Proceedings of the International Conference on Education Vol. 8, Issue. 1, 2022, pp. 125-135

ISSN 2424 - 6700 online
DOI: https://doi.org/10.17501/24246700.2022.8111

ARTBOTS IN SPECIAL EDUCATION: POSSIBLE APPLICATIONS AND BENEFITS

Souliotou AZ*

Department of Early Childhood Education, University of Thessaly, Greece

Abstract: Artbots are moving toys and objects which draw automatically with simple materials and technologies combining art with science and technology in a way that equitably connects the components of the STEAM (Science, Technology, Engineering, Arts and Mathematics) approach's equation (STEM + Arts = STEAM) and dynamically opens further up to many other disciplines. This paper deals with possible applications of artbots activities in Special Education. It draws on relevant literature review about STEAM in education and Special Education and presents artbots' concept. Furthermore, the methodology involves practice-based research through experiential workshops and implementation of artbots activities with children with disabilities. The views of Special Education teachers and professionals with regards to the benefits of artbots activities for children with different disabilities are also described. As population of children with disabilities constitute a highly heterogeneous group, emphasis will be placed upon specific examples of applications with children with different type of disabilities. It is argued that artbots activities should foster creativity, engagement, social interaction, motor and other skills and enrich learning process both in special and in inclusive educational settings.

Keywords: artbots, Special Education, STEAM, creativity, skills development

Introduction

Artbots (art + robots) are constructions, i.e. robots, which draw or paint automatically. Their construction, form and function vary depending on their materials and moving mechanisms: from very simple and cheap materials to sophisticated and advanced technologies. This wide range of forms, materials and robot building techniques permit artbots' use in a wide range of educational and other contexts. Artbots combine art with science and technology in a way that equitably connects the components of the STEAM approach's equation (STEM + Arts = STEAM) and dynamically opens further up to many other disciplines (Souliotou, 2016; Souliotou&Gerontopoulou, 2021).

This paper deals with possible applications of artbots activities in Special Education. It draws on relevant literature review about STEAM (Science, Technology, Engineering, Arts & Mathematics) in education and Special Education and presents specific examples of applications with children with different types of disabilities. More specifically, in the activities of this paper the artbots are do-it-yourself constructions made of ready-made moving toys and/or simple materials and objects with embedded moving mechanisms which draw with markers. The simple and creative process of their construction and use –without needing sophisticated design or drawing skills and without requiring expensive equipment– as well as the fact that they draw automatically provide opportunities for hands-on creative activities that promote STEM and STEAM learning (Schoonover & Schwind, 2018; Wyffels et al, 2016), stimulate many senses and lead to a creative response and fruitful experience for

*Corresponding Author's Email: asouliotou@gmail.com

all children including children with disabilities and with different levels of cognitive, communication, motor and academic skills.

STEAM Education

STEAM is an interdisciplinary approach which blurs the boundaries and interconnects STEM and Art disciplines with possible applications in education and multiple benefits for all children or participants (Guyotte et al., 2014; Souliotou, Zoi &Santorineos, 2020). The importance of STEAM education is highlighted in relevant research and practices which show the effectiveness of STEAM with regards to the promotion of social skills (Guyotte et al., 2014), creativity, problem-solving, problem-seeking, research skills, aesthetic knowledge as well as habits of mind and hand which are aligned with very important 21st century skills (Gess, 2017; Land, 2013; Yakman, 2008; Zayyad, 2019). The invention of STEAM approach is also connected with the objective to make STEM disciplines more attractive through the Arts and to encourage, thus, children to consolidate STEM knowledge or even to follow careers in STEM (Conner, 2016).

STEAM is a promising field in Special Education with multiple benefits for children's individualised needs towards their learning and skills, in different educational settings and other learning contexts and environments, as for example special schools, inclusive educational settings, museums, science centres, etc (Kanari &Souliotou, 2020; Lu et al., 2022; Watson Institute, 2020).

Although most STEAM research and practices focus on students without disabilities, applying STEAM in Special Education is also considered appropriate for boosting creativity and enhancing learning and participants' competencies (Lu et al, 2022). Relevant researches indicate a range of learning outcomes for all children including those with disabilities and/or special educational needs (Maslyc, 2016). STEAM benefits all children (Butera et al., 2016) through: appropriate design of activities; suitable and accessible educational materials; and theoretical frameworks that responds to all students' heterogeneous skills and needs, as for example Differentiated Instruction (Tomlinson, 2014) and Universal Design for Learning (CAST, 2018). The learning outcomes for children with disabilities mainly include: creativity, development of various skills (e.g., linguistic, cognitive, motor, social skills, etc), cooperation and interaction with other children and teachers, motivation, and concentration. (Hwang & Taylor, 2016; Lu et al., 2022; Maslyk, 2016; Zayyad, 2019). However, bibliography on STEAM practices in Special Education is still little and narrow: with some articles about STEM or STEAM mostly with students in the autism spectrum and students with learning disabilities.

Design principles, methods and materials

The main aim of the artbots activities mentioned in this paper is to provide children with a multisensory and creative experience in order to develop various skills. In specific, the objectives of the artbots activities with children include: to observe children's reactions; to catch their attention and inspire their interest; to activate their motor skills; to give children the chance to come across different colours and shapes, as for example geometric shapes (see for example Figures 3 and 6) or even letters of the alphabet (Figure 7); to stimulate children's senses; to encourage expression and foster creativity and learning. Since persons with disabilities are a very heterogeneous group of people, the objectives

vary and the process needs to be differentiated. Thus, the objectives highly depend on each child's profile.

The artbots presented in this paper are original, creative materials which form the basis of the research process in order to investigate possible applications with children with disabilities. For this reason practice-based research was adopted (Candy, 2006). Furthermore, according to Gauntlett (2021), practice-based research is "exploratory and embedded in a creative practice", which means that making things is part of the whole research process. Thus, in the frame of practice-based research, the methodology of the present paper involves: a. demonstrations of artbots to special education teachers and other professionals related with Special Education, Early Special Education and Early Intervention, b. experiential workshops and c. implementation of artbots activities with children with disabilities.

Regarding the materials, as stated above, the artbots which were used in the activities presented in this paper are made of simple and cheap materials. They are often ready-made moving toys which are transformed by the author into an artbot with a simple addition of one or more markers. Other artbots are made of sponges, plastic cups or other simple materials by the author and move with motor or even with electric toothbrush. These artbots can be used in activities and workshops with children of every age both in general and in special education (Souliotou, 2022).

The views of Special Education teachers and professionals with regards to the benefits of artbots activities for children with different disabilities are also described. Their views were written in a research diary after the artbots workshop, based on the discussion about artbots' possible applications in Special Education.

Examples of artbots applications in Special Education

Example of in-service Special Education teachers' training

In this section artbots demonstrations and activities will be presented as examples which reveal possible applications and benefits of artbots activities in Special Education. The first example refers to the case of a course for in-service Special Education teachers' training in the frame of in-school training activities in Greece. It is worth mentioning that the Ministry of Education and Religious Affairs in Greece place strong emphasis on programs and activities that enhance 21st century skills for all children. This initiative includes teachers' training, development of various programs and activities, educational material, etc. The programs have also various themes (e.g., well-being, the environment, cultural and natural heritage, social responsibility, human rights, inclusion, STEM, creativity, etc). Thus, programs about STEM and STEAM are developed in different educational settings in Greece (Institute of Educational Policy – Ministry of Education and Religious Affairs, 2022).

In this framework a two-hour training workshop was implemented in a Special School for Special Education teachers and other professionals. Figure 1 shows images of this training workshop at a Special School in Greece. The participants were 10 members of the school staff who had students with various disabilities and with different level of skills and needs. The workshop was structured in two parts: a. theoretical introduction and demonstration of artbots, their materials, function and how

they move and draw, and b. creative activities where Special Education teachers created their own drawings with the use of artbots (see Figures 1 and 2). The emphasis was placed on the simple materials and the fact that these artbots can be constructed as part of creative activities with the collaboration between children and teachers and the support required according to the needs and skills of each child. It was also made clear that the creative process can be further developed with drawing and artworks made by children with disabilities with the supervision of Special Education teachers. Thus, it is an on-going creative process: from the construction of the artbots to the creation of new drawings and artworks. This provides different possibilities to Special Education teachers to use artbots in different ways, to promote children's participation, action and creative expression. Children with (or without) disabilities are creators at every stage of the process. At the same time they cultivate different skills, explore materials, concepts as well as moving and drawing mechanisms. It is also important to note that all children can participate and contribute according to their needs and skills with various levels of adaptation and support.

Figure 1: Anastasia Zoi Souliotou, 2021, demonstration during an artbots workshop and in-service Special Education teachers' training at a Special School in Greece. https://blogs.sch.gr/2dimeidv/?p=362

After the author's demonstration of the way in which each artbot functions and draws, the teachers asked questions and expressed their views about the artbots. More precisely, a Special Education teacher stated that "These (meaning: the artbots) are tailor-made for us (the Special Education teachers)." This is largely due to the fact that the artbots presented in this workshop are easy-to-use and do not require deep knowledge of code. This gives to Special Education teachers the possibility to directly implement artbots and STEAM activities with children with disabilities in order to develop their senses and skills. Since for many Special Education teachers deep knowledge of code and advanced mathematics or acquisition of high-level STEM skills is not considered a reachable goal for all children with disabilities, the artbots presented in this paper and the ideas of transforming ready-made toys into artbots were considered very suitable for special education.

Afterwards the Special Education teachers made their own artbots drawings. They worked collectively, put the artbots into function and made drawings on paper. The author also provided the Special Education teachers with stencils and they made figurative drawings, as for example the boat of the photo on the right in Figure 2. In this photo both the drawing (positive) and its stencil (negative) appear. It is important to note that the shape of this boat is widely used as a symbol of the Ancient Greek and Modern Greek navy and it often appears in logos as well as in other kinds of

representations of the Argonauts' Argo or other Ancient Greek or Modern Greek ships. The Special Education teachers also made other drawings with other stencils provided by the author. It was made clear that with the artbots of simple materials presented in this paper Special Education teachers can make both abstract and figurative drawings and that it is possible to easily apply this activity with children with disabilities, since it does not require fine motor skills or any kind of mastery in drawing. Furthermore, it was explained that the artbots activities are suitable for teaching colour mixture or for working with many senses –including vision, touch and hearing– according to the profile and needs of each child.

Figure 2: Anastasia Zoi Souliotou, 2021, demonstration (picture on the left) and artmaking (picture on the right) during an artbots workshop and in-service Special Education teachers' training at a Special School in Greece. The picture in the middle presents several artbots made of sponges and ready-made toys. The picture on the right presents an artbots drawing (the positive drawing) underneath its stencil (negative drawing). Source: https://blogs.sch.gr/2dimeidv/?p=362

Examples of artbots activities with children with disabilities

This section presents specific examples of applications of artbots activities with children with different type of disabilities in Early Intervention settings. In these activities different artbots were used in order to observe and test children's reactions. The duration of each artbots activity was not more than 45 minutes. Attention was given to the order of the artbots' presentation and manipulation by the children: the simplest and smallest artbots were presented and put into function first and gradually the bigger, more complex and phantasmagorical artbots followed, in order to maintain children's attention.

In Figure 3 a moving car (toy) is transformed into an artbot which plays music, has embedded colourful LED (Light Emitting Diode) lights and movement sensors and draws on paper. This artbot is then used during the implementation of an artbots activity in Early Intervention. A circular hoop is used for the restriction of the artbot's movement within a circle. Children activate their motor skills and respond to the stimuli of the artbot's movement and drawing by touching and displacing the artbot. They seemed to be attracted by the artbot's movement, but it also seemed that the artbot's music and LED lights largely contributed to the stimulation of their senses. Moreover, children interacted and were touching the artbot without being irritated or anxious. Instead, they were curious and motivated to touch and play with the artbot without disturbing each other.

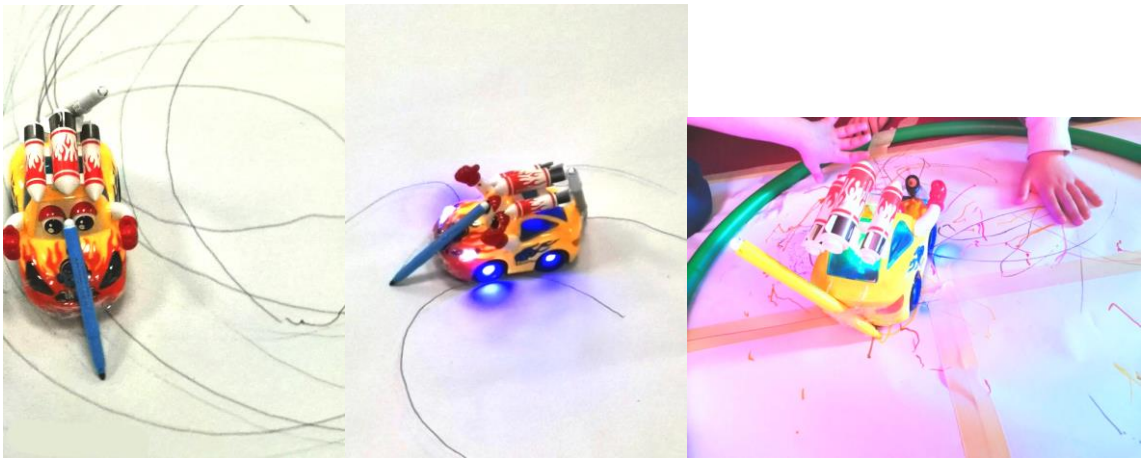

Figure 3: Anastasia Zoi Souliotou, 2022, a car (toy) is transformed into an artbot and draws on paper. This artbot is then used during the implementation of an artbots activity in an Early Intervention centre in Greece.

Figure 4 presents a hand-wound toy which is transformed into an artbot and draws a straight line. It catches the attention of the children and their eyes track and follow the artbots movement and creation of a straight line. One child moved towards the artbot in order to touch it and play with it, which shows that the artbot stimulated the child to act.

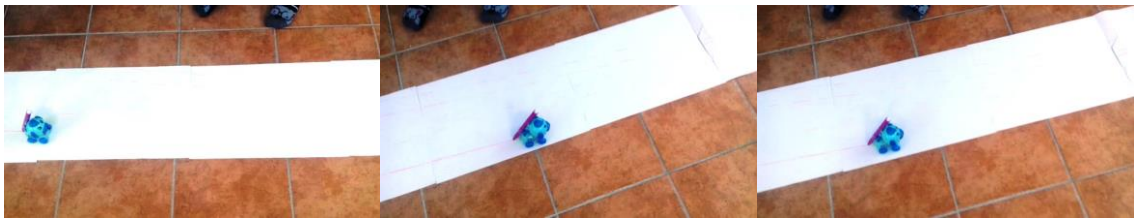

Figure 4: Anastasia Zoi Souliotou, 2022, hand-wound toy transformed into an artbot draws a straight line and catches the attention of the kids in ELEPAP organization for the rehabilitation of disabled children in Greece.

In Figure 5 a bouncing ball, i.e. a ready-made toy, was transformed into an artbot with the addition of colourful markers. The artbot/bouncing ball moves and produces vibration while at the same time it plays music and colourful LED lights rotate dynamically. It draws abstract lines in a heart-shaped stencil, so the final drawing is a heart. At the beginning the occupational therapist guided the hand of the child to follow the contour of the stencil which, as said, formed a heart and was considerably thick in order to be durable. When the artbot/bouncing ball was put into function, the child leaned towards the artbot/bouncing ball, put their hands on it and sometimes they embraced the artbot and was holding it constantly. It seemed that all multisensory experience provided by the bouncing ball (with a combination of colours, lights, vibration, movement and music) excited the child who focused their attention on the bouncing ball.

Figure 5: Anastasia Zoi Souliotou, 2022, a bouncing ball (toy) is transformed into an artbot, draws a heart with the aid of a cardboard stencil and catches the attention of the child who grabs and holds the ball in an Early Intervention programme of ELEPAP organization in Greece.

In Figure 6 an artbot made of sponge moves with the aid of a toothbrush and draws with markers in an Early Intervention programme of ELEPAP organization in Greece. A child with multiple disabilities touches the artbot, feels its vibration, hears its noise and remains calm and focused on the stimulus, while sometimes they smile and show happiness.

Figure 6: Anastasia Zoi Souliotou, 2022, an artbot made of sponge moves with the aid of a toothbrush and draws with markers in an Early Intervention programme of ELEPAP organization in Greece. The child touches the artbot, feels its vibration, hears its noise and remains calm and focused on the stimulus.

The case of an artbots activity in an inclusive educational setting

This case study refers to a preschooler with special educational needs in an inclusive educational setting and the use of artbots for the improvement of their linguistic and writing skills (Figure 7). The preschooler used stencils with the Greek letter forms (as for example 'Γ' gamma, 'Λ' lamda, 'K' kappa and others) and made drawings with artbots. Then they invited their classmates to do together the artbots activity and draw letters with artbots. This approach expands and extends the possibilities of using artbots in interdisciplinary practices further than STEAM, as for example in activities for emergent literacy (Souliotou&Vasilogiannaki, 2022).

Figure 7: Anastasia Zoi Souliotou& Styliani Vasilogiannaki, 2019, artbot made with simple materials (sponge and electric toothbrush) and used for drawing letters. Souliotou, A. Z. &Vasilogiannaki, S. (2022). Artbots, Emergent Literacy & Special Education: A case study. Forthcoming participation in OMEP 2022 Conference.

Discussion/Conclusion

Despite current lack of research and little bibliography of relevant practices, it is argued that STEAM in Special Education should contribute to the fulfilment of Sustainable Development Goal 4 (SDG4) for accessible and inclusive quality education (Global Education Cooperation Mechanism #Education2030, 2022). In order to meet this goal, a wider range of STEAM activities applied to different cases of children with disabilities and properly adjusted to their profiles and needs is expected to shed light on the benefits of STEAM in Special Education.

Following the above rationale, the artbots activities presented in this paper cover basic STEM objectives without requiring code or advanced mathematical knowledge. Children come across mathematical concepts, as for example the straight line (see for example Figure 4), the circle (see for example the circular hoop in Figure 3), geometrical and other shapes (as for example the heart of Figure 5 and the shapes of the letters in Figure 7) and their potential repetition through versions of various colours with the aid of stencils. The activities also involve science (as for example physics), technology (lights, motor and electric movement) and engineering issues (movement, balance) related to material properties. The strong presence of the Arts is obvious through the abstract colourful drawings and colour mixing which sometimes take a more concrete form (see for example the boat in Figure 2 and the heart-shaped stencil in Figure 5) with the aid of stencils, hoops and other media and, thus, both parts of the equation STEM + Arts = STEAM are fulfilled. Artbots activities presented in this research also expand and extend the possibilities of using artbots in interdisciplinary practices further than STEAM, as for example in a rich, creative and joyful environment for emergent literacy and linguistics (Section 3.3. and Figure 7).

Furthermore, in the examples of this paper the artbots activities created positive feelings to children, attracted their attention and helped them remain calm and focused on the artbots' movement, while in some cases the children were also motivated to act. It is very important to note that children's reactions varied and this largely depended on each child's profile, but the common characteristic in

their reactions was that artbots clearly caught their attention and children remained focused and responsive to the activity at all times. Concerning their social skills, during the artbots activities the children coexisted in the same space and interacted with the artbots without disturbing each other and without being irritated. Notably in the case of the artbots activity with letters (Figure 7) the fact that the child invited other classmates to participate shows that an artbots activity is possible to increase social interaction and to unify a group of children towards a creative goal which, at the same time, facilitates their learning.

As a conclusion, it is argued that further artbots activities and adaptations should benefit children by fostering creativity, engagement, social interaction, motor and other skills (Morales, 2014; Schoonover & Schwind, 2018; Souliotou, 2019) and they should also enrich learning process both in special and in inclusive educational settings. According to RobotLab (2022), Smithsonian Learning Lab (2022) and other research labs for general and/or special education, the overall outcome of artbots activities should highly contribute to children's improvement of learning, social interaction, emotions and life. Children with disabilities present an enormous heterogeneity and there is a need for a more systematic research. Obviously, a limitation of the present paper is that it constitutes a presentation of specific cases of artbots activities with children with disabilities. Although it is not possible to generalise the results, children's responses indicate the dynamic field of STEAM and Special Education. Future research should have more focused orientation with regards to children's skills improvement and learning through more systematic activities and in different educational settings.

The empowerment of teachers is also considered a crucial parameter in order to promote relevant activities with appropriate adaptation and accessible materials as well as with different objectives based on each child's profile. There is a need for teachers' in-service training, like the one presented in this paper, as well as in a broader level. This will enhance their exploration of further possible applications of STEAM and artbots activities, collaboration with other teachers and investigation of their own creativity in combination with their professional experience and scientific background. Reflection on their own work will lead to further improvement and development of STEAM in Special Education. In addition, the diffusion of these practices, the exchange of ideas, experiences and results in terms of children's responses will enrich existing knowledge. There is a lot of further research and activities which should be carried out through the application of artbots and other STEAM activities in Special Education and this should enrich bibliography with interesting research outcomes as well as with different or differentiated activities and literature.

Acknowledgements

I highly acknowledge ELEPAP staff for their support in artbots activities with children with disabilities.

Declaration of Interest Statement

The author declares that they have no conflict of interests.

References

Butera G., Horn, E. M., Palmer, S. B., Friesen, A., & Lieber, J. (2016). Understanding Science, Technology, Engineering, Arts, and Mathematics (STEAM) within early childhood Special

Education. In: B. Reichow, B. Boyd, E. Barton & S. Odom (Eds), Handbook of early childhood Special Education (pp. 143-161). Switzerland: Springer International Publishing.

Candy, L. (2006). Practice Based Research: A Guide. CCS Report: 2006-V1.0 November, Retrieved from https://www.creativityandcognition.com/resources/PBR%20Guide-1.1-2006.pdf

CAST (2018). Universal Design for Learning Guidelines version 2.2. Retrieved from http://udlguidelines.cast.org

Conner, L. (2016, November). Broadening Participation in Science by Integrating Art with STEM, caise INFORMAL SCIENCE, Retrieved from http://www.informalscience.org/news-views/broadening-participation-science-integrating-art-stem#.WCyphRaO5nI.facebook

Gauntlett, D. (2021, March 26). What is practice-based research? Retrieved from https://davidgauntlett.com/research-practice/what-is-practice-based-research/

Gess, A. H. (2017). STEAM education: Separating fact from fiction. Technology and Engineering Teacher 7 (3), 39-41.

Global Education Cooperation Mechanism #Education2030 (2022). Sustainable Development Goal 4 (SDG 4). Retrieved from https://sdg4education2030.org/the-goal

Guyotte, K. W., Sochacka, N. W., Constantino, T. E. Wakter, J. &Kellam, N. N. (2014). Steam as Social Practice: Cultivating Creativity in Transdisciplinary Spaces, *Journal of Art Education*, 67:6, 12-19, DOI: 10.1080/00043125.2014.11519293

Hwang, J., & Taylor, J. (2016). Stemming on STEM: A STEM education framework for students with disabilities. *Journal of Science Education for Students with Disabilities*19 (1), 39-49.

Institute of Educational Policy – Ministry of Education and Religious Affairs, (2022). 21st century skills workshops. Retrieved from http://www.iep.edu.gr/el/psifiako-apothetirio/skill-labs

Kanari, C., &Souliotou, A. (2020). Education of children with disabilities in nonformal learning environments: a cross-disciplinary approach of STEAM education in a technological museum in Greece. *European Journal of Alternative Education Studies*, 5(2). Retrieved from https://oapub.org/edu/index.php/ejae/article/view/3188

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. Procedia Computer Science, 20, 547-552, doi.org/10.1016/j.procs.2013.09.317

Lu, S.-Y., Wu, C.-L. & Y.-M. Huang. (2022). Evaluation of Disabled STEAM-Students' Education Learning Outcomes and Creativity under the UN Sustainable Development Goal: Project-Based Learning Oriented STEAM Curriculum with Micro:bit. Sustainability 2022, 14, 679. https://doi.org/10.3390/su14020679

Maslyc, J. (2016). STEAM makers:Fosteringcreativity and innovation in the elementaryclassroom. Thousand Oaks, CA:CorwinPress.

Morales, K. B. (2014, November 20). Building connections between art and science. Mary Frances Early College of Education, University of Georgia. Retrieved from https://coe.uga.edu/news/2014-11-building-connections-between-art-and-science/

RobotLab. Smart. Useful. Robot. (2022). Retrieved from: https://www.robotlab.com/special-education

Schoonover, J. & Schwind, D. B. (2018). DIY Adapted Repurposed Tool (ART) Kit-A recipe for success. *Journal of Occupational Therapy, Schools, & Early Intervention*, 11:1, 7-14, DOI: 10.1080/19411243.2018.1396016

Smithsonian Learning Lab. (2022). Activity Collection: ArtBots! Retrieved from: https://learninglab.si.edu/collections/activity-collection-artbots/Bs4TXY3Ym8M9uC75

Souliotou, A. Z. (2022). Artistic and educational utilization of object transformation in painting toys. 2nd Panhellenic Conference "The educational game and art in education and culture" - Conference Proceedings, B, 367-375. Retrieved fromhttps://ekedisy.gr/praktika-2oy-panellinioy-synedrioy-to-ekpaideytiko-paichnidi-stin-typiki-kai-mi-typiki-mathisi/ [in Greek]

Souliotou, A. Z. &Gerontopoulou, V. (2021). Artbots: an art-and-technology workshop with historical routes in the Charta of Rigas Velestinlis. Culture - Journal of Culture in Tourism, Art and Education, 1 (1). Athens: National Centre of Research & Preservation of School Material, 74-86. Retrieved from https://journalculture.weebly.com/ [in Greek]

Souliotou, A. Z., Zoi, S. & M. Santorineos. (2020). (Co)Creation & Interaction at the Crossroad of Art, Technology & Special Education. Experimental Workshop with the @Postasis Real-Time Multiuser Collaboration Platform. Proceedings of Filodiritto Editore – 10th International Conference the Future of Education – Virtual Edition, 147-152.

Souliotou, A. Z., (2019). The Benefits of ArtBots Activities in Education and Society. In F. Uslu, T. Güçlü, M. Özdemir, K. Altan, S. Aslan (Eds.), SOCIOINT 2019 - 6th International Conference on Education, Social Sciences and Humanities, 24-26 June 2019 - Istanbul, Turkey (pp. 149-158). Retrieved fromhttp://www.ocerints.org/socioint19_e-publication/abstracts/a486.html.

Souliotou, A. Z. (2016). The importance of including the Arts in STEM education, Hellenic Conference on Innovating STEM Education [HiSTEM 2016], National and Kapodistrian University of Athens. [in Greek] Retrieved June 23, 2020 from: https://stemeducation.upatras.gr/histem2016/

Tomlinson, C. A. (2014). The differentiated classroom: Responding to the needs of all learners (2nd ed.). Alexandria, VA: ASCD.

Watson Institute (2020). Incorporating STEAM Learning into Special Education Curriculum. Retrieved from https://www.thewatsoninstitute.org/incorporating-steam-learning-into-special-education-curriculum/

Wyffels, F., Van de Steene, W., Roets, J., Ciocci, M. C. &Carbajal, J. P. (2016). Building ArtBots to Attract Students into STEM Learning. arXiv:1608.03405, Cornell University. Retrieved from: https://arxiv.org/abs/1608.03405

Yakman, G. (2008). STΣ@M Education: an overview of creating a model of integrative education. Pupils Attitudes Towards Technology 2008 Annual Proceedings. Netherlands.

Zayyad, M. (2019). STEAM Education for students with specific learning disorders. In: W. Wu & S. Alan (Eds), Research highlights in education and science 2019 (pp. 31- 42). ISRES Publishing. Retrieved May 8, 2020 from https://www.isres.org/books/RHES2019_01-01-2020.pdf.