Chapter 8

Strategies for Digital Creative Pedagogies in Today's Education

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Additional information is available at the end of the chapter

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Abstract

Creativity and digital technologies are considered to be central for success and development in the current society, becoming crucial educational objectives worldwide. Nevertheless, education often fails to keep pace with creative and digital economies; this is mainly because teachers are not prepared for adopting pedagogical strategies that foster creativity or for fully exploiting the educational potential of digital technologies. Based on the seminal theories of creativity, we propose an innovative framework for applying creative teaching practices mediated by digital technologies: in the light of constructivist and constructionist approaches, we suggest a series of digital tools which are particularly suitable to the emergence of creativity, i.e. manipulative technologies, educational robotics and game design and coding. Furthermore, we shape the concept of digital creative pedagogies (DCP) and establish a set of characteristic components of teaching practices which contribute to the development of students' creativity. Drawing on a substantial body of research, the chapter intends to embed educational creativity in the digital culture.

Keywords: creativity, digital creativityd, digital creative pedagogies, manipulative technologies, educational robotics, game design and coding

1. Introduction

Creativity is considered to be critical for facing the social and economic changes of today's society [1, 2], as well as for attaining personal development, social inclusion, active citizenship and employment [3]. In addition, the labour market depends more and more on employees' abilities to work with technologies, as well as to generate new ideas, products and practices [4]. In this context, digital and creative skills have gained the attention of worldwide policies and have become important educational objectives [5].

Nevertheless, a gap remains between policies and practices, as education often fails to keep pace with creative and digital economies [4, 6]. This is mainly because teachers are not prepared for adopting pedagogical strategies that foster creativity or for fully exploiting the educational potential of digital technologies.

Beghetto [2] identified a series of obstacles to the integration of creativity in the classroom, including convergent teaching practices and teachers' negative beliefs towards creativity. Furthermore, educators are not prepared to apply creative teaching strategies which match their institutional and curricular requirements [7].

Regarding digital technologies, the 'EC report on initial teacher education in Europe' [8] states that only half of European countries integrate digital education in teacher education. Furthermore, most teachers use digital technologies mainly to prepare their teaching, rather than to work with students during lessons. As a result, between 50 and 80% of students in Europe never use digital textbooks, exercise software, simulations or learning games.

This chapter proposes an innovative framework aiming to prepare educators for applying creative teaching practices mediated by digital technologies. We first attempt to conceptualise educational creativity, i.e. we present the seminal theories and definitions of creativity and the main characteristics of creative education, as well as a series of creative pedagogies. Afterwards, we propose a framework for digital creativity in education, including a definition, a series of pedagogical theories and digital tools which are particularly suitable to the emergence of creativity. We finally establish a set of characteristic components of digital creative pedagogies (DCP), that is, teaching practices which contribute to the development of students' creativity.

2. Creativity in education

2.1. Different approaches to the study of creativity

Creativity constitutes a complex and elusive concept which remains difficult to explore. It has been studied through the lens of different paradigms, for example, pragmatic, psychodynamic, psychometric, cognitive and evolutionary approaches [9]. Some of those have brought valuable contributions to the understanding of creativity; nevertheless they do not allow for a holistic approach of the phenomenon. Hence, several theories attempted to explore its different dimensions in a comprehensive manner.

For instance, Csikszentmihalyi [10] described creativity as the result of a system composed of three distinct elements: (a) the *domain*, which contains a specific set of rules and practices; (b) the *individual*, who produces a novel variation in the content of the domain through cognitive processes, personality traits and motivation; this variation is evaluated by (c) the *field* for its inclusion in the domain.

Furthermore, Rhodes [11] developed the four P's model, which places creativity at the interplay of four distinct strands, i.e. process (the different stages of a creative activity), person (the characteristics of individuals), press (the qualities of the environment where creativity happens) and product (the tangible or intangible outcomes of the creative process). Rhodes' classification has become a major framework for the holistic exploration of creativity. The next subsections examine the four components in the light of influential theories of creativity.

2.1.1. Process-oriented approaches

Those theories mostly explore and describe the creative process through an iterative sequence of stages [12], which commonly consist of the identification of the task, a phase of preparation and an evaluation of the obtained outcome. Nevertheless, process models present some discrepancies: some researchers view the emergence of ideas as a sudden and intuitive process characterised by an illumination or insight (e.g. [10]); on the contrary, other theories describe a mindful process of idea generation [12]. For instance, the well-known componential model of Amabile [13] proposes a system of five phases: (a) problem or task identification (conscious recognition of the task or problem), (b) preparation (building or reactivation of the information which is useful to the completion of the task), (c) response generation (creation of possible solutions or responses), (d) response validation (evaluation of the possible responses or solutions) and (e) outcome (evaluation and diffusion of the outcome).

2.1.2. Person-oriented approaches

Here researchers use biographical and historiometric methodologies to explore the individual characteristics and personality traits of creative persons. Such theories result in a series of creative individual components which include thinking styles, personality attributes (e.g. a positive disposition towards overcoming obstacles, taking risks and tolerating ambiguity) and intellectual abilities [14], as well as concentration, playfulness, discipline, passion and objectivity [10]. Amabile [13] brings a classification which differentiates domain-relevant skills (knowledge and skills in the domain), task motivation (extrinsic and/or intrinsic) and creativity-relevant skills (personality characteristics, like flexibility and a persistent work style).

2.1.3. Press-oriented approaches

This strand concentrates on the characteristics of the environment which may nurture or hinder creativity. First, social, cultural and political factors may influence creativity [15], like family upbringing, cultural traditions and the historical milieu [16]. In addition, Csikszentmihalyi [10] highlighted some environmental features which may foster creativity, including training, expectations, resources, recognition and reward. Similarly, Amabile and Gryskiewicz [17] identified a series of elements of the workplace environment which may foster creativity, such as freedom, challenge and leaders' recognition. At the contrary, some factors proved to hinder creativity, like time pressure, evaluation [17], lack of respect and competition [18].

2.1.4. Product-oriented approaches

The last dimension focuses on the tangible or intangible outcomes of the creative process. Researchers commonly define two characteristics of creative products, namely, usefulness and novelty [12, 13]. Usefulness refers to the adequacy of the outcome to its context of use. As for novelty, literature distinguishes between Big-C (consensual) and little-c (personal) creativity [19]. Kaufman and Beghetto [20] proposed a Four-C Model which differentiates mini-c (interpretive creativity), little-c (everyday creativity), Pro-C (expert creativity) and Big-C ('legendary' creativity).

2.2. Towards a definition

Defining creativity results to be a complex task [21]. The word has been applied to a variety of fields, settings and theories [22]; hence, scientific literature lacks a sound definition. Nevertheless, there appears to be consensus on the main features of creativity [23]: it refers to the ability to create something novel and appropriate [24]. The term 'novel' describes an original solution, while the term 'appropriate' refers to the usefulness of the product as applied to a specific need [9].

As applied to the field of education, the NACCCE [22] provided a comprehensive definition, which does not limit to the product dimension, describing creativity as an 'imaginative activity fashioned so as to produce outcomes that are both original and of value' (p. 30). Cremin et al. [25] added some components to this definition, so that it matches a personal view of creativity (little-c): 'purposive imaginative activity generating outcomes that are original and valuable in relation to the learner'. In this view, creativity processes involve four characteristics: (a) they consist of thinking imaginatively, (b) they are purposeful (i.e. directed towards a specific goal), (c) they result in an original and valuable outcome and (d) the learner constitutes the reference point.

2.3. Characteristics of creative education

The research community views creativity as a developmental quality which is amenable to teaching [7]. A review of literature in creative education allows for identifying three clear characteristics of creative education:

- *A democratic approach*: traditionally, creativity is seen as a quality reserved for exceptionally talented individuals [22]. This exclusive perspective recently changed towards an inclusive one, to which all people from all ages can be creative [16, 26]. This new angle is widely adopted in the field of education, considering that all students have a creative potential which can be fostered or hindered depending on the teaching strategies used [27].
- *A focus on little-c creativity*: small levels of creativity give importance to personal processes beyond outstanding accomplishments. As applied to education, this perspective encourages students to develop new and personally meaningful insights and discoveries, as well as to attain their full potential in their everyday domains [27].
- *A domain-wide approach*: creativity is often associated to the domain of arts [22]. Recently, this scope has been widened to other areas of everyday life [27]. Hence, in the field of education, creativity can be developed in all curricular subjects, such as languages and science [28].

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2.4. Creative pedagogies

Creativity and education literature highlights a series of creative pedagogies, that is, teaching practices which contribute to the development of students' creativity. In a review of 210 pieces of educational research, Davies et al. [29] mentioned the flexible use of space and time, the study outside the classroom, collaborative and game-based learning approaches, as well as respectful relationships, non-prescriptive planning and the participation of educators as learners in the classroom activities.

Cremin and Barnes [30] outlined similar characteristics, i.e. an agency-oriented ethos, multimodal methodologies, exploration and discovery, risk-taking, tolerance of ambiguity and uncertainty and safe and non-judgemental environments. In this line, Sawyer [31] considers the possibility to try before getting it right and the use of failure as a positive learning factor. The author also considers collaborative and improvisational practices which allow students for externalising their understandings and reflecting on their learning processes.

Barajas and Frossard [32] proposed a set of four main creative pedagogies, each one characterised by different components: (a) learner-centred approaches (matching curricular objectives with students' interests, making learning relevant and engaging, encouraging students' ownership and problem-solving, value learning processes above outcomes so to promote students' reflection on their learning trajectory), (b) open-ended ethos (providing space for uncertainty, exploration and spontaneity in a safe classroom environment), (c) synergistic collaboration (rich collaborative practices based on joint problem-solving and collective decision-making) and (d) knowledge connection (linking content to real-life situations, bridging different domains and disciplines and placing knowledge in a wider context).

3. Digital creativity in education: a proposal framework

Technological devices have entered all aspects of our everyday life [33]. In this digital society, the concept of creativity is being rethought. Indeed, the affordances of technologies may have a strong influence on creative processes and achievements. As mentioned by Loveless [34], 'digital technologies can be tools which afford learners the potential to extend or enhance their abilities, allow users to create novel ways of dealing with tasks which might then change the nature of the activity itself, or provide limitations and structure which influence the nature and boundaries of the activity' (p. 64). Nevertheless, understanding the interplay between digital and creative yet appears as a challenge, and the two are often studied as separate domains [4].

As a first step to bridge this gap, we propose the following definition of digital creativity, as applied to education (based on [22, 25]): 'purposive imaginative activity, mediated by digital technologies, generating outcomes that are original and valuable in relation to the learner'. As applied to education, digital creative teaching would consist of applying digital technologies with the aim to support creative pedagogies, that is, learner-centred approaches, open-ended ethos, synergistic collaboration and knowledge connection.

The following sections propose pedagogical theories and digital tools which may support the development of digital creativity in the classroom.

3.1. Pedagogical underpinnings

To our view, four pedagogical theories are particularly suitable to the application of digital creative teaching practices, namely, experiential education, critical pedagogy, constructivism and constructionism.

3.1.1. Experiential education

This movement questioned the pedagogical assumptions of its time, to which education relates to an accumulation of knowledge, in favour of active student-centred methodologies based on learning by doing and problem-based learning. To this view, learners build knowledge on the basis of the present experience and the active interaction with their environment [35, 36].

3.1.2. Critical pedagogy

This philosophy and social movement denounces the 'banking concept of education' which consists of simply depositing knowledge in a decontextualised manner [37]. At the contrary, Freire promoted the importance of developing learners' critical awareness towards the society and viewed education as a path to empowerment and emancipation. In this line, education should directly connect to meaningful problem-solving [38].

3.1.3. Constructivism

This influential paradigm considers knowledge as an experience that is developed by interacting with the world on the basis of prior knowledge. Hence, students are not passive recipients of knowledge. Rather, they make sense of the world by actively building and transforming meaning [39]; teachers become facilitators who guide students towards processing information through active exploration. From this perspective, every learning process is creative, as learners create their own meaning as they attempt to understand the world. As stated by Craft [40], 'in a constructivist frame, learning and creativity are close, if not identical' (p. 61).

3.1.4. Constructionism

Influenced by Freire and Piaget, Papert elaborated the theory of constructionism. He shares Freire's endeavour to free the latent potential of students, by creating learning environments which connect to their passions [38]. Building on constructivism, constructionism argues that learning better occurs when students make and share tangible artefacts [41]. Hence, this theory is directly related to the *maker* and *digital making* movements.

Papert pioneered the educational use of digital technologies. More than information and communication devices, he considers technologies as powerful educational tools which allow students for concretising and expressing their ideas by designing, building and engineering. Constructionist learning environments are usually not based on a fixed curriculum. Rather, students use technology to build their own projects, while teachers act as facilitators of the process [38]. Hence, learners become designers. The constructionist view highlights

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the importance of social participation in the knowledge construction process and considers making as an inherently social activity, through which learners design artefacts that are of relevance to a larger community [42].

3.2. Digital tools for creativity

We suggest the following tools and educational strategies which may support digital creative teaching activities.

3.2.1. Manipulative technologies

Manipulatives, in the context of education, are physical tools that engage students in hands-on learning. Based on the constructivist theories, the manipulation (i.e. organisation, combination, comparison, etc.) of objects, such as blocks, figures and puzzles, is central to the learning process, as it stimulates multisensory experience. Commonly, manipulatives are used to teach STEAM to young students and to bring fun to the learning process [43]. Recent studies show a high level of acceptance of digital manipulatives by teachers and students, as well as a positive impact on learning (e.g. [44]).

For example, Magic Blocks [45] are RFID-tagged logical blocks which children can manipulate in order to perform educational tasks set by a real or a virtual teacher, to stimulate learning of mathematical and logics concepts. LittleBits[1] are small electronic objects, each one with a distinct function (motion, light, sound, sensor, etc.) that easily fits to each other through magnets, used to create electronic circuits. They stimulate the inventive nature of children to create numberless projects while they learn not only logic, maths and electronics but also product design, prototyping and entrepreneurship. Furthermore, digital manipulatives stimulate a *makers* attitude, turning students into active creators. Learning in a makers environment provide opportunities for disrupting students' conventional practices of invention, exploring through play, failure, risk-taking and refiguring creation as remix and craft [46].

Virtual manipulatives, such as Wolfram Demonstrations Project,[2] Shodor Interactivate Activities[3] and GeoGebra,[4] completely substitute the physical elements. Empirical studies show that virtual manipulatives encourage creativity and increase the variety of solutions that students encounter [46], which is in line with the constructivist theory.

Cubelets[5] and Robo Wunderkind[6] enable young children to design and construct robots through manipulatives—mountable blocks that contain the functions of a robot (a switch, a motor, a sensor, etc.). These tools demonstrated to positively change students' attitude towards STEM and computer science [48], as well as to foster critical thinking skills [49].

[1] https://www.littlebits.com/
[2] http://demonstrations.wolfram.com/
[3] http://www.shodor.org/interactivate/activities/
[4] https://www.geogebra.org/
[5] https://www.modrobotics.com/
[6] https://robowunderkind.com/en/

3.2.2. Educational robotics

Educational robotics uses tangible materials to teach a variety of topics, including STEM, literacy, social studies, dance, music and art [50]. Such teaching strategy enhances students' learning experience through hands-on/mind-on activities integrated with technology. Nowadays, a large number of educational robotics tools are available on the market, including LEGO WeDo[7] and LEGO Mindstorms,[8] mBot,[9] Bee-Bot,[10] Ozobot[11] and Dash and Dot.[12] For the younger learners (age below 6 years) educational robotics often focuses on learning the basic programming principles, simple logics and mathematics concepts. Commonly, the creation of both hardware and software parts of a robot encourages children to think imaginatively, stimulates them to analyse situations and applies critical thinking in solving real-world problems.

Ina addition, robots can be involved in teaching and learning social skills [51]. Indeed, robotics activities are usually organised in a collaborative manner, with a small number of students working together to achieve the proposed objectives [52]. Hence, teamwork and cooperation are an integral part of any robotics project: students learn to express their ideas and listen to those of their peers; all can offer arguments and reach conclusions jointly. Students focus on resolving problems for achieving the goals of their projects and learn from their errors on the way.

3.2.3. Game design and coding

Since Papert first introduced the Logo programming language and the 'Logo turtle', coding and developing computational thinking skills have become more and more important in today's world and particularly in education [53]. Mass acceptance is enabled by the availability of programming tools which are appropriate for younger learners. Indeed, several visual programming languages using puzzle-like blocks appeared in recent years, such as Scratch[13], Kodu[14] and Alice.[15] Students focus on learning programming concepts and practise a variety of skills [54], instead of solving syntax problems. Those programming environments, when appropriately integrated in teaching practices, promote exploration, risk-taking and autonomous learning, as well as increase students' motivation [55] and spark students' imagination [56].

3.3. Digital creative pedagogies (DCP)

Based on the literature presented in the previous sections, it is possible to establish a series of characteristic components of DCP, that is, teaching practices which contribute to the development of students' creativity. We organised them into four dimensions:

[7] https://education.lego.com/en-us/support/wedo
[8] https://education.lego.com/en-us/support/mindstorms-ev3
[9] http://www.makeblock.com/mbot
[10] https://www.bee-bot.us/bee-bot.html
[11] http://ozobot.com/
[12] https://www.makewonder.com/dash
[13] https://scratch.mit.edu/
[14] https://www.kodugamelab.com/
[15] https://www.alice.org/

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DCP dimensions	Components
Learning environment	Flexible use of space and time
	Use of the outdoor environment
	Space for exploration and discovery
	Safe and non-judgemental climate
	Connect knowledge to students' life and interests
	Place knowledge in a wider context
Teaching strategies	Inquiry-/project-/problem-based learning
	Collaborative and improvisational practices
	Game-based learning approaches
	Multimodal teaching approaches
Teacher-student interactions	Non-prescriptive planning
	Participation of educators as learners
	Agency-oriented ethos
	Value learning processes above outcomes
	Tolerance of ambiguity and uncertainty
	Promotion of risk-taking and use of failure as a positive learning factor
	Mutual respect, dialogue and negotiation
Digital tools	Manipulative technologies
	Educational robotics
	Game design and coding

Table 1. The components of digital creative pedagogies (DCP).

- *Learning environments* refer to both the physical and organisational aspects of creativity at stage. Among other components, creative learning environments promote exploration and discovery and present few constraints in terms of space and time, as well as provide a safe and non-judgemental climate.
- *Teaching strategies* refer to the approaches and methodologies used by the teacher to reach specific pedagogical objectives. For example, problem-based learning, project-based learning and inquiry-based learning allow for exploring scientific phenomena by fostering students' curiosity. Usually, inquiry processes apply a cycle of learning actions, which do not necessarily occur in a linear sequence, that is, asking questions, proposing hypotheses, investigating those hypotheses, generating new knowledge, discussing results, presenting evidences and reflecting on emerging solutions. This open-ended process engages students in creative problem-solving and evidence-based reasoning. Students learn how to formulate problems into key questions so to get the best possible answers and propose creative solutions.

- *Teacher-student interactions* constitute an essential factor to provide rich learning processes. Indeed, learning occurs in social contexts, and creativity emerges with respectful exchanges which promote risk-taking, tolerate uncertainty, see failure as positive and promote students' autonomy.
- *Digital tools* are instruments which mediate the learning process; they aim to facilitate learners' expression, as well as to extend their possibilities and abilities while carrying a task. Digital tools also enhance manipulation, experimentation or risk-taking, which are key aspects of creativity. As argued earlier, manipulative technologies, educational robotics tools and game design/coding environments are particularly suitable to support digital creative practices.

Table 1 summarises the characteristic components of DCP and their corresponding dimensions.

4. Conclusions

This chapter aimed to embed educational creativity in today's digital society. Based on the seminal theories of creativity and creative education, we proposed an innovative framework for applying creative teaching practices mediated by digital technologies: in the light of constructivist and constructionist approaches, we suggested a series of digital tools which are particularly suitable to the emergence of creativity, i.e. manipulative technologies, educational robotics and game design and coding. Furthermore, we shaped the concept of digital creative pedagogies (DCP) and established a set of characteristic components of teaching practices which contribute to the development of students' creativity. We make the assumption that the application of this framework allows for engaging students in new, personally meaningful processes and in the creation of original outcomes, as well as for enhancing learning in any curricular subject.

The proposed framework highlights four different dimensions of DCP, namely, learning environment, teaching strategies, teacher-student interactions and digital tools. Each of these dimensions is equally important for ensuring the emergence of creative learning processes. Indeed, the use of adequate teaching strategies would allow for fully exploiting the affordances of the selected digital tools. Furthermore, a safe and flexible learning environment, paired with supportive interactions between teachers and learners (and among learners themselves), would create the necessary conditions and balance so that the learning activity takes on its full meaning.

The chapter contributes to linking two key educational research trends: one on creativity and the other on digital technologies. It provides educational practitioners and researchers with concrete strategies and tools for shaping and applying creativity in the digital classroom.

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References

[1] Craft A. Childhood, possibility thinking and wise, humanising educational futures. International Journal of Educational Research. 2013;**61**:126-134. DOI: 10.1016/j.ijer.2013.02.005

[2] Beghetto RA. Creativity in the classroom. In: Kaufman JC, Sternberg RJ, editors. The Cambridge Handbook of Creativity. Cambridge: Cambridge University Press; 2010. pp. 447-463

[3] European Commission. Lifelong Learning for Creativity and Innovation. A Background Paper. Ljubljana: Slovenian EU Council Presidency; 2008. 19 p

[4] Sefton-Green J, Brown L. Mapping Progression into Digital Creativity—Catalysts and Disconnects: A State of the Art Report for the Nominet Trust. Oxford: Nominet Trust; 2014. 147 p

[5] Ferrari A, Cachia R, Punie Y. ICT as a driver for creative learning and innovative teaching. In: Villalba E, editor. Measure Creativity: Proceedings for the Conference, "Can Creativity be Measured?"; Luxembourg: Publications Office of the European Union; 2009. pp. 345-368

[6] Beghetto RA, Kaufman JC. Classroom contexts for creativity. High Ability Studies. 2014;**25**(1):53-69. DOI: 10.1080/13598139.2014.905247

[7] Lin YS. Fostering creativity through education: Conceptual framework of creative pedagogy. Creative Education. 2011;**2**(3):149-155. DOI: 10.4236/ce.2011.23021

[8] European Commission. Initial Teacher Education in Europe: An Overview of Policy Issues. Brussels: European Commission; 2014. 21 p

[9] Sternberg RJ, Lubart TI. Handbook of Creativity. Cambridge: Cambridge University Press; 1999. 493 p

[10] Csikszentmihalyi M. Creativity: Flow and the Psychology of Discovery and Invention. New York: Harper Perennial; 1996. 480 p. DOI: 10.1080/10400419.1996.9651177

[11] Rhodes M. An analysis of creativity. Phi Delta Kappan. 1961;**42**:305-310

[12] Howard TJ, Culley SJ, Dekoninck E. Describing the creative design process by the integration of engineering design and cognitive. Design Studies. 2008;**29**(2):160-180. DOI: 10.1016/j.destud.2008.01.001

[13] Amabile T. The social psychology of creativity: A componential conceptualization. Journal of Personality and Social Psychology. 1983;**45**(2):357-376. DOI: 10.1037/0022-3514.45.2.357

[14] Sternberg RJ, Lubart TI. An investment theory of creativity and its development. Human Development. 1991;**34**(1):1-31. DOI: 10.1159/000277029

[15] Simonton DK. Origins of genius: Darwinian perspectives on creativity. New York: Oxford University Press; 1999. 320 p. ISBN: 978-0195128796

[16] Runco MA, Pagnani AR. Psychological research on creativity. In: Sefton-Green J, Thomson P, Jones K, Bresler L, editors. The Routledge International Handbook of Creative Learning. London: Routledge; 2011. pp. 63-71

[17] Amabile T, Gryskiewicz N. The creative environment scales: The work environment inventory. Creativity Research Journal. 1989;**2**(4):231-254. DOI: 10.1080/10400418909534321

[18] Runco MA. Creativity. Annual Review of Psychology. 2004;**55**:657-687. DOI: 10.1146/annurev.psych.55.090902.141502

[19] Craft A. Little c creativity. In: Craft A, Jeffrey R, Leibling M, editors. Creativity in Education. London: Continuum; 2001. pp. 45-61

[20] Kaufman JC, Beghetto RA. Beyond big and little: The four c model of creativity. Review of General Psychology. 2009;**13**(1):1-12. DOI: 10.1037/a0013688

[21] Sawyer RK. Explaining Creativity: The Science of Human Innovation. 2nd ed. New York: Oxford University Press; 2011. p. 568. ISBN: 9780199737574

[22] NACCCE. All our Futures: Creativity, Culture and Education. London: Department for Education and Employment; 1999. 242 p

[23] Villalba E. On Creativity. Towards an Understanding of Creativity and Its Measures. JRC Scientific and Technical Reports, EUR 23561. Luxembourg: Office for Official Publications of the European Communities; 2008. 40 p. ISBN: 978-92-79-10647-7

[24] Amabile T, Pillemer J. Perspectives on the social psychology of creativity. The Journal of Creative Behavior. 2012;**46**(1):3-15. DOI: 10.1002/jocb.001

[25] Cremin T, Clack J, Craft A. Creative Little Scientists: Enabling Creativity through Science and Mathematics in Preschool and First Years of Primary Education. D2.2. Conceptual Framework: Literature Review of Creativity in Education. Athens: Ellinogermaniki Agogi; 2012. 171 p

[26] Loveless A. Literature review in creativity, new technologies and learning. Bristol: NESTA Futurelab Series; 2002. 36 p. ISBN: 0-9544695-4-2

[27] Ferrari A, Cachia R, Punie Y. Innovation and creativity in education and training in the EU member states: Fostering creative learning and supporting innovative teaching. Luxembourg: Office for Official Publications of the European Communities. 2009. 54 p

[28] Craft A, Cremin T, Hay P, Clack J. Creative primary schools: developing and maintaining pedagogy for creativity. Ethnography and Education. 2014;**9**(1):16-34. DOI: 10.1080/17457823.2013.828474

[29] Davies D, Jindal-Snape D, Collier C, Digby R, Hay P, Howe A. Creative environments for learning in schools. Thinking Skills and Creativity. 2013;8:80-91. DOI: 10.1016/j.tsc.2012.07.004

[30] Barajas M, Frossard F. Mapping creative pedagogies in open wiki learning environments. Education and Information Technologies. 2018;**23**(3):1403-1419

[31] Cremin T, Barnes J. Creativity and creative teaching and learning. In: Cremin T, Arthur J, editors. Learning to Teach in the Primary School (3rd ed.). Abingdon: Routledge. 2014. p. 467-481

[32] Sawyer RK. A call to action: the challenges of creative teaching and learning. Teachers College Record. 2011;**117**:1-34

[33] Lee MR, Chen TT. Digital creativity: Research themes and framework. Computers in Human Behavior. 2015;42(1):12-19. DOI: 10.1016/j.chb.2014.04.001

[34] Loveless A. Creative learning and new technology? A provocation paper. In: Sefton-Green J, editor. Creative learning. London: Creative Partnerships. 2008. p. 61-72

[35] Dewey J. Experience and Education. New York: Collier; 1938. 91 p. ISBN: 0684838281

[36] Kolb DA. Experiential Learning: Experience as the Source of Learning and Development. Englewood Cliffs: Prentice-Hall; 1984. 390 p. ISBN: 9780132952613

[37] Freire P. Pedagogy of the oppressed. New York: Seabury Press; 1974. 186 p. ISBN: 0816491321

[38] Blikstein P. Digital Fabrication and 'Making' in Education: The Democratization of Invention. In: Walter-Herrmann J, Büching C, editors. FabLabs: Of Machines, Makers and Inventors. Bielefeld: Transcript Publishers. 2013. p 203-222

[39] Jordan A., Carlile O, Stack A. Approaches to Learning: A Guide for Teachers: A Guide for Educators. Maidenhead: McGraw-Hill Education; 2008. 296 p. ISBN: 0335226701

[40] Craft A. Creativity in schools: tensions and dilemmas. London: Routledge; 2005. 224 p. ISBN: 0415324157

[41] Ackermann E, Gauntlett D, Wolbers T, Weckstrom C. Defining systematic creativity in the digital realm. Billund: LEGO Learning Institute; 2009. 58 p

[42] Kafai B, Burke Q. Connected Gaming: What Making Video Games Can Teach Us about Learning and Literacy. Cambridge: MIT press; 2016. 224 p. ISBN: 9780262035378

[43] Moyer PS. Are we having fun yet? How teachers use manipulatives to teach mathematics. Educational Studies in mathematics. 2001;47(2):175-197. DOI: 10.1023/A:1014596316942

[44] Miglino O, Di Fuccio R, Di Ferdinando A, Barajas M, Trifonova A, Ceccarani P, et al. BlockMagic: Enhancing traditional didactic materials with smart objects technology. In: Proceedings of the International Academic Conference on Education, Teaching and E-learning. Prague: MAC Prague consulting Ltd; 2013. ISBN: 978-80-905442-1-5

[45] Di Ferdinando A, Di Fuccio R, Ponticorvo M, Miglino O. Block magic: a prototype bridging digital and physical educational materials to support children learning processes. In: Uskov V, Howlett R, Jain L, editors. Smart Education and Smart e-Learning. London: Springer. 2015. p. 171-180. DOI: 10.1007/978-3-319-56538-5

[46] Faris, M, Blick A, Labriola J, Hankey L, May J, Mangum R. Building Rhetoric One Bit at a Time: A Case of Maker Rhetoric with littleBits. 2018. Available from: http://kairos.technorhetoric.net/22.2/praxis/faris-et-al/ [Accessed: 2018-07-19]

[47] Moyer-Packenham, P, Westenskow A. Effects of virtual manipulatives on student achievement and mathematics learning. International Journal of Virtual and Personal Learning Environments. 2013;**4**(3):35-50. DOI: 10.4018/jvple.2013070103

[48] Correll, N, Wailes C, Slaby S. A One-hour curriculum to engage middle school students in robotics and computer science using Cubelets. In: Ani Hsieh M, Chirikjian G, editors. Distributed Autonomous Robotic Systems. Berlin: Spinger; 2014 p. 165-176

[49] Gross M, Veitch C. Beyond top down: Designing with cubelets. Tecnologias, Sociedade e Conhecimento. 2013;**1**(1):150-164

[50] Eguchi, A. Robotics as a learning tool for educational transformation. In: Proceeding of 4th International Workshop Teaching Robotics, Teaching with Robotics & 5th International Conference Robotics in Education. 18 July 2014; Padova. p. 27-34

[51] Ray B, Faure C. Mini-robots as smart gadgets: Promoting active learning of key K-12 social science skills. In: Ali Khan A, Umair S, editors. Handbook of Research on Mobile Devices and Smart Gadgets in K-12 Education. Hershey: IGI Global; 2018. pp. 16-31. DOI: 10.4018/978-1-5225-2706-0.ch002

[52] Denis B, Hubert S. Collaborative learning in an educational robotics environment. Computers in Human Behavior. 2001;**17**(5-6):DOI:465-480.10.1016/S0747-5632(01)00018-8

[53] Bers MU. Coding as a Playground: Programming and Computational Thinking in the Early Childhood Classroom. London: Routledge; 2017. 196 p. ISBN: 978-1138225626

[54] Lye S, Koh J. Review on teaching and learning of computational thinking through programming: What is next for K-12?. Computers in Human Behavior. 2014;**41**:51-61. DOI: 10.1016/j.chb.2014.09.012

[55] Fowler A, Cusack B. Kodu game lab: improving the motivation for learning programming concepts. In: Proceedings of the 6th International Conference on Foundations of Digital Games; 28 June-01 July 01 2011; Bordeaux. p. 238-240

[56] Tsur, M, Rusk N. Scratch Microworlds: Designing project-based introductions to coding. In: Proceedings of the 49th ACM Technical Symposium on Computer Science Education; 21-24 February 2018; Baltimore. p. 894-899