaching materials are required.

Overall, research has shown that there is no systematic and principle-based framework for teaching educational robotics concepts in early childhood settings. What appears to be missing is a developmentally appropriate educational context for developing mathematical abilities and reinforcing inner motives of children in early childhood. This is important because integration and use of a programmable toy within an appropriate teaching and learning context may infuse cognitive development (Depover et al., 2007) such as mathematical skills and problem-solving abilities in children. Thus an educational scenario-based approach was employed to deliver spatial concepts through the development of programming abilities.

Methodological framework

Subjects

This study follows a model of developmental design based mixed research and uses the method of multiple case studies for collecting qualitative and quantitative data (Kelly, Lesh, & Baek, 2008). The educational scenario focused on spatial concepts, has been implemented for two years through the scientific European project Fibonacci by 17 educators and 309 children between the ages of 4-6. The educators were randomly chosen as they volunteered to participate within the scientific European project Fibonacci (http://www.fibonacci-project.eu/) and consequently children are from diverse settings.

Educational scenario – programming environment for teaching and learning

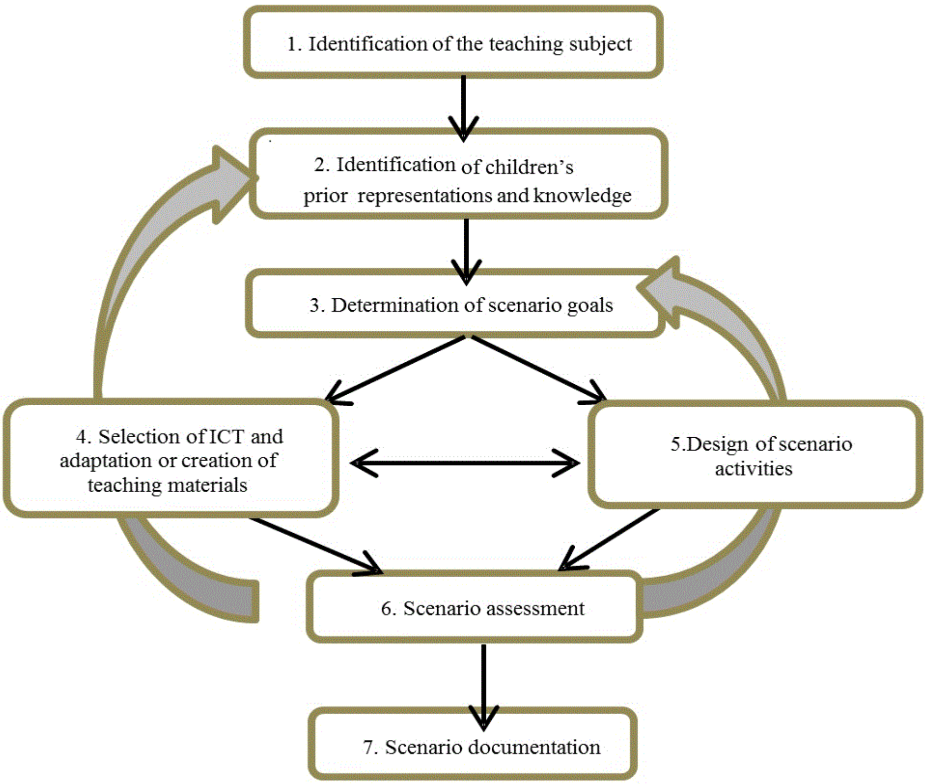
Educators have access to plenty materials and each of them may be used as cognitive tools integrated in a context where appropriate strategies support for reaching any particular educational goal. In that case the main point for an educator is considering the added value that is implied when using a tool in a means of cognitive development. In our case the educational tool was the programmable toy Bee-Bot (Misirli & Komis, 2014; Komis & Misirli, 2015) which was used to reinforce the spatial development although we were primarily aimed to develop children's programming ability. A scenario-based approach for designing educational robotics activities aimed to develop skills such as problem solving and spatial thinking.

The conceptualization of an educational scenario includes seven phases which are constructing basically a linear model for designing a full teaching intervention based on robotic themes (fig. 1). The core part of the scenario model includes phases four (4) and five (5) where there is an inner relationship between them in order to be achieved the most appropriate integration of the programmable toy Bee-Bot to the teaching activities and consequently to the adequate learning concepts. It was developed adequate teaching material (mats, cards of commands) and problem-solving situations to support the undertaken learning concepts.

The first educational scenario designed and implemented in the first year of experimentation several case studies (ninety two children). The data gathered from that implementation, indicated that children were having difficulties understanding spatial concepts and especially those concerning orientation (Komis & Misirli, 2011). The findings showed the need to engage children with spatial concepts and especially orientation. Thus the second year of the research another educational scenario was conducted focused on orientation concepts. This scenario implemented for two consequent years.

The educational scenario focusing on spatial thinking had main objective children to construct concepts of directionality and orientation having as system of reference the programmable toy Bee-Bot. Besides this process children would construct programming knowledge through the function and control of the programmable toy.

FIGURE 1



The phases in designing educational scenarios in robotics

Instruments and Data collection

Concerning the techniques gathering the qualitative data; different research protocols (instruments) were developed and introduced to the distinct phases of an educational scenario (figure 1). All these instruments were tools for educators for recording and evaluating the learning process. A structured interview was introduced at the phase where children's prior representations and knowledge about the spatial concepts were to be identified. These concepts are symbolic represented on the keyboard of the programmable toy by arrows. Four (4) open-ended questions among eleven (11) focused on direction (Forward-Backward) and orientation (Left-Right) concepts and was used to assess pre and to evaluate post-intervention children's representations. These questions formed the categorical variables of our analysis. The results from the post-intervention interview are embedded in the phase where the scenario activities are designed and particular to the sub-category of subject evaluation process.

In the same sub-category three more instruments have been applied. After the first section of teaching activities (function and use of programmable toy), an instrument for assessing every child's prior knowledge on the spatial concepts was introduced. Another instrument was used to record each child's evaluation on the programming and spatial concepts through the use of cards-commands along with the completion of particular path. All these instruments shared the same technique of a structured interview. The scale which was used to measure pre and post-test compiled of two values: *Complete* and *Incomplete*. We use the interviews individually so as to assess and evaluate the degree of children's representations and their recognition about the graphic representations concerning the symbols of spatial concepts founded on the keyboard on the programmable toy Bee-Bot (Logo-like language commands). To be more precise and to reinforce children's verbal representations it was also asked of them to show the additional movement by moving the programmable toy to the way they were describing. It should be mentioned that the latter technique provide the educator with the opportunity to verify early childhood children's verbal representations since at this age different approaches are required to facilitate verbal communication. As concerns the pre-schoolers all these instruments engage them in methods such as visualisation and reflection to facilitate their learning process.

Results

Data Analysis

The analysis clearly shows the evolution of abilities in spatial structures and more precisely orientation and direction abilities. The development and the evolution of these specific cognitive abilities is facilitated through designing and implementing developmentally appropriate educational scenarios which may in turn lead to the creation of relative cognitive representations on the function and the use of the Bee-Bot programmable toy (Komis & Misirli 2011, 2012). Four variables-constituted each one by two values (Complete and Incomplete)-were used to measure spatial concepts (forward, backwards, left, right). The non-parametric test McNemar was performed to compare and control the children's interpretations (pre-test and post-test). As it shown in the following tables a statistically significant movement of the subjects from the pre-test to the post-test ($p<0.05$) was occurred.

In table 1 the variable «ArrowForward_Tracing» records the children's pre-test representations concerning the interpretation of symbolic graphic representation (button arrow–'Forward') on the keyboard of the programmable toy. Respectively the variable «ArrowForward_Evaluation» concerns the recording of the children's post-test representations on the same symbolic graphic representation after the teaching intervention was accomplished. The categories 'Complete' and 'Incomplete' signify the degree of coherence that children accomplish in the pre and post-test. The category 'Complete' stands for the complete representation and verbal expression of the children such as: 'forward' where the category 'Incomplete' for the non-complete one such as: 'it goes like this (the child shows the movement forward), 'straight' or 'up'. As it shown in table 1 the majority of 'Incomplete' representations of children (111 in 117) refer to prior intervention while for those subjects after the intervention a statistically significant movement towards the category 'Complete' is observed.

TABLE 1

Variable 'ArrowForward_Tracing_Evaluation'

	ArrowForward _Ev_Incomplete	ArrowForward _Ev _Complete	Row Total
ArrowForward_Tr_ Incomplete	6	111	117
ArrowForward_Tr_ Complete	7	135	142
Column Total	13	246	N=259

TABLE 2

Variable 'ArrowBackwards_Tracing_Evaluation'

	ArrowBackwards _Ev_ Incomplete	ArrowBackwards _Ev_ Complete	Row Total
ArrowBackwards_Tr_ Incomplete	5	99	104
ArrowBackwards_Tr_ Complete	9	145	154
Column Total	14	244	N=258

In table 2 the variable «ArrowBackwards_Tracing» records the children's pre-test representations concerning the interpretation of symbolic graphic representation (button arrow–'Backwards') on the keyboard of the programmable toy. Respectively the variable «ArrowBackwards_Evaluation» concerns the recording of the children's post-test representations on the same symbolic graphic representation after the teaching intervention was accomplished. The categories 'Complete' and 'Incomplete' signify the degree of completeness that children accomplish in the pre and post-test. The category 'Complete' stands for the complete representation and verbal expression of the children such as: 'backwards' where the category 'Incomplete' for the non-complete one such as: 'it goes like this (the child shows the movement backwards), 'reverse' or 'down'. As it shown in table 2 the majority of 'Incomplete' representations of children (99 in 104) refer to prior intervention while for those subjects after the intervention a statistically significant movement towards the category 'Complete' is observed.

TABLE 3

Variable 'ArrowLeft_Tracing_Evaluation'

	ArrowLeft_Ev_ Incomplete	ArrowLeft_Ev_ Complete	Row Total
ArrowLeft_Tr_Incomplete	0	0	0
ArrowLeft_Tr_Complete	44	213	257
Column Total	44	213	N=257

In table 3 the variable «ArrowLeft_Tracing» records the children's pre-test representations concerning the interpretation of symbolic graphic representation (button arrow–'Left') on the keyboard of the programmable toy. Respectively the variable «ArrowLeft_Evaluation» concerns the recording of the children's post-test representations on the same symbolic graphic representation after the teaching intervention was accomplished. The categories 'Complete' and 'Incomplete' signify the degree of completeness that children accomplish in the pre and post-test. The category 'Complete' stands for the complete representation and verbal expression of the children such as: 'left' where the category 'Incomplete' for the non-complete one such as: 'it goes like this (the child shows the turn left, shows a shift to the left side) and 'right'. As it shown in table 3 while the majority of 'Complete' representations of children (213 in 257) for the symbolic representation of the arrow showing turn 'Left' are categorised as having adequate representation there is still a significant part of children (44 in 257) characterised as having 'Incomplete' representations on that concept. A further analysis examined whether the variable 'Gender' may give us further interpretations on that matter. More precisely from the 44 children remained with incomplete mental representations most of them (29 in 44) are in the age of four years.

TABLE 4

Variable 'ArrowRight_Tracing_Evaluation'

	ArrowRight_Ev_ Incomplete	ArrowRight_Ev_ Complete	Row Total
ArrowRight_Tr_ Incomplete	43	148	191
ArrowRight_Tr_Complete	3	65	68
Column Total	46	213	N=259

In table 4 the variable «ArrowRight_Tracing» records the children's pre-test representations concerning the interpretation of symbolic graphic representation (button arrow–'Right') on the keyboard of the programmable toy. Respectively the variable «ArrowRight_Evaluation» concerns the recording of the children's post-test representations on the same symbolic graphic representation after the teaching intervention was accomplished. The categories 'Complete' and 'Incomplete' signify the degree of completeness that children accomplish in the pre and post-test. The category 'Complete' stands for the complete representation and verbal expression of the children such as: 'right' where the category 'Incomplete' for the non-complete one such as: 'it goes like this (the child shows the turn right, shows a shift to the right side) and 'right'. As it shown in table 4 while the majority of 'Incomplete' representations of children (148 in 191) for the symbolic representation of the arrow showing turn 'Right' are categorised as having adequate representation there is still a significant part of children (43 in 191) characterised as having 'Incomplete' representations on that concept. A further analysis examined whether the variable 'Gender' may give us further interpretations on that matter. More precisely from the 44 children remained with incomplete mental representations most of them (26 in 43) are in the age of four years.

The above-mentioned findings concerning the number of children presenting no significant difference in their representations, is also supported by Clements & Sarama (2009). It is stated that it is developmentally appropriate for educators to initiate the learning of 'left' and 'right' at the age of four and to use spatial vocabulary to direct attention to spatial relations at the age of five. Moreover for the use of Logo language as it is implied that educators should use the coordination on maps which in our case that happened when children planned a path on the mat of the programmable toy. The analysis made included the variable of gender has shown no statistical differentiation.

Discussion

In this study we presented the effect of a scenario-based teaching intervention on robotics to develop children's spatial awareness. Our proposed intervention seems to be appropriate and relevant to the learning process addressing for preschool children to construct spatial concepts and additionally graphic-symbolic relations. The findings corresponded to the conceptual constructs of high-level abilities in spatial thinking while the teaching intervention provided a meaningful context for developing the spatial relations.

We identified significant differences on pre-schoolers' post-test representations as they present an evolution to more complex thinking skills since they accomplished to relate objects not only according to their own for left-right orientation as it was implied by Lockavitch (1975) but moreover according to the orientation of another reference system (Germanos et al., 1997) that of the programmable toy. The child called to design paths for moving the programmable toy to a particular direction. All the paths were solutions to given problem-solving situations; each solution included spatial orientation and were designed and represented by every child individually using the cards commands. Thus the path-programme was introduced to and executed by the programmable toy reinforcing the child's design and choice of commands and validating the given solution. The tool itself leads the child to construct and reflect on its own learning trajectory and in turn offers to the child the opportunity for adequate repositioning.

Therefore, a modest constructivist approach for designing teaching environments and using the programmable toy Bee-Bot could be adopted, which takes into consideration so much the necessity of guidance during the learning process as well as the importance of scaffolding and collaborative construction of knowledge. The educational robotics activities introduced through a scenario-based approach are aligned to the development of the 21st century skills such as collaboration, problem solving, creativity, critical thinking and computational thinking (Komis, Romero, & Misirli, 2017). In the proposed conceptual framework, the affordances of the programmable toys aimed to serve particular educational objectives through the organization of several resources would be a matter of further research.

Références

Bers, M., & Horn, M. (2010). Tangible programming in early childhood: Revisiting developmental assumptions through new technologies. In I. R. Berson & M. J. Berson (Eds.), *High-Tech tots: Childhood in a digital world* (pp. 49-69). North Carolina: Information Age Publishing.

Bishop, A. J. (1980). Spatial abilities and mathematics achievement: A review. *Educational Studies in Mathematics, 11*, 257-269.

Blades, M., & Spencer, C. P. (1987). The use of maps by 4 to 6 year old children in a large scale maze. *British Journal of Developmental Psychology, 5*, 19-24.

Blades, M., Blaut, J., Davizeh, Z., Elguea, S., Sowden, S., Soni, D., Spencer, C., Stea, D., Surajpauli, R., & Uttal, D. (1998). A cross-cultural study of young children's mapping abilities. *Transactions of the Institute of British Geographers, 23*, 269-277.

Carlson, L. S., & White, H. S. (1998). The effectiveness of a computer program in helping kindergarten students learn the concepts of left and right. *Journal of Computing in Childhood Education*, *9*(2), 133-147.

Clements, H. D., & Nastasi, B. K. (1999). Metacognition, learning, and educational computer environments. *Information Technology in Childhood Education Annual, 1*, 5-38.

Clements, H. D., & Sarama, J. (2002). The role of technology in early childhood learning. *Teaching Children Mathematics, 8*(6), 340-343.

Clements, H. D., & Sarama, J. (2009). *Early childhood mathematics education research: Learning trajectories for young children*. New York: Routledge.

DeLoache, J. D. (2000). Dual representation and young children's use of scale models. *Child Development, 71*(2), 329-338.

Denis, B., & Baron, G. L. (Éds.) (1994). *Regards sur la robotique pédagogique - Actes du quatrième colloque international sur la robotique pédagogique*. Paris: INRP.

Depover, C., Karsenti, T., & Komis, V. (2007). *Enseigner avec les technologies*. Québec, Canada: Presses de l'Université du Québec.

Germanos, D., Oikonomou, A., & Tzekaki, M. (1997). A spatio-pedagogical approach to the learning process in early childhood: An application on space-mathematical concepts. *European Early Childhood Education Research Journal, 5*(1), 77-88.

Greff, E. (2001). Résolution de problèmes en GS autour des pivotements à l'aide du robot du plancher. *Grand N, 68*, 7-16.

Harris, I. (1972). Discrimination of left and right, and development of the logic of relations. *Merrill-Palmer Quarterly, 18*, 307-320.

Highfield, K. (2010). Robotic toys as a catalyst for mathematical problem solving. *Australian Primary Mathematics Classroom*, *15*(2), 22-27.

Highfield, K., & Goodwin, K. (2008). A review of recent research in early mathematics learning and technology. In M. Goos, R. Brown & K. Makar (Eds.), *Mathematics Education Research Group of Australasia* (pp. 259-264). Brisbane: Mathematics Education Research Group of Australasia.

Highfield, K., Mulligan, J., & Hedberg, J. (2008). Early mathematics learning through exploration with programmable toys. In O. Figueras, J. L. Cortina, S. Alatorre, T. Rojano & A. Sepulveda (Eds.), *Proceedings of the Joint Meeting of Pme 32 And Pme-Na Xxx,* (Vol. 3, pp. 169-176). Mexico: Cinvestav-UMSNH.

Huttenlocher, J. E., Newcombe, N., & Vasilyeva, M. (1999). Spatial scaling in young children. *Psychological Science, 10*(5), 393-398.

João-Monteiro, M., Cristóvão-Morgado, R., Bulas-Cruz, M., & Morgado, L. (2003). A robot in kindergarten. In *Eurologo'2003 Proceedings - Re-inventing technology on education.* Coimbra, Portugal: Eurologo'2003. Retrieved from http://hal.archives-ouvertes.fr/hal-00190327/fr/.

Keller, J., & Shannahan, D. (1983). Robots in kindergarten. *The Computing Teacher, 10*(9), 66-67.

Kelly, E. A., Lesh, A. R., & Baek, Y. J. (2008). *Handbook of Design Research Methods in Education*. New York, NY: Routledge.

Kilia, M., Zacharos, K., & Ravanis, K. (2015). Four to six years old children use photographs as sources of information about space. *European Early Childhood Education Research Journal*, *23*(2), 164-182.

Komis, V., & Misirli, A. (2011). Robotique pédagogique et concepts préliminaires de la programmation à l'école maternelle : Une étude de cas basée sur le jouet programmable Bee-Bot. In *Proceedings of the 4th conference of "Didactics of Informatics" – DIDAPRO* (pp. 271-284). Athènes: New Technologies Editions.

Komis, V., & Misirli, A. (2012). L'usage des jouets programmables à l'école maternelle : concevoir et utiliser des scenarios éducatifs de robotique pédagogique. *Revue Skhôlé, 17*, 143-154.

Komis, V., & Misirli, A. (2015). Apprendre à programmer à l'école maternelle à l' aide de jouets programmables. In G.-L. Baron, É. Bruillard & B. Drot-Delange (Éds.), *Informatique en éducation : Perspectives curriculaires et didactiques* (pp. 209-226). Clermont-Ferrand: Presses Universitaires Blaise-Pascal.

Komis, V., Romero, M., & Misirli, A. (2017). A scenario-based approach for designing educational robotics activities for co-creative problem solving. In *Advances in Intelligent Systems and Computing* (pp. 158-169). New York: Springer.

Leroux, P., Nonnon P., & Ginestié J. (2005). *Actes du 8ème colloque francophone de Robotique Pédagogique*. Marseille: Revue Skhôlé.

Liben, L. S., & Downs, R. M. (1993). Understanding person-scale-map relations: Cartographic and developmental perspectives. *Developmental Psychology, 29*(4), 739-752.

Lockavitch, J. (1975). Of course I'm not stupid…I just don't know my right from my left. *Academic Therapy*, *10*(2), 159-165.

Misirli, A., & Komis, V. (2014). Robotics and programming concepts in Early Childhood Education: A conceptual framework for designing educational scenarios. In C. Karagiannidis, P. Politis & I. Karasavvidis (Eds.), *Research on e-Learning and ICT in Education* (pp. 99-118). New York: Springer.

Mulligan, J., & Highfield, K. (2008). Young children's engagement with technological tools: The impact on mathematics learning. In *Proceedings of International Congress in Mathematical Education 11* (pp. 1-8). Monterrey, Mexico: International Congress of Mathematics Education.

Pekarova, J. (2008). Using a programmable toy at preschool age: Why and how? In *Workshop Proceedings of SIMPAR 2008 Intl. Conf. on Simulation, Modeling and Programming for Autonomous Robots* (pp. 112-121). Venice, Italy: SIMPAR.

Piaget, J. (1952). *Judgement and reasoning in the child*. London: Routledge.

Piaget, J., & Inhelder, B. (1956). *The child's conception of space*. London: Routledge and Kegan Paul.

Yelland, N. (2007). *Shift to the future: Rethinking learning with new technologies in education*. New York: Routledge.

Zacharos, K., Kilia, M., & Ravanis, K. (2014). Familiarizing pupils 4-6 years old with forms of spatial representation. The use of photography as an auxiliary tool. *Journal of Social Science Research*, *4*(1), 454-463.