Inclusive Robotics for a better Society

INTRODUCING THE INBOTS ROBOTICS CURRICULA

Authors:

Rene Alimisi, Chrissa Papasarantou (EDUMOTIVA- European Lab for Educational Technology)

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Introduction

In the context of the INBOTS European project, exemplary curricula on robotics are developed to reflect upon the needs of pre-school, primary and secondary school education as far as STEM and the acquisition of 21st century skills (i.e., creativity, critical thinking, problem solving, social competences) are concerned. Their aim is to propose several learning activities, revolving around the DIY culture and the constructivist methodology, and thus addressing specific content such as electronic circuits, programming structures and engineering concepts. The ultimate goal is a pedagogical shift where students become active learners and makers, with high need of exploring, discussing and sharing experiences and ideas, while teachers are facilitating them as their coaches, helping and encouraging them to explore and construct their own knowledge. This section aims to present the theoretical background and the methodology upon which the aforementioned curricula were based and structured.

The first step towards the realization of the curricula, was the exploration of the existing needs on robotics for each educational grade. For this purpose, it was initially decided the introduction and development of a persona. As a persona is defined a fictional character, representing a rather real-life teacher and her/his immanent needs concerning teaching. In this sense, three different personas (one for each level of education) were developed: one for kindergarten and early elementary education; one for primary education and one for secondary education. Each of them has a background story regarding her/his teaching methods, the motivation behind her/his decision to get involved with educational robotics, as well as the ways s/he envisions introducing robotics to her/his class. Another issue that is stressed through each persona is the diversities that can be met in a school class. This is done through the description of the group of students that each of them is working with. Through this lens a number of parameters/qualities such as the educational level, the number and the age of students, as well as their background on robotics, are reflected.

The development of a persona and her/his needs led also to another emerging issue regarding the available equipment for supporting a curriculum in robotics education. Therefore, and again from the perspective of each persona, a number of different technologies and tools that can be found in a school or can be easily accessible (by buying or borrowing them), were recorded, leading to the formation of three different lists (one for each educational grade). These lists, combined with the aforementioned qualities that were stressed out, shaped the guidelines for unfolding the sessions of the INBOTS curricula. The description of the 3 personas are available here.

Apart from the aforementioned key considerations, our work draws upon fundamental principles and ideas inherent in the Maker Movement in Education trend as well as additional constructionist educational practices. Team work, expression of creativity, hands-on practice, playful explorations, embracement of DIY culture and spirit, problem solving, embodied interactions, as well as storytelling are infused in the sessions towards robotic artefact constructions, adapted to the needs of each target group, namely early elementary (5-6 years old), primary (7-12 years old), and secondary (13+ years old).

In the next sections, a number of methods and practices emerging from pedagogical theories are highlighted and analysed. The ultimate goal is the creation of a solid pedagogical infrastructure upon which the curricula will be developed.

Pedagogical framework and key considerations

The INBOTS curricula invite learners to playfully explore robotic artefacts and meaningfully engage in robotic artefact constructions. Towards this end, the design of the curricula draws heavily upon the learning theory of “constructionism” introduced by Papert and his group at the Media Lab (Kafai and Resnick 1996). Constructionism, constitutes an expansion of Jean Piaget‟s constructivism (Kafai and Resnick 1996) according to which:

> “learning is not the result of a transmission of knowledge, but an active process of knowledge construction, based on the experiences gained from the real world and linked to personal unique pre-knowledge” (Piaget 1972;).

The learning experience is stronger when the children construct artefacts and knowledge by playing with and exploring concrete materials (Papert 1993). The social context of these explorations is also crucial, and teachers can provide scaffolding by creating a learning environment that supports children’s collaborative explorations and experimentation.

The aforementioned social aspect is reflected in the Resnick’s creative spiralling cycle of *Imagine, Create, Play, Share, Reflect*, and back to *Imagine* – and is used to describe a process where children “imagine what they want to do, create a project based on their ideas, play with their creations, share their ideas and creations with others, reflect on their experiences – all of which leads them to imagine new ideas and new projects‟ (Resnick 2007b, p.18).

This spiralling cycle has a place in the INBOTS curricula and it is used as the backbone of proposed sessions, activities and projects (adapted to the needs of each target group). This spiralling cycle is identified in several activities in kindergarten and based on Resnick, it is worth keeping it live to additional upper educational levels.

In addition, the INBOTS curricula draw inspiration from the Maker Movement in education, a global trend that encourages young students to create and develop new things (digital or non digital) using new technologies and tools (Blikstein 2013, Schön et al 2014, Alimisis 2020). Since the INBOTS curricula are intended for classroom deployment, we aspire to bring making practices in the classroom and sow the seeds for a more creative school that values and embraces the DIY spirit and the making culture.

Going through the three curricula one can identify a number of additional considerations and pedagogical ideas that derive to a great extent from the aforementioned pedagogical theories and trends. The focus is placed on how these ideas have been integrated in the INBOTS curricula.

Building further on the ideas of constructionism

The INBOTS curricula are based on the implementation of projects towards robotic artefact exploration and construction. An idea that is highly embraced is related to the provision of projects that have *“Low floor, high ceiling, wide walls”.* The robotic projects, designed under this principle, offer an easy entry for novices (low floor) while enabling more experienced learners to work on increasingly more complicated projects (high ceiling); noteworthy, they have also “wide walls” as they can support a wide range of different explorations (Resnick and Silverman 2005).

The projects and the activities that are described in the INBOTS curricula are student-centered and bring into focus the concept of *“hard fun‟*. The emphasis on “hard fun” refers to the way according to which students become active participants in the learning process through activities that support playful learning and are challenging but not straightforward (Papert 1993; Resnick 2006,).

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Interdisciplinary approach to learning

The projects integrated in the INBOTS curricula are also interdisciplinary in nature. Interdisciplinarity/multidisciplinarity is mainly related to the creative combination of more than one subject area. In example, the construction of the robotic DIY automobile, a key session in the INBOTS curriculum for secondary education, invites students to explore concepts from different subject disciplines namely maths, engineering, technology, science, and environmental education. Under this approach, the infusion of arts is also promoted through the INBOTS curricula. Art subjects can impact positively on the development of essential skills like collaboration, communication, problem-solving, and critical thinking encouraging deeper levels of expressing themselves, creating artefacts and responding to challenges.

A note on collaboration and sharing

The National Education Association’s guide (2010) on the 4C’s puts emphasis on the value of creating collaborative learning experiences in the classroom:

> “Not only does a collaborative effort create more holistic results than individual efforts, but it also creates knowledge for a greater number of people. As a result of students working collaboratively, the group can generate more knowledge, making collaboration a key ingredient to student success in today’s global society”.

It is important to offer students opportunities to practice collaboration and understand that they can build upon the experiences and results of others and others can learn from their own experiences and outcomes. Sharing can be crucial for developing social skills, as well as for enhancing student’s self-esteem. The making process itself offers ideal opportunities for team-work: tinkering and artefact construction support collaborative, iterative design methodology, where student-centered projects prepare students for real-world challenges where group discussion, ideas and knowledge exchange have a place.

The INBOTS curricula deploy a number of strategies towards boosting collaboration and sharing:

- Promotion of discussion and brainstorming: The INBOTS curricula invite students to discuss in groups 1) topics related to robots 2) plans for solving robotic challenges 3) plans for communicating and demonstrating the work or the current status of the work.
- Provision of feedback: The INBOTS curricula encourage students to exchange ideas and to support one another. Provision and eliciting of feedback is highly encouraged on a regular basis.
- Making the learning process and results visible: The INBOTS curricula call often the group of students to present the current status of work or the final artefact in the plenary, to elaborate on their designs and communicate their future plans and ways of dealing with emerging problems.
- Design of activities and projects that encourage collaboration: The projects and the activities integrated in the INBOTS curricula are indented for team work. Role interchange among the teams is also foreseen.

Fostering embodiment and embodied skills

Embodiment is a rather complex and multifaceted notion. A short research will reveal an extended number of definitions coming from interrelated, but also different, scientific

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fields, such as philosophy, phenomenology, psychology, cognitive science etc. In summary, the notion of embodiment denotes the physical (and organic) existence of an embodied entity, namely of an organism who perceives, communicates, and interacts with her/his environment (spatial and social) through her/his body and mind (Merleau-Ponty 1945; Lakoff and Johnson 1999; Damasio 1994; Clark 1997 etc.). Therefore, through her/his embodied skills (senses, memories, behaviors, movements, gestures, feelings etc.) a person is able to feel, perceive and shape her/his lived experience over the world (Gibson 1979; Thiel 1997; Elkins 1999; Hummels 2000; Mantovani and Castelnuovo 2003 etc.). In this sense, the notion of embodiment is also closely related to the learning ability and process (especially in tasks that are implicitly or explicitly related to spatiality).

The notion of embodiment can be considered as one of the main key words on the development of STEAM related educational activities in two ways:

- The first one concerns methods and activities that are mostly addressed – and in the context of INBOTS suggested – to preschool or/and primary school curriculum. Since embodiment is inextricably related to a person’s sense of self-awareness for her/his presence in a specific place, it is considered as the most proper notion to describe activities concerning the familiarization of students with new technologies through their own body. Terms such as, self-awareness, spatial awareness, social awareness, and sensory perception can be considered suitable for generating questions regarding students’ embodied experience. Moreover, sensory perception reflects all the embodied skills that are included and applied during kinaesthetic learning (i.e. performing physical activities, making sense of the world through their body, reflecting this knowledge to another person through oral commands or recreating this somatic experience by using a robot etc.).
- The second one concerns methods and activities that are mostly applied to the Secondary School curriculum. In this age group, the suggested activities are more advanced as far as concept and interactivity are concerned, while hands-on activity has a principal role. Thus, the sense of embodiment is considered as an already obtained skill and is mainly approached through the lens of embodied interaction, a parameter that reveals the embodied skills that should be taken into consideration in the process of designing an interactive object or environment (Dourish 1999; Spagnolli and Gamberini 2002; Larssen 2008 etc.). In this sense, students should be encouraged to include bodily skills as a main parameter to the design process of an interactive artefact, so as to determine easier the nature of input and output components (sensors, switches, motors etc.). If, for example, their intention is to create an artefact that is buzzing an alarm when some kind of movement is detected, then they should determine what kind of movements want to trigger their system so as to search for the proper electrical components. This information can also determine the scale and the form of their construction. Students should be also encouraged to get familiar with experiences that are related with feelings such as success or failure, and reflect their thought upon these experiences, since it is argued that these behaviors can be related to methods of obtaining knowledge, through recalling previous gained learning experiences (Mantovani and Castelnuovo 2003).

Seeing learners as explorers and designers of games

Game is also an intricate and multidimensional notion, which can be perceived not only as a playful act of escaping from reality, but as an engaging activity associated with social life (Leach in Borries et al 2007, p.328). Game can be considered as “a problem-solving activity approached with a playful attitude” (Schell 2008, p.37), and as a spatial situation that combines a number of rules (inspired by real life) with fiction (Juuls 2005, p.163), while being characterized -among others - by interactivity (Schell 2008, p.34) and decision-making processes towards a meaningful outcome (Salen and Zimmerman 2004). There are four basic elements that constitute a game and these are: mechanics (namely the procedures and rules of the game), story (sequence of events that unfold in the game), aesthetics (elements concerning the general experience denoted by a game), and technology (any medium that activates and shares the aforementioned three elements, making the game feasible) (Schell 2008, pp.41-42).

Games are “per se motivating” (De Gloria et al 2014) and are inextricably related to the act of playing (Schell 2008; Salen and Zimmerman 2004). In this sense, they should be also linked to the process of learning (Resnick 2007, p.3). Games, such as video games and particularly those belonging to the field of “serious games”, are “information-rich” interactive environments and therefore are considered as valuable tools for STE(A)M related learning activities since they are enhancing the acquisition of knowledge, while supporting behaviors of exploration, problem solving and team-building (Mayo 2009, p.80; De Gloria et al 2014). In addition, they are having a positive impact on skills such as “communication, adaptability and resourcefulness” (Barr 2017, p.96). All these assets are not only related to the act of playing, but also to the act and process of designing. After all, as Bogost argues (in Borries et al 2007, p.307), a reason that we are playing games is to make sense of the possibilities lying behind them and think of their implications in our daily life.

According to De Gloria (2014, p.5), designing and using games (and particularly serious games) are highly interrelated to constructivist learning theories about the creation of knowledge through the experience of “exploring the world and performing activities''. Thinking of ways that new technologies could be implemented for integrating play, design and learning – and based on Kafai’s documentation on elementary school students who became more creative thinkers through designing their own games – Resnick (2007, p.4) argues that a possible way could be through providing children “the opportunity to design their own games”. As a result, he and his research group in MIT, in collaboration with Kafai, developed Scratch, the block-based programming environment (*proposed here together with additional block-based programming environments as a tool in primary school educational curricula*) that enables novices to apply programming concept for instructing different elements, thus designing interactive digital models (games included) through a rather playful and pedagogically meaningful process.

Several programming environments and robotic kits promoting constructivist learning theories and strategies of gamification have been developed since then. Makey-Makey for example (which is also introduced in primary school educational curriculum*)* can enable learners to extend virtual games to the physical environment, adding the parameter of embodiment to the design process. Towards this direction and through the implementation of such technologies, the proposed curricula introduce the notion of game in two ways:

- through the lens of playing in early and primary education and by introducing strategies and practices of role playing, storytelling as well as collaboration,

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while fostering learning activities that encourage students to progressively create their own artefacts, shifting the entire process from playing to designing.

- through the lens of designing and resourcefulness in secondary education by adopting strategies of gamification (exploring real scenarios, solving problems, communicating and sharing the content) and implementing them through the creation of (interactive) robotic artefacts.

Putting forward "storytelling" practices

> *"We are educated and motivated by Story, and a good story telling can change our perspective, give us new insights, shape our dreams and desires" (Bigbeacon site: http://bigbeacon.org/2013/12/twitter-chat-2013-12-11-8-pmstorytelling-in-stem-education/).*

Stories are inextricably related to the nature of human communication (Boris 2017). Over time, it is through stories and storytelling that people share their ideas, their culture and their values (Boris 2017). In a sense people are defined through and by their stories (Ibarra and Lineback 2005).

Studies report that narration (and consequently storytelling) has a major impact on learners through building a sense of connection among them and consequently motivating them to engage in cooperative behaviors (Zak 2014; Boris 2017). It is also argued that learners can become easier engaged in activities when information is presented in a form of story (and not as a list of bullets, a short text etc.), since they are able to easily remember and grasp the content and the context of the task. Moreover, if storytelling revolves around characters and role adaptation methods, learners feel that they are related to the entire process in a more mediate way.

Storytelling coupled with STEM methodologies/practices, can address the integration of interdisciplinarity across the curriculum (since it assists students to "think more critically about the interconnectedness between the many branches of science and the world as a whole"), which leads to reaching the learning needs of the majority of the students, and especially the female students (who tend to perceive STEM activities as more creative and artistic when storytelling is included) (Harrop 2018; Sarkisyan 2018; Kuchments 2013). For example, there are teachers who implement texts from novels as the vehicles for carrying the concept of a lesson (i.e. Maths, Physics etc.) (Sarkisyan 2018; Kuchment 2013).

Therefore, the INBOTS activities and projects (included in several sessions of the present curricula) aim to familiarize students with several robotic challenges that are engineered through a story/narration/plot. In a more advanced stage the learners are encouraged to collaboratively create their own stories and/or narrations that act as vehicles of robotic challenges practicing further their creative and critical thinking as well as their problem solving skills.

Pushing against tool-oriented approaches

Last, the INBOTS curricula invite teachers and educators to explore a variety of affordable constructive technologies and tools towards robotic artefact construction. In other words, the curricula are not tool-oriented. Indicative tools that can be used are mentioned and alternative solutions are also presented. Noteworthy, at a great extent an attempt is made to propose the use of open-source, low-cost technologies and tools that can be used by the learners to move from passive receivers of knowledge to explorers and makers or robotic artefacts.

With inspiration from the aforementioned educational constructionist pathways and modern pedagogical approaches, the INBOTS curricula propose a flexible educational scheme that aims at encouraging students to explore, create, re-create, assembly and extend robotic artefacts by using low-cost technologies, tools and everyday materials.The success of classroom learning is dependent on how students relate to one another, what the classroom environment is, how effectively the students' collaboration and communication is and the roles that the teachers and the students play. Below the roles of teachers/educators and the learners within the classroom where the INBOTS curriculum is applied are described:

Role of teacher: the teachers are not the sages on the stage and they are not supposed to have all the answers to the questions that may emerge. They rather help and encourage the students to explore and construct their own knowledge, to organise their thoughts and ideas, to work effectively in teams. They encourage teamwork, experimentation, hands-on activity, challenge seeking and the sharing of knowledge. As Seymour Papert (1993) advocated, "the role of the teacher is to create conditions for invention rather than to provide ready-made knowledge". Through questions and observations, the teacher engages students in articulating and extending their own observations, through processes, and explorations. The teacher may not directly answer students' questions but rather show them how to find it themselves. This kind of exploration fosters an environment in which what we often see as **"failure"** is actually a natural step of the learning process, a signal to ask questions and explore further. A shift from teacher control and decision making over students' learning can support students to develop self-regulation and become independent and effective learners The INBOTS curriculum embraces this approach and encourages teachers to take several roles (the roles of the mentor, trainer, facilitator of the learning process, self-esteem booster, co-maker, co-learner, evaluator) and adapt their support and guidance based on the needs along the way.

Role of learners: In going through this process, school students develop and refine their abilities as creative thinkers. They learn to develop their own ideas, try them out, test the boundaries, experiment with alternatives, get input from others – and, perhaps most significantly, generate new ideas based on their experiences (extending the given project scenarios). They also learn to develop concept-generated ideas through the implementation of storytelling-oriented activities (this is mostly applicable to primary school students).

Learning Objectives

Making in education with an emphasis on robotic artefact construction, may address specific learning content, for example electronic circuits, programming structures, engineering concepts, debugging procedures and more. Besides STEM and technology interest, knowledge and competencies, this includes creativity, innovation skills development, artistic expression and problem solving. Maker students are active learners, with a high need to explore, to discuss and to share experiences and ideas. Also, social and personal competences are to be included in our potential learning goals. In general, the skills of creating and innovating can have a broad impact on students' lifelong learning and ultimately for education and society (Schon et al 2014).

In pre-school education, the curricula focus on the familiarization with robotic artefacts. Through age-appropriate tools (i.e., tangible robots, tile-based visual coding etc.) and embodied tasks, kindergarten children are encouraged to identify a robotic artefact and implement simple programming commands. In primary school education, the students will also become familiar with hands-on practices (i.e., crafting, electrical circuit making), while being acquainted with certain techniques of programming, turning the entire process of coding from something abstract and ambiguous to a more concrete and meaningful procedure. Multimodality is also promoted through the introduction of additional methods for supporting learning experiences such as storytelling, use of role-playing games and more. Finally, in secondary education through the introduction of open-source technology and the engagement in DIY projects students learn how to put the already gained knowledge to a context, and progressively support their own ideas towards robotic artefact construction.

Through the proposed curricula, attitudes such as expressing self-confidence in solving robotic tasks, as well as positivity regarding working together with other people are foreseen. Boosting students’ self-confidence on forming new ideas and making recommendations as well as exploring their own abilities and skills through the adaptation of different roles are also encouraged.

5-6 years old **Learning objectives**
Knowledge
- to explain what robot is - to explain what a robot does - to identify robots in their daily life - to explain in simple words what is an electrical circuit - to name materials and items that can be used for making circuits - to identify and explain how symbols and icons are used to communicate a message/address a behaviour - to describe the various ways that robots can move
Skills
- to put directional commands in a sequence? - to make lines and figures using floor robots - to create stories/plots for the floor robot - to test different sequences of icons/commands - to solve robotic challenges collaboratively - to create electrical circuits using simple materials
Attitudes
- to express self-confidence in solving robotic challenges

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- to participate meaningfully in classroom activities

-to express positive attitudes regarding team work

-to direct an effort to achieve a desired result

- to propose ideas and make suggestions for overcoming problems

- to formulate questions related to the behaviour of the robot

- to creatively express themselves

7- 12 years old **Learning objectives**
Knowledge
- to describe what a robot is and what it can do - to name robots that are used in daily life - to describe what a command is - to explain what a sequence of commands does - to recognize everyday symbols for addressing directional commands - to distinguish between conductive and non conductive materials - to name basic electrical components - to explain with simple words how an electrical circuit works - to demonstrate a scenario with robots - to explain basic programming constructs/concepts
Skills
- to program a robot using icons and/or block-based commands -to trace visual code - to assembly electrical components - to use conductive items -to experiment with alternative ways or more optimal ones for controlling the robot - to give directional commands - to make measurements in order to instruct the robot reach a goal -to make figures and shapes using mathematics and geometry - to direct others with oral guidelines (orientation skills) - to interact with others in order to find solutions - to create their own games/stories/plots - to organise and plan their work towards robotic artefact constructions

Attitudes

- to express self-confidence in solving robotic tasks
- to express positive attitudes regarding working together with other people
- to direct an effort to achieve a desired result
- to form new ideas
- to make recommendations regarding optimal solutions
- to appraise scientific work in the area of robotics
- to formulate questions related to the behaviour of the robot
- to value art work
- to creatively express themselves

13+ years old

Learning objectives

Knowledge

- to explain what the field of robotics is
- to define what a robot is
- to identify and explain how block-based commands and constructs are used to communicate a message/address a behaviour
- to explain what sensors are and how they work
- to discuss on how robots facilitate real-life situations
- to explain what a script does
- to explain what conductivity is
- to identify electrical components
- to explain how an electrical circuit works
- to explain basic programming constructs/concepts

Skills

- to construct a robotic artefact using simple materials
- to re-use materials towards creating something new

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- to create electrical circuits as part of a robotic construction
- to use programming commands to address a specific behaviour to the robotic artefact
- to experiment with alternative solutions regarding programming and modelling
- to program a robot so that to interact with the environment (using sensors and actuators)
- to build or construct a robotic artefact following a design process
- to exchange ideas and views in groups regarding emerging robotic challenges

Attitudes

- to express self-confidence in creating robotic artefacts
- to set a plan for overcoming problems/challenges

-to express positive attitudes regarding working together with other people

-to direct an effort to achieve a desired result

- to form new ideas and make recommendations
- to creatively express themselves

-to appraise scientific work in the field of robotics

- to express positive attitudes towards scientific careers
- to value experts’ opinions and build upon them

Presenting the INBOTS curricula

The INBOTS curricula include several proposed activities in the form of sessions. The sessions are gradually introducing and involving students to the Do It Yourself (DIY) culture and making practices, taking into account the diversities that can be met in a school class as far as the background on new technologies are concerned. The variety of ages included in each educational group constitutes another critical parameter. There are no compulsory sessions. However the links between the sessions are mentioned. Therefore, it is up to teachers/coaches to choose among those that fit better to their class needs and dynamics. Additional educational practices such as storytelling, role-playing in the class, connections with experts/scientific community, and engagement in information searching online on specific topics are also introduced through the INBOTS curricula.

Each session follows a basic structure, and for each educational group there are some common stages, such as introduction to the activity (mainly through warm-up activities or collaborative challenges), brainstorming and planning, work in groups, sharing and free exploration of new ideas.

Each session (in the curriculum) is accompanied by a short description, the outline of the session, the activities that students will perform, the learning objectives, as well as the resources that can be used (including resources that have been specifically designed for the INBOTS curriculum and others that are freely available online and can be reused in the context

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of the proposed activities), a list of indicative technologies that can be used and the knowledge that is pre-required. The time per session may vary and can be extended or shortened given students’ needs and group dynamic.

References

1. Alimisis D. (2020) Emerging Pedagogies in Robotics Education: Towards a Paradigm Shift. In: Pons J. (eds) Inclusive Robotics for a Better Society. INBOTS 2018. Biosystems & Biorobotics, vol 25. Springer, Cham. https://doi.org/10.1007/978-3-030-24074-5_22

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No. 780073.

2. Barr, M 2017, “Video games can develop graduate skills in higher education students: A randomised trial”, *Computers & Education*, 113, pp.86–97.
3. Blikstein, P. (2013). Digital Fabrication and ’Making’ in Education: The Democratization of Invention. In J. Walter-Herrmann & C. Büching (Eds.), FabLabs: Of Machines, Makers, and Inventors. Bielefeld: Transcript Publishers,
4. Boris, V 2017, “What makes storytelling so effective for learning?”, *Harvard Buisness Publicing*, available online: https://www.harvardbusiness.org/what-makes-storytelling-so-effective-for-learning/
5. Borries, FV, Walz, S, and Bottger, M 2007, *Space, Time, Place: Computer Games*, Architecture and Urbanism: The next Level, Birkhauser, Basel_Boston_Berlin.
6. Clark, A 1997, *Being There: Putting Brain, Body, and World together again*, The MIT Press.
7. Damasio, A.R 1994, *Descartes’ error: Emotion, Reason and the Human Brain*, Avon Books, New York.
8. De Gloria, A, Belloty, F, Berta, R, Lavagnino, E 2014, “Serious Games for education and training”, *international Journal of Serious Games,* Vol 1, issue 1, available online: http://dx.doi.org/10.17083/ijsg.v1i1.11
9. Dourish, P 1999, “Embodied Interaction: Exploring the foundations of a new approach to HCI”, *draft paper in preparation for a special issue of Transactions on Computer-Human Interaction on “HCI in the New Millennium”* (available online: http://www.dourish.com/embodied/embodied99.pdf)
10. Elkins, J 1999, *Pictures of the Body: Pain and Metamorphosis*, Stanford University Press, Stanford, California.
11. Gibson, J 1979, *The ecological approach to visual perception*, Houghton Mifflin Company, Boston.
12. Harrop, W 2018, “STEM and Storytelling — Integration across the Curriculum”, *presentation* available online: https://www.stemforward.org/stem-storytelling
13. Hummels, C 2000, “Gestural design tools: prototypes, experiments and scenarios”, PhD thesis, TU Delft.
14. Ibarra, H and Lineback, K 2005, “What’s your story”, *Harvard Business Review*, available online: https://hbr.org/2005/01/whats-your-story
15. Juul, J 2005, *Half-real: Video Games between Real Rules and Fictional Worlds*, Cambridge MA: The MIT Press.
16. Kafai, Y and Resnick, M 1996, *Constructionism in practice: Designing, thinking, and learning in a digital world*, Lawrence Erlbaum Associates, Mahwah, NJ.
17. Kuchment, A 2013, “To Attract More Girls to STEM, Bring More Storytelling to Science”, available online: https://blogs.scientificamerican.com/budding-scientist/to-attract-more-girls-to-stem-bring-storytelling-to-science/
18. Lakoff, G and Johnson, M 1999, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Though*, Harper Collins Publishers.
19. Larssen, AT, Robertson, T and Edwards, J 2007, "The feel dimension of technology interaction: exploring tangibles through movement and touch", *Proceedings of the 1st international conference on Tangible and embedded interaction (TEI 2007)*, Baton Rouge, Louisiana, USA, Feb. 15 - 17, pp. 271 – 278.
20. Mantovani, F and Castelnuovo, G 2003, “Sense of presence in virtual training: Enhance skills acquisition and transfer of knowledge through learning experience in virtual environments”, *Being There: Concepts, effects and measurement of user presence in synthetic environments,* G. Riva, F. Davide, W.A IJsselsteijn (Eds.) Ios Press, 2003, Amsterdam, The Netherlands, pp. 168-180.
21. Mayo, MJ 2009, “Video Games: A Route to Large-Scale STEM Education?”, *Science*, 323, pp. 79-82.
22. Merleau-Ponty, M 2003, *Phenomenology of perception*, re-edition, routledge, London and New York.

23. National Education Association 2010, Preparing 21st Century Students for a Global Society: An Educator's Guide to the "Four Cs". https://www.academia.edu/36311252/Preparing_21st_Century_Students_for_a_Global_Society_An_Educators_Guide_to_the_Four_Cs_Great_Public_Schools_for_Every_Student (last accessed 01/03/2021)
24. Papert, S 1993, *Mindstorms: Children,Computers, and Powerful Ideas*, London: Basic Books, 2nd Edition.
25. Piaget, J 1972, *The principles of Genetic Epistemology*, N.Y.: BasicBooks
26. Resnick, M 2007, "All I really need to know (about creative thinking) I learned (by studying how children learn) in kindergarten", *C&C '07: Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition*, June 2007, pp. 1–6, https://doi.org/10.1145/1254960.1254961
27. Resnick, M 2007b, "Sowing the Seeds for a More Creative Society", *International Society for Technology in Education*, pp.18-22.
28. Resnick, M 2006, "Computer as Paintbrush: Technology, Play, and the Creative Society", In: D. Singer, R. Golikoff, and K. Hirsh-Pasek (eds), *Play =Learning: How play motivates and enhances children's cognitive and social-emotional growth*, Oxford University Press.
29. Resnick, M and Silverman, B 2005, "Some Reflections on Designing Construction Kits for Kids", *Proceedings of Interaction Design and Children conference*, available at: http://llk.media.mit.edu/papers/IDC-2005.pdf
30. Salen K and Zimmerman E 2004, *Rules of Play – Game Design Fundamentals*, The MIT Press Cambridge, Massachusetts London England.
31. Sarkisyan, A 2018, "Storytelling in STEM – can changing the narrative (finally) give girls a voice?", *"Learnosity" site,* available online: https://learnosity.com/storytelling-in-stem-changing-the-narrative/
32. Schell, J 2008, *The Art of Game Design: A book of lens*, Carnegie Mellon University, Morgan Kaufmann Publishers, USA.
33. Schön, S, Ebner, M, and Kumar, S 2014, "The Maker Movement. Implications of new digital gadgets, fabrication tools and spaces for creative learning and teaching", *eLearning papers* , *39*, pp.14-25.
34. Spagnolli, A and Gamberini, L 2002, "Immersion/emersion: Presence in hybrid environments", *Proceedings of the Fifth Annual International Workshop on Presence*, Universitade Fernando Pessoa Press, Porto, pp. 421-434.
35. Thiel, P 1997, *People, Paths and Purposes: Notations for a participatory envirotecture*, The University of Washington Press.
36. Zak, PJ 2014, "Why your brains loves good storytelling", Harvard Business Review, available online: https://hbr.org/2014/10/why-your-brain-loves-good-storytelling

Technologies and tools

(mentioned in the 3 curricula):

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Robots:

Kubo: https://kubo.education/

Blue-bot: https://www.terrapinlogo.com/products/robots/blue/blue-bot-family.html

Bee-bot: https://www.terrapinlogo.com/products/robots/bee/bee-bot-family.html

Pro-Bot: https://www.terrapinlogo.com/products/robots/pro/probot.html

Botley: https://www.learningresources.com/shop/collections/botley

Roamer: https://www.roamer-educational-robot.com/

Colby mouse: https://blog.generationrobots.com/en/tutorial-robot-mouse-colby/

Cubelets: https://www.modrobotics.com/

Thymio: https://www.thymio.org/

Dash: https://www.makewonder.com/robots/dash/

Dot: https://www.makewonder.com/robots/dot-creativity-kit/

Edison: https://meetedison.com/

Kits and open-source technologies:

Little Bits: https://sphero.com/collections/all/family_littlebits

Chibitronics: https://chibitronics.com/

Makey-Makey: https://makeymakey.com/

SnapIno: https://shop.elenco.com/consumers/snapino.html

Arduino: https://www.arduino.cc/

Software and apps:

Wonder Workshop INC:
https://play.google.com/store/apps/developer?id=WONDER+WORKSHOP,+INC.

Edscratch: https://meetedison.com/robot-programming-software/edscratch/

Scratch: https://scratch.mit.edu/

Microsoft Makecode Editor: https://makecode.chibitronics.com/

mBlock: https://mblock.makeblock.com/en-us/

Snap4Arduino: http://snap4arduino.rocks/

Open Roberta Lab: https://lab.open-roberta.org/

TinkerCad: https://www.tinkercad.com/learn/circuits

App Inventor: https://appinventor.mit.edu/

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