

History and Educational Potential of LEGO Mindstorms NXT

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Abstract: Educational usage of the robotics has accelerated recently because of educational potential of robotics has been recognized by educators and popularity of international robotics tournaments. Many university and schools prepare technology and robotics related summer schools for children. LEGO Mindstorms NXT is the most popular and commonly used robotics set for educational purposes. These robot sets rooted to Seymour Papert's LOGO studies which have much influence Instructional Technology in 1960's. This study aims to present a literature review on educational potential of LEGO Mindstorms NXT robotics sets. Robotics mainly used in education for supporting the STEM (Science, Technology, Engineering and Mathematics) education. Most of the related studies resulted with positive effects of the robotics activities in STEM education. Robotics also used in education to increase some skills of the children such as discovery learning, critical thinking and social skills.

Key words: LEGO Mindstorms NXT, robotics, educational potential

Özet: LEGO Mindstorms NXT'lerin Tarihi ve Eğitsel Potansiyeli: Robotların eğitsel amaçlarla kullanımı giderek artmaktadır. Eğitimcilerin robotların eğitsel potansiyelinin farkına varmaları ve uluslararası robot turnuvalarının popülerlik kazanmasının robotların eğitsel kullanımına katkısı büyüktür. Birçok üniversite ve okul, teknoloji ve robotlar konulu yaz kampları düzenlemektedirler. LEGO Mindstorms NXT en popüler ve en çok kullanılan eğitsel robot setleridir. Bu robot setlerinin geçmişi, Seymour Papert'in LOGO çalışmalarına dayanmaktadır. Bu çalışmaların 1960'larda eğitim teknolojisine büyük etkileri olmuştur. Bu tarama çalışmasının amacı son zamanlarda eğitimcilerin ilgisini çeken, robotların eğitsel amaçlarla kullanımına yönelik çalışmaları inceleyerek, LEGO Mindstorms NXT robot setlerinin eğitim amaçlı kullanım potansiyellerinin belirlenmesidir. Robotlar eğitimde en çok FTMM (Fen, Teknoloji, Mühendislik ve Matematik) eğitimini desteklemek amaçlı kullanılmışlardır. Bu konuda yapılan çalışmaların büyük bir bölümü robotların FTMM eğitimine pozitif etkisiyle sonuçlanmıştır. Robotların eğitimde bir diğer kullanım alanı ise çocukların keşfetme, eleştirel düşünebilme ve sosyal becerilerini geliştirme amaçlıdır.

Anahtar Kelimeler: LEGO Mindstorms NXT, robotik, eğitsel potansiyel

Introduction

Robots' educational potential as teaching tools and motivators has long been recognized by educators, but economic constraints prohibited its extensive deployment. However, in the past few years cost of the robots has been decreased and their performance has been increased. Nowadays, robots are affordable, powerful and reliable to be deployed in college and even high schools. With the popularity of international robot championship, educational usage of the robots has accelerated recently.

Many universities and schools prepare technology and robotics related summer schools for children (Cannon et al., 2006; Cannon, Panciera, & Papanikolopoulos, 2007; Keathly & Akl, 2007; Nordstrom, Reasonover, & Hutchinson, 2009; Williams, Ma, Prejean, & Ford, 2008). Some of the technology related camps were prepared especially for girls to increase their curiosity and interest toward STEM (Science, Technology, Engineering and Mathematics) and also increase the possibilities of the engineering careers (Burket, Small, Rossetti, Hill, & Gattis, 2008).

Robotics and STEM relations are not limited with the study of STEM careers. Robotics became the new approach to provide students with hands on experience while learning science subjects (Jim, 2010). Williams et al. (2008) stated that the summer robotics camp, they designed for their study, enhanced middle school students' physics content knowledge. Also, Mataric, Koenig, and Feil-Seifer (2007) concluded that robotics has been proved that a superb tool for hands-on learning, not only of robotics itself, but also general science, technology, engineering, and mathematics (STEM).

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Aim of this literature review is to explore educational potential of robotics. Because of its popularity and common usage, LEGO Mindstorms NXT robotics sets are focused in the study. The theoretical background of the robotics and historical development of NXT robotics sets also reviewed to better evaluation of related studies.

Theoretical Background: Constructionism

In the 1960s, Seymour Papert and colleagues initiated a research projects at Massachusetts Institute of Technology (MIT), to understand how children think and learn. They invented the programming language is LOGO. LOGO has been used by tens of millions of school children all over the world. Its theoretical background influenced educators and researchers direction of educational reform and roles of the technology in education. That theoretical background is known as “constructionism” (Kafai & Resnick, 1996).

Papert worked with Piaget at late 1950’s and early 1960’s in Switzerland, and he stated that “in 1964, after five years at Piaget’s Center for Genetic Epistemology in Geneva, I came away impressed by his way of looking at children as the active builders of their own intellectual structures” (Papert, 1993, p. 19). Papert built his theory of learning on the constructivist theories of Jean Piaget, stating that learning is active construction of the knowledge in the learner’s mind, knowledge is not simply transmitted from teacher to student. In addition to constructivist theory, Papert constructed his learning theory based on artificial intelligence theories and gender and personality studies (Harel, 1991).

Papert makes the simplest definition of the constructionism as “learning by making” (Papert & Harel, 1991). He adopted the word constructionism refer to everything that related to “learning by making” and the idea behind constructionism includes and goes far beyond the idea of “learning by doing”, that is the idea behind constructivism (Papert, 1999). Seymour Papert and Idit Harel made following definition of constructionism in the first chapter of their book Constructionism.

Constructionism--the N word as opposed to the V word--shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe (Papert & Harel, 1991, p. 1).

Constructionism, Constructivism Similarities and Differences

Piaget and Papert are both constructivists. They viewed children as the builders of their own knowledge. Knowledge is not merely an asset to be transmitted, encoded, grasped, retained but constructed and reconstructed through personal experience. Learning means the creating of concepts and rules through an active process of doing and thinking (Ackermann, 2001; Harel, 1991).

According to Ackermann (2001), Piaget and Papert are also both developmentalists which means they have common idea on incremental knowledge construction. They both studied the learning conditions. Learners are likely to keep or change their theories about given phenomenon through interacting with it. However, Papert in his book *Mindstorms Children, Computers, and Powerful Ideas* (1993) stated that he does not fully accept Piaget’s distinction concrete thinking and formal thinking but he accepts that this distinction close enough to reality. Piaget believed that computer can concretize (and personalize) the formal thinking. Therefore, computer can allow us to shift the boundary separating concrete and formal thinking.

Constructionist view sees children as the active builder of their knowledge rather than passive receiver of the knowledge from teacher, as in constructivist view, however constructionist view adds extra emphasis to “external artifact” and “sharing with others” (Kafai & Resnick, 1996; Maxwell, 2006). “Unlike Piaget, Papert believes that learning as particularly effective when it takes place in the context of a rich and concrete activity, which the learner (child as well as adult) experiences while constructing a meaningful product such as a piece of artwork, a story, or a research report. Therefore, he creates and emphasizes far richer learning environments than does Piaget in his experiments” (Harel, 1991, p. 26). While accepting the Piaget’s cognitive stages, “Papert is interested in how learners engage in a conversation with [their own or other people’s] artifacts, and how these conversations boost self-directed learning, and ultimately facilitate the construction of new knowledge” (Ackermann, 2001, p. 1). He

stresses the importance of tools, media, and context in human development (Ackermann, 2001; Harel, 1991).

History: LOGO to Mindstorms

What is LOGO

After returning to the United States, Seymour Papert founded MIT Artificial Intelligence Laboratory with Marvin Minsky. Early work of the Papert with his research group included the development of the LOGO programming language. First version of LOGO was created in 1967. LOGO was computer language which communication with the Turtle which is basketball sized, dome shaped robot. Turtle could move across the floor by LOGO commands like FORWARD, BACKWARD, LEFT and RIGHT; and made drawings on butcher paper with mounted pen (Martin, Mikhak, Resnick, Silverman, & Berg, 2000; Papert, 1993; Watt, 1982). For example FORWARD 100 makes the Turtle move in a straight line about 100 millimeter. Typing PENDOWN causes the turtle to lower a pen to draw trace of the turtle (Papert, 1993). According to Papert (1993) turtle served as an “object-to-think-with”

Most popular version of LOGO has floor turtle. In 1970s the turtle migrated to computer screen. Screen turtle was more accurate and much faster than the floor turtle that allow to children to create and examine more complex geometric shapes. Some turtle shapes can change shape to birds, cars, planes or whatever the designer chooses (Martin et al., 2000; Sargent et al., 1996; Watt, 1982).

LEGO/LOGO

In the mid-1980s LOGO research group began to collaboration with LEGO group. They created LEGO/LOGO system which is combination of LEGO Technic product (which includes beams, gears, and motors) and LOGO language. Therefore, the turtle was of the screen and turned back to into the world. However, LEGO/LOGO was different from the earlier floor turtle. LEGO/LOGO was not already built mechanical object. Children can build their own machines such as a Ferris wheel, elevator, and robot creature before programming them. Children did not restrict to the turtles (Martin et al., 2000; Sargent et al., 1996; Watt, 1982).

In the late 1980s, LEGO/LOGO system became commercially available. It was sold to schools with the name “LEGO to LOGO” by the Lego group. It was used more than 15.000 elementary and middle schools in the United States (Martin et al., 2000; Sargent et al., 1996; Watt, 1982).

Programmable Brick

LEGO/LOGO had limitations. The machines constructed by children had to be connected to computer with wires. When children used LEGO/LOGO to create mobile machines, wires limited its mobility. Wires got tangled with other objects in the environments also they restrict the range of machines. Each motors and sensors should be connected to the computer with their own cable. Therefore, they get twisted in knots as the machine rotates. Moreover, it was difficult to think LEGO/LOGO machine as an autonomous while it was attached to a computer (Martin et al., 2000; Sargent et al., 1996). Fred Martin (1988) and his research group have overcome this deficiency by first Programmable Bricks in 1987. The Programmable Brick had a computer inside, therefore to program the Programmable Brick you first write the program on the computer, and then download the program to the Programmable Brick via a cable. Then, the brick can be disconnected from the computer. The program stored on the brick and the brick can be carried anywhere and the program can be executed without connected to a computer (Sargent et al., 1996).

RCX

From 1992 to 1996 Randy Sargent and his colleagues created second generation Programmable Bricks (Gray Brick and Red Brick). Fieldwork with tree classroom usage of Red Brick were resulted some design upgrades at size, LC screen, and LOGO programming environment. The idea of putting LOGO statements as blocks (called Logo Blocks) serves as the basis for the Lego Group later commercial usage. Red Brick and its field works would be basis for the development of the Lego RCX Brick which shares many common features with the MIT Red Brick (Martin et al., 2000; Mindell et al., n.d.). In their article “Building and Learning with Programmable Bricks”, Sargent and colleagues listed twenty things to do

with a programmable brick, inspired on Papert and Solomon's (1971) memo called Twenty things to Do with a Computer.

Lego Mindstorms

In 1998, the Lego Company released a new product called the LEGO Mindstorms Robotic Invention Kit consisting of 717 pieces including LEGO bricks, motors, gears, different sensors, and a RCX Brick which contains three input ports and three output ports attached to a Hitachi H8/3292 micro controller (McWhorter, 2005; Mindell et al., n.d.). Lego Company believed in robot design concept so strongly that they gave the name of Seymour Papert's book (Martin et al., 2000).

First-generation Lego Mindstorms kit was replaced with Lego Mindstorms NXT kit in 2006 (Figure 1). At the heart of the system is NXT brick which is a multipurpose controller that interfaces easily with a development or graphics computer. The main processor of the NXT is a 32-bit Atmel® ARM® processor operating at 48 MHz, with 256 kB flash memory and 64 kB RAM; an 8-bit, 8 MHz co-processor provides additional functionality. It has four-button interface and a 100 x 64 pixel (26 x 40.6 mm) LCD display. It can communicate with a desktop or laptop computer with the integral USB 2.0 port (12 Mbit/s) or the wireless Bluetooth port, based on the single-chip CSR BlueCore™ 4 ("Lego Mindstorms NXT Hardware Developer Kit," n.d.). In addition to the NXT brick, Lego Mindstorms NXT kit consists of 577 pieces, including: 3 servo motors, 4 sensors ([ultrasonic](#), sound, [touch](#), and [light](#)) (See Figure 1). The kit also includes NXT-G, a graphical programming environment that enables the creation and downloading of programs to the NXT.



Figure 1 Components of LEGO Mindstorms NXT

Robotics Studies in Education

Papert (1993) says that robots are one of the best tools to implement constructivist learning principles. Some of the studies with robotics activities resulted that robotics activities increased students' motivation toward mathematics and science courses (Robinson, 2005; Rogers & Portsmore, 2004). They provide practice platform for science and mathematics principles (Rogers & Portsmore, 2004), and increased students problem solving skills (Beer et al., 1999; Nourbakhsh et al., 2004; Petre & Price, 2004; Robinson, 2005; Rogers & Portsmore, 2004). However, some studies could not find positive effect of robotics in

educational settings (Bjoerner, 2009; Fagin & Merkle, 2003; Hussain, Lindh, & Shukur, 2006; McNally, Goldweber, Fagin, & Klassner, 2006).

One of the large scale studies about robotics was conducted in Peru (Iturrizaga, 2000). The quasi-experimental, posttest-only approach was used. Fourteen schools were selected to participate in the study. The sample involved 553 students in grade 2, 566 students in grade 4, and 534 students in grade 6. Many post-test employed to assess the students' ability to use mathematical skills related to real world problems, technology knowledge, Spanish performance, eye-hand coordination, problem solving and self-esteem. After one year usage of LEGO, the results revealed that students in the experimental group had outperformed the students control group in math, technology, Spanish, and eye-hand coordination. The difference between the boys and girls were not significant.

Hussain, Lindh, and Shukur (2006) made similar large scale study to investigate the effect of one year of regular LEGO training on pupils' performance in schools in Sweden. There were 322 students, 193 at fifth grade and 129 at ninth grade in experimental group and there were 374 students, 169 at fifth grade and 205 at ninth grade in control group. Then they looked at achievements in mathematics for fifth grade students before and after the training by using the standard two-sample t-test, they found a positive shift in the mean from 0.711 to 0.817 with p-value = 0.000 indicating better performances in mathematics for the trained group (the group trained with LEGO). For the problem solving, on the other hand, they have found a slight shift in the opposite direction from 0.696 to 0.649 with p-value = 0.023 which is rather significant. When ninth grade students were compared they did not find any significant difference neither mathematics nor problem solving.

In another study, Fagin and Merkle (2003) used robots to teach computer science at 2000 - 2001 academic year. Their computer science course was given to 938 freshman year students in 48 sections of 15-20 students each. Nine of these sections were designated as "robotics" sections, where they provided laboratory instruction using Lego Mindstorms robots and programming environments. They found that the test scores were lower in the robotics sections than in the non-robotic section. They concluded that this result occurred because students in robotics section must run and debug their programs on robots during assigned lab times, therefore deprived of both reflective time and the rapid compile-run-debug cycle outside of class that was an important part of the learning process.

Williams, Ma, Prejean, and Ford, (2008) prepared a two week summer robotics camp to explore middle school students' physics content knowledge and scientific inquiry skills. A single group of 21 summer camp participants was pre-tested, exposed to the summer camp program, and post-tested. The result of the study revealed that the robotics summer camp had a statistically significant impact on students' gains in physics content knowledge, however, no statistically significant difference was found on scientific inquiry skills.

Robinson (2005) has interviewed with the science teachers who used Robolab (Mindstorms programming environment) in 8th grade physics courses; the teachers reported that; robotics activities increased students' motivation and attitude toward the physics and students' inquiry skills. Moreover, Petre and Price, (2004) observed and interviewed the children who attended RoboCup Junior (6 - 18 years old) and RoboFiesta (12 -14 years old). The children stated that robots had positive effect on their programming, problem solving, and team work skills also hardware and electronic knowledge had increased.

McNally, Goldweber, Fagin, and Klassner (2006) focused on disadvantages of the robots in educational settings. They defined logistical and pedagogical disadvantages. "The primary logistical disadvantage is cost. While it is not overly expensive to outfit a lab with Mindstorms-based robots, it is too expensive to provide each Computer Science 1 (CS 1) student with their own robot. This implies that all student experimentation is limited to the robot lab's operating hours" (p.61). This disadvantage was similar to result of Fagin and Merkle's (2003) study. Unfortunately, various sensor of Mindstorms need to be recalibrated for changing physical environments, and battery level of the robot will change turning angle and speed of the robots. Learned programming skills should be both worthwhile and useful; however learned programming skills from Mindstorms will not be reused or reinforced anywhere else in the undergraduate CS curriculum.

One of the study conducted by Barker and Ansoorge (2007) focused on investigation of the effectiveness of an informal 4-H science curriculum to teach SET (Science, Engineering and Technology) concepts and validation of assessment instruments. LEGO Mindstorms kit and Robolab programming

software were used at an after-school program and 42 students aged 9 to 11 participated the study. The result of the study showed that even though there was improvement on the post-test with the experimental group, the control group scored better on some items.

Ruiz-del-Solar and Aviles (2004) developed range of robotics activities to motivate school children for pursuing studies in science and technology and university careers in science and technology, increasing their technological literacy and becoming technology-friendly adults. More than 700 children from 7th through 10th grade and 90 teachers participated in the workshops. They evaluated the workshops with questionnaires focused children's satisfaction, the level of completed work and interest in pursuing an engineering career. They reported that 92% of the participants satisfied with the workshop, 88% finished all the basic tasks during the workshop and 86% of the participants indicated they will follow an engineering or science university career in the future. They found that children's self-motivation seems to be the key element for their success during the workshop; unmotivated children do rather poorly. Moreover, the group structure also plays an important role for success of the workshop. Best group works occurred when previously unknown participants meet each other for the first time during the workshop to form a working team.

In the fall of 1998, the Pennsylvania Department of Education granted Bloomsburg University to support the creation of an innovative problem-solving course that would use a combination of logic, hands-on experience, and trial and error to help students identify the process behind effectively solving problems (Mauch, 2001). During summer of 1999, eight middle school teachers from many districts enrolled in a twenty hours course to learn about the LEGO Mindstorms system and how to implement it within their curricula. In the second week, forty gifted students from 6th to 8th grade attended a thirty hours camp taught by these teachers. The students were placed in a group of four and each one received a specific task such as builder, programmer etc. The teacher reported that three students would be ideal and the system should be more readily implemented in a classroom where the same students had the same robotic system each day for several weeks. Mauch (2001) concluded that this new product has shown promise, "students remain highly engaged throughout the process because they visualize their robots as a toy" (p. 212). However, cost, and classroom implementation are the primary problems. In addition, the nature of the system requires considerable time engagement for both students and teachers.

Bjoerner (2009) conducted a study with 300 Danish children aged 9-14 focused on the question of children's attitudes towards robotics technology. Half of the children participated in the robotics competition FLL (First Lego League) and the other group (from the same geographic area) did not. He concluded that there were no significant differences concerning attitudes towards robots between children who participated in the robotics competition FLL and children who did not.

Benitti, (2012) made a systematic review on educational usage of robotics. Results of the review showed that 80% of the study explore physics and mathematics related subjects which are Newton's Laws of Motion, distances, angles, kinematics, graph construction and interpretation, fractions, ratios and geospatial concepts. That is in the related literature also support that, educational usage of robotics are not limited with subjects that are closely related to the robotics field, such as robot programming, robot construction, or mechatronics. Moreover she reported that the articles also emphasize problem solving, logic and scientific inquiry have improved through robotics.

Conclusion and Discussion

This study presents a review of published literature on the use of educational robotics, to identify educational potential of robotics, especially LEGO Mindstorms NXT robotics sets. The most common outcome of the use of robotics is to support the STEM education. Although most of the studies resulted with positive effects of the robotics activities in STEM education, there are some implementation problems of robotics in today's formal STEM education.

When the STEM (Science and Technology, Mathematics and Technology & Design courses in Turkey) curricula are investigated, it could be seen that vision of these courses are to give questioning, critical thinking, and problem solving skills to children (TTKB, 2006a, 2006b, 2009). There are many robotics studies in the literature aimed to measure effects of robotics activities on these skills (Barak & Zadok, 2007; Barker & Ansorge, 2007; Beer, Chiel, & Drushel, 1999; Hussain, Lindh, & Shukur, 2006; Johnson, 2003; Lindh & Holgersson, 2007; Mauch, 2001; Mosley & Kline, 2006; Nugent, Barker, & Grandgenett, 2010; Robinson, 2005; Sullivan, 2008; Wyeth, Venz & Wyeth, 2004). Review of the related

literature revealed that robotics activities have positive effects on children's discovery learning and critical thinking skills because robotics activities give children to use questioning, critical thinking and problem solving skills. It is obvious that a robot is a good tool not only of robotics itself, but also for general science, technology, engineering, and mathematics (STEM) concepts (Mataric et al., 2007).

To investigate potentials of using robots in formal STEM education, a robotic camp can be organized with STEM teachers. Six teachers from different STEM areas (Science and technology, mathematics and technology and design courses) could attend first week of the camp and teachers get training on robotics and programming. Then, the teachers prepare activities with robots aimed to teach a subject in their field. Second week of the camp, children attend to camp and they work with teachers in group work. After they have learnt robotics and programming they work on the activities that teachers had prepared. At the end of the camp, children and teachers' opinions could be taken about implementation of the robots in the formal education.

Another common usage of robotics in education is to increase children's interest toward technology, computing, and engineering. The literature review shows that robotics have potential to increase their curiosity and interest toward STEM and also increase the possibilities of the engineering careers (Burket et al., 2008). Interested researcher could design long term research to investigate the relation between robotics activities and career choices of the children.

Another suggestion for future research is to evaluate the effects of robotics activities on children's social skills such as team working skills. Literature about this subject is limited and inaccurate (Benitti, 2012). Lastly, use of robotics in other areas of learning not related to STEM or social learning could also be investigated.

This review shown that educational robotics has potential as a learning tool; not only robotics and programming but also STEM related concepts. It is expected that this review will provide useful guidance for those who interested robotics activities in education.

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Geniş Özet

Robotların eğitsel amaçlarla kullanımı giderek artmaktadır. Eğitimcilerin robotların eğitsel potansiyelinin farkına varmaları ve uluslararası robot turnuvalarının popülerlik kazanmasının robotların eğitsel kullanımına katkısı büyüktür. Birçok üniversite ve okul, teknoloji ve robotlar konulu yaz kampları düzenlemektedirler. LEGO Mindstorms NXT en popüler ve en çok kullanılan eğitsel robot setleridir. Bu robot setlerinin geçmişi, Seymour Papert'in LOGO çalışmalarına dayanmaktadır. Papert, çocukların doğuştan öğrenmeye karşı yetenekli olduklarına ve çocukların bilgisayarlar ile iletişiminin, bilgisayarların uygun tasarımı ile onlar için doğal bir işlem haline gelebileceğine inanmaktaydı. Aynı Fransa'da yaşayarak, Fransızca öğrenmek gibi (Papert, 1993). Papert ve öğrencilerinin çocuklara bilgisayarı tanıtmak ve programlamayı onların fiziksel dünyasına taşımaya yönelik çalışmaları, 1967 yılında LOGO programlama ortamının geliştirilmesi ile sonuçlanmıştır (McNerney, 2004; McWhorter, 2005). LOGO programlama dili ile basketbol topu büyüklüğünde, kubbe şeklindeki kaplumbağa (turtle) robot kontrol ediliyordu. Kaplumbağa zeminde LOGO komutları ile ileri, geri, sağa ve sola gidebilmekte ve bütünleşik kalem sayesinde büyük kâğıtlara çizimler yapabilmekteydi (Martin, Mikhak, Resnick, Silverman, & Berg, 2000; Papert, 1993; Watt, 1982).

LOGO tüm dünyada on milyonlarca çocuk tarafından kullanıldı. Onun teorik altyapısı inşacılık (constructionism) olarak bilinir ve eğitimcileri, araştırmacıları, eğitsel reformları ve teknolojinin eğitimdeki yerini çok etkilemiştir (Kafai & Resnick, 1996). Papert inşacılık kuramını basitçe "yaparak öğrenme" (learning by making) olarak tanımlamıştır" (Papert & Harel, 1991). Papert'e göre inşacılık kuramı, yapılandırmacı kuramının (constructivism) temelindeki "yaparak öğrenmeyi" (learning by doing) kapsar ve onun ötesine geçer (Papert, 1999).

1980'lerin ortalarında LEGO oyuncak firması ile LOGO yazılım ekibi birlikte çalışmalar başladı. Var olan kaplumbağa, LEGO parçaları ile değiştirildi. Bu birleşimin sonucunda LEGO/LOGO ürünü marketlerde yerini aldı. Böylece çocuklar robotlarını programlamadan önce LEGO parçalarını kullanarak istedikleri şekilde tasarlayabiliyorlardı. Fakat LEGO/LOGO kablolar ile bilgisayara bağlı olduğundan kullanımı ile ilgili problemler vardı (Martin et al., 2000; Sargent et al., 1996; Watt, 1982). Bu problemler 1988 yılında Fred Martin ve arkadaşları tarafından geliştirilen "Programlanabilir tuğla" ile aşıldı. Böylece bilgisayarda yazılan program, tuğlaya yükleniyor daha sonra bilgisayar ile olan bağlantısı kesilerek, tuğlanın programı kendi başına çalıştırması sağlanabiliyordu. 1996 yılında Randy Sargent ve arkadaşları ikinci nesil programlanabilir tuğlayı geliştirdiler. Bu tuğla daha sonra LEGO tarafından RCX olarak piyasaya sürülecektir. 1998 yılında LEGO, ismini Papert'in kitabından alan (Martin et al., 2000) Mindstorms NXT robot setlerini piyasaya sürdü. Bu setlerde; Lego Teknik tuğlaları, bilgisayar tarafından kontrol edilebilir bir mikroişlemci, mikroişlemciyi programlamaya imkan veren grafik arayüzüne sahip bir yazılım, sensörler (sese, ışığa, uzaklığa ve dokunmaya duyarlı) ve hareket sağlamak için motorlar bulunmaktadır.

Papert'e (1993) göre robotlar yapılandırmacı kuramını uygulayabilmek için en iyi araçlardır. Robotik etkinliklerin araştırıldığı çalışmaların birçoğu öğrencilerin matematik ve fen derslerine karşı daha fazla güdülenmeleri (Robinson, 2005; Rogers & Portsmore, 2004), matematik ve fen dersleri için iyi bir uygulama ortamları olmaları (Rogers & Portsmore, 2004), öğrencilerin problem çözme becerilerinin artması (Beer et al., 1999; Nourbakhsh et al., 2004; Petre & Price, 2004; Robinson, 2005; Rogers & Portsmore, 2004) ile sonuçlanmıştır. Bu konudaki alanyazını robotların herhangi bir pozitif etkisinin bulunmadığı çalışmaları da içermektedir (Bjoerner, 2009; Fagin & Merkle, 2003; Hussain et al., 2006; McNally et al., 2006).

Robotların eğitimde en yaygın kullanımı FTMM (Fen, Teknoloji, Mühendislik ve Matematik) eğitimini desteklemeye yönelik kullanımıdır. Bu alanda yapılan çalışmaların büyük bir kısmı robotların FTMM eğitiminde pozitif etkisi ile sonuçlanmıştır. Robotların FTMM eğitimine uygulanması konusunda hala problemler mevcuttur. Örneğin, maliyet (McNally, Goldweber, Fagin, and Klassner, 2006) farklı fiziksel ortamlarda sensörlerin kalibrasyon ihtiyacı, pil düzeyine göre dönme ve robotun hızının değişmesi (Fagin and Merkle's, 2003).

Türkiyedeki FTMM müfredatı (Fen ve Teknoloji, Matematik ve Teknoloji ve tasarım dersleri) incelendiğinde, bu derslerin genel kazanımlarının öğrencilere sorgulama, eleştirel düşünme ve problem çözme becerilerini kazandırmak olduğu görülmektedir (TTKB, 2006a, 2006b, 2009). Robotların çocukların sorgulama, eleştirel düşünme ve problem çözme becerilerine olan etkilerini

araştırmaya yönelik birçok çalışma yapılmıştır (Barak & Zadok, 2007; Barker & Ansoerge, 2007; Beer, Chiel, & Drushel, 1999; Hussain, Lindh, & Shukur, 2006; Johnson, 2003; Lindh & Holgersson, 2007; Mauch, 2001; Mosley & Kline, 2006; Nugent, Barker, & Grandgenett, 2010; Robinson, 2005; Sullivan, 2008; Wyeth, Venz & Wyeth, 2004). Bu çalışmalar göstermektedir ki, robotlar öğrencilerin bu becerileri kazanmasında etkili olmaktadır. Robotlar, robotlarla ilgi alanlarda örneğin programlama ve mekanik kullanılacak iyi bir araç olması yanında, fen, matematik, teknoloji ve mühendislik (FTMM) alanlarında da kullanılabilir bir araçtır (Mataric et al., 2007).

Robotların eğitimde kullanım amaçlarından biri de öğrencilerin teknoloji, bilgisayar ve mühendislik alanlarına olan ilgilerini arttırmaya yöneliktir. Bu konuda yapılan çalışmalar göstermektedir ki, robotlar öğrencilerin bu alanlara olan ilgisini arttırmakta ve mühendislik kariyerine yönelmelerinde yardımcı olmaktadır (Burket et al., 2008).

Robotların eğitsel kullanımına yönelik çalışmalar yapacak araştırmacılara katkı sağlayabilmek amacıyla yapılan bu alan yazın tarama çalışması robot setlerinin eğitsel olarak yalnızca robotlar ile ilgili alanlarda kullanımı ile sınırlı olmayıp, FTMM eğitiminde de kullanılabilme potansiyeli olduğunu göstermektedir.