Thematic Article

Digital Creativity Development in an E-learning Environment – A 3D Design Project

Gábor Klima[1], Andrea Kárpáti[2]

Recommended citation:

Klima, G., & Kárpáti, A. (2021). Digital creativity development in an e-learning environment – A 3D design project. *Central European Journal of Educational Research, 3*(3), 49–54. https://doi.org/10.37441/cejer/2021/3/3/10016

Abstract

During the pandemic, arts disciplines had to seek new paths for creation to continue visual skills development outside the studio. ICTs offer a natural tool set for individual and collaborative work and sharing online. 3D design and the development of digital creativity can represent new directions for Hungarian art education and its major discipline called Visual Culture. With this tool, visual art education can proceed on the bumpy road to teach the visual language of the 21st century. Certainly, technological focus is not the only option for progress in art education. Nevertheless, if we look for possible directions for renewal, we cannot ignore the use of software products that support visual creativity,and are becoming more and more easily available, simpler and free of charge. This paper focuses on the pedagogical possibilities of 3D printing. We present an experimental program with secondary school students aged 16 years, that started and ended face–to–face and was partly ealized online. As the project manifests a creative synergy of Visual Culture and Information Technology disciplines that may be of interest for art and ICT educators as well.

Keywords: visual art; art education; 3D education; digital creativity; distance learning; creativity development; 3D printing

---

Introduction

Theoretical framework

The 3D project presented here builds on the STEAM educational model. Arts have been integrated in the long-standing synergy of STEM disciplines (Science, Technology, Engineering and Mathematics) to open up new trajectories for creative problem solving. STEAM involves the arts through Design Thinking (Doorley et al., 2018), a human-centered problem solving process that designers utilise to observe existing and future needs, model potential solutions, test them with potential users and modify concepts and products according to their experiences. Usage of the finished product is also observed, as it inspires designers (scientists, engineers, businessmen) to perfect their solution or come up with a new, improved idea that restarts the Design Thinking process. The model has been adopted by some of the world's leading brands, (Apple, Google, Samsung and GE, etc.) and is being taught at the faculties of science and business, as well as arts and design, at leading universities, including Stanford (from where the model originates, cf. Brown, 2008), Harvard and MIT. Apart from scientific visualisations that may lead to new discoveries, this user-centered approach for identifying and solving problems is the most important contribution of the arts to STEAM methodology (Cheska, 2017; David, 2016).

When faced with the challenges of online education that prevented students from developing their artwork in a studio setting, where they are inspired by the support of their teacher and remarks of their peers, we decided to develop a design program that can be realised online, that develops the same skills as classroom activities. The STEAM model has rarely been used in public education so far, but first results are encouraging (Hegedűs et al., 2016). The interdisciplinary approach was proven to enhance basic workplace skills like spatial abilities and visual communication of science concepts (Bush et al., 2018). STEAM pedagogy is technique and

[1] Eötvös Loránd Tudományegyetem, Budapest, Hungary; klimagabo@gmail.com
[2] Corvinus University Budapest, Hungary; andrea.karpati@uni-corvinus.hu

technology dependent, but the majority of experiments also involve aesthetic considerations in the design and construction of objects (Plonczak, et al., 2015; Schramm, 2000). Therefore, the model can smoothly be integrated in art education.

Integration of ecologically and socially conscious art education practices with science disciplines has become a major international trend (Jacobson et al., 2016). Integration of social issues in art education has become an urgent necessity in our times (Knochel, 2013; Errázuriz, 2019). As conceptual art forms have become dominant at the end of the 20th century, visual arts education has become one of the most important pedagogical areas for the practice of critical thinking, taking responsibility, social sensitivity and sensitization (Graham, 2007; Lucero, 2016). The Design Thinking model that is often integrated with the STEAM approach is human centered and socially sensitive. As art education curricula, integrate visual culture with "high arts," critical pedagogy that reflects on and sensitizes for social problems and is related to social design (Baldacchino, 2012) became an important inspiration for selecting areas of study. Visual culture is a curriculum design strategy that integrates everyday visual language with artistic expression in the curriculum (Kárpáti et al., 2016).

Integration of arts and science disciplines may result in new methodological approaches in art education. During the pandemic, a holistic approach to social issues, involving research─based understanding of the COVID pandemic and artistic expression of emotional growth, have become crucially important learning objectives. Online learning intensified the need for digital creativity: tools of expression that may be practiced with the help of ICTs at home or in class (Stokrocki, 2014). The new National Core Curriculum of "Visual Culture," the Hungarian discipline for art education, issued in 2020, integrates media literacy with the development of visual competencies. There are very few research based educational programs available in this area yet, so the project presented here does not only manifest a methodology to be used in online art education during a pandemic situation, but offers a model for the synergy of ICTs and the arts.

3D technology is an emerging field in science, engineering, medicine, archeology and history just to mention a few STEAM–related areas of application that are relevant for the project discussed here. 3D visualisation supports the development of both digital and visual literacy and thus offers new, open-ended, expressive tasks for the integration of ICTs and Visual Culture. The content of the tasks and projects can involve any thematic areas that enable the creative application of digital technology. 3D modelling helps archeology and history to provide faithful reconstructions of partially damaged objects and buildings. Imaginary 3D portraits of important personalities of the past, based on historic facts and images, serve the authentic reconstruction of historic events (Forte, 2014; Sanders, 2014). In mathematics, modelling of theoretically conceived objects yields important new insights (Leszczynski et al., 2017). Through 3D printing, we can visualise geometric shapes and show resection, completion and other shape changes.

3D design embedded in the program of the Hungarian discipline for art education, called Visual Culture, can be interpreted as a digital creativity development program that simultaneously focuses on the integration of science and the visualization of social processes. This methodology can serve as a model for the creation of a new pedagogical paradigm, where Visual Culture introduces the element of aesthetics in science and mathematics education.

The relevance of 3D technology for the arts

An important function of Visual Culture as a school discipline is to introduce contemporary artistic and cultural phenomena. The use of 3D design is a relatively new phenomenon in the visual arts. It is enough to think of 3D visualisation rendering in architecture and interior design as well as object design. Works of visual communication may also contain 3D images. Conceptual media art also uses 3D design and seeks and expands its boundaries. Contemporary artists embrace technology more and more intensively. Augmented and Virtual Reality artistic avatars in an imaginary digital environment have been accepted creative options for decades.

An inspiring example for the use of 3D printing in contemporary art is the Nimoca Project, an intermedia creation by the Hungarian conceptual artist Veronika Romhány (https://www.nimovaprojeckt.org/). Romhány created an imaginary world including fragments of real-life objects printed in 3D. Her creative use of tangible materials as well as digital images project a reality where virtual and hands-on imagery is juxtaposed, re-creating our 21st century reality.

Creative use of 3D printing is at the crossroads of sculpture and design, art and technology. A recent creative software called ZBrush combines 2D and 3D design technology and supports collaboration in a virtual space called 2.5D. Rudolf Béres, a Hungarian artist who identifies himself as a digital sculptor, employs this technology for animation film character design (https://www.artstation.com/brud). As ZBrush supports virtual collaboration, the educational potentials of this technique should be exploited for a simultaneous development of painting and sculpting skills.

The best known example for collaborative play that develops design skills is Minecraft. This community-based gaming environment of the Swedish Mojang Studios first launched in 2009. With 125 million registered users per month (as of 2020), this software is the most popular gaming application that promotes 3D design. The software platform has been expanded with an educational subpage (https://education.minecraft.net/it-it/homepage). One of the important educational benefits of Minecraft is that it teaches the basics of 3D design and, given its immense worldwide appeal, contributes to the development of an important area of digital literacy. This program focuses on young users, but also has a high adult player base (average age: 24 years, cf. https://www.pcgamesn.com/minecraft/player-age). For art educators, Minecraft is an asset: a popular game that enhances basic design skills in a current technological environment. STEAM educators have embraced this potential and examples of successful use – predominantly in mathematics education (Boss et al., 2014). Good results encourage us to consider its integration in art education and further develop suggestions published on the software's educational platform (https://education.minecraft.net/content/minecraft-edu/language-masters/en-us/resources/art-and-design-subject-kit.html).

A 3D design project for STEAM learning

ICTs are rarely utilised in primary and secondary level art education, as school principals and parents still consider creativity and machine-created imagery incompatible. Artists, however, have been using digital tools for their creations for decades (Wood, 2004). Art studios at schools are generally ill equipped with computers that meet the requirements of graphic software, so most art education projects published utilise smartphones (e. g. De Arriba et al., 2020). Smartphone technology is a good starting point for experimenting with digital creation, but the pandemic taught art educators to explore new toolsets and creative methods to continue offering similarly high quality art and design education online as in the art studio.

The first author of this paper planned and executed a five-week experimental program with secondary school students. When he started planning a project for the acquisition of the basics of 3D design, the computer lab of the school was still a possible venue for teaching and learning.

The classes involved in the experiment were mathematics and science departments, with a total of 63 students. The participating students were 15–16 years old (ninth grade, secondary school) at the time of the program. In the two classes, the gender distribution is balanced; in both cases there are more boys than girls, but the difference is not significant. As the institutional average is 4.75 (2019 data), the class averages do not differ significantly from this either. The socio-cultural background of the students is the so-called urban middle or urban upper middle class. The institutional background of the experiment is one of the strongest secondary schools in the country. The teacher was able to rely heavily on students' high mathematics, comprehension and digital competencies, as expected. Students' prior knowledge of 3D design was assessed in the form of an online question. Based on this, it seemed that no negative surprises should be expected regarding the use of software or digital competencies.

Most 3D design applications are not available for smartphones, and the major objective of the 3D project – teaching a set of skills that will be important for many professions in the coming decade - could not be realised through these relatively simple devices. The other option was inviting students to realise their designs at home, using their own PCs or laptops, and print their work at school, using the 3D printer that many thousand educational institutions in Hungary had been furnished with in 2019–20. This second option soon turned out to be the only one - when the pandemic reached Hungary and schools had to turn to online education. We hoped that the designs of the students, executed with the help of teacher mentoring would be successfully realised and, after the reopening of schools for face–to–face education, printed and discussed in the art studio.

Tinkercad (https://www.tinkercad.com), a free, easy-to-use web application is a browser-based program developed for educational use. Through digital control functions, teachers can follow the students' online design and creative workflow in real time and offer mentoring remarks if necessary. Its interface is simple, ideal for school use. Another advantage is that it is optimized for both smartphones and tablets, so teachers can use it in the art studio. When installed on smartphones, the user experience is obviously less satisfactory, but still enjoyable. Students may continue working on their designs at home. Flexibility of use was a big advantage during the pandemic. Students used their computer to design their objects or buildings, and their smartphone to animate the characters they designed to populate the buildings with the Stop Motion Studio application.

The designs of students were printed with 3D printing. Thousands of Hungarian schools are already furnished with this equipment through the 3DTech for Schools project launched in 2017 in Hungary. However, 3D design projects can be successful even without a printer to show their work in reality, as the design process itself develops spatial imagination and composition skills. If 3D printing technology is available, we can increase the developmental effects to the task and enhance an important workplace skill: spatial manipulation as well. Digital literacy is also developed through the inclusion of another exciting ICTs–based application: animating the objects through stop motion animation technique. This technology has been used regularly in Hungarian art education for a decade and in this project, but our experiment is the first effort to integrate it with 3D design.

Assessment of project results

Assessment of projects in art education is generally based on face-to-face discussion of student work or the portfolio of individual students or groups. Both of these assessment methods require a set of predefined criteria that the teachers share with the class when assigning the project tasks. Complete with research notes about the project theme, sketches and plans, and presented by the student as part of the assessment process, a portfolio does not only communicate what has been learnt, but provides evidence about the level of understanding of the tasks and the quality of the work process (Boughton, 2005). Portfolios are often assessed by outside reviewers or other students. Student self-assessment is also an important component in the portfolio process.

During the online education period, portfolio assessment could not be used, as many phases of the usual project procedure (research about the theme, modelling the task, testing the model with peers, etc. could not be organised. Therefore, student learning could only be evaluated through presentations. Students showed their work online, supported by PowerPoint slides. The checklist developed for the assessment of the project tasks was explained and students were invited to discuss the criteria and present their work with self-evaluation. Sharing their screens in the Google Classroom online learning environment, young creators were able to identify strengths and weaknesses of their designs. During the pandemic, students had more time to develop their ideas, and the general level of 3D designs realised in the Tinkercad software environment was higher than that of similar planning tasks, executed in the art studio or the school computer lab before.

Students returned to school for the last three weeks of the second term of the school year of 2020/2021. In the last two phases of the project, 3D designs were printed and discussed. The teacher and the class met in the classroom and compared the designs with the 3D prints of the buildings and the characters (human figures, animals, alien creatures etc. inhabiting or using the edifice for other purposes. Here, self, peer and teacher assessment could be performed and debated about the design idea, and planning and filming (stop-motion film about the building and its user) could be organised.

Assessment criteria for the design of the building and its user involved technical and creative criteria was developed as well. Technical assessment involved the level of Tinkercad software use. Creative solution assessment included the aesthetic quality and originality of the work. We did not assign grades but employed a "soft" narrative feedback methodology. (A general characteristic feature of assessment during pandemic: teachers were more benevolent when judging student performance, cf. People for Education, 2020).

Due to the school lockdown, assessment was restricted to the final product, and the creative process was only presented through the narrative of the young creator. Here, we realised the major handicap of the school lockdown: the teaching process was restricted to online mentoring, like in an evening course for adults. 16 – year – old secondary school students, however, need more encouragement and critique during the realisation of a complex design project. On average, student works were better than before. More time was available for developing ideas during school closure, and also the urge to create – and escape the boredom of isolation – yielded more sophisticated and technically more elaborate solutions. However, those who have difficulties with the visual language, lagged behind. In a face–to–face classroom environment, their problems would have been disclosed by them or realised by the teacher soon, and individual tutoring would have been installed from the start.

Of the 63 students, everyone made their 3D plans during distance learning. Quality and creativity ranged widely, but the digital design phase of the project was rated excellent by all students. Using the method of positive motivation, we wanted to encourage performance and provide encouragement to students. Since it was a pilot program, the teacher also studied together with the students, like in a visual learning group (Kárpáti et al., 2016).

Male students generally produced higher quality work. Research has shown that at this age, girls spatial thinking and creativity, as well as their spatial visual expression, develop differently than those of boys (Babály et al., 2016). We have seen this confirmed in the students' works. According to their own statements, they took an average of 1–2 hours to make 3D plans.

Discussion: Educational relevance of the project

The development of spatial creation and perception is an important goal of teaching visual culture. 3D design has obvious points of connection with science disciplines and mathematics. In collaboration with teachers of mathematics, for example, we can develop projects that enhance students' visual creativity and, at the same time, support knowledge acquisition in geometry – an area of mathematics that can be taught more effectively through the integration of 3D visualisation.

The other educational area we targeted during the program was sensitization to social problems. We asked students to consider such issues when creating their fictional world. An important problem area in city planning is the integration of inhabitants coming from different cultures and create spaces for community cohesion development. Students reflected on these problems through planning a multicultural playground and a football stadium complete with community areas. As a first step in the development of the experimental program, we focused on getting to know and using technology. Social relevance of architectural design can be strengthened through a more pronounced project theme.

The technical and technological renewal of international art education seeks to integrate the visual language of the 21st century into more and more thematic areas of the art and design curriculum. Introducing aesthetics, digital creativity tasks complement existing classroom practices with new technologies. The changing media landscape of our age challenges art education as new visual technologies need to be integrated into classroom practices.

3D technology can be a motivating tool for the art teacher to use. The project presented in this paper shows its potential in the development of visual and digital creativity.

Acknowledgments: We thank Victoria Congdon for the English language editing. Her work was supported by the Central Connecticut State University, America.

References

Babály, B., & Kárpáti, A. (2016). The impact of creative construction tasks on visuospatial information processing and problem solving. *Acta Polytechnica Hungarica, 13*(7), 159–180.

Baldacchino, J. (2012). *Art's Way Out: exit pedagogy and the cultural Condition.* Rotterdam: Sense.

Bos, B., Wilder, L., Cook, M., & O'Donnell, R. (2014). Learning mathematics through Minecraft. *Teaching Children Mathematics, 21*(1), 56–59.

Boughton, D. (2005). From fine art to visual culture: assessment and the changing role of art education. *International Journal of Education through Art, 1*(3), 211–223. https://doi.org/10.1386/etar.1.3.211/1

Bush, S., Karp, K., Cox, R., Cook, K., Albanese, J., & Karp, M. (2018). Design Thinking Framework: Shaping Powerful Mathematics. *Mathematics Teaching in the Middle School, 23*(1), 1–5. (electronic publication). https://doi.org/10.5951/mathteacmiddscho.23.4.00e1

Brown, T. (2008). Design Thinking. *Harvard Business Review*. https://reading.design/PDF/Tim%20Brown,%20Design%20Thinking.pdf

Cheska, R. (2017). Add more STEAM to your classes. *Science Scope, 41*(1), 18–22.

David, G. (2016). Dewey from STEM to STEAM. *Education and Culture, 32*(2), 1–3.

De Arriba, R., & Vidagañ, M. (2020). Sharing Drawings with Smartphones in the Classroom – Art–Based Education in Social Sciences. *International Journal of Emerging Technologies in Learning (iJET), 15*(15), 229–232. https://doi.org/10.3991/ijet.v15i15.14259

Doorley, S., Holcomb, S., Klebahn, P., Segovia, K., & Utley, J. (2018). *Design Thinking Bootleg*. Stanford School of Design. https://dschool.stanford.edu/resources/design-thinking-bootleg

Errázuriz, L. (2019). Metamorphosis of visual literacy: From 'reading images' to a critical visual education. *International Journal of Education Through Art, 15*(1), 15–26.

Forte, M. (2014). 3D Archeology. New perspectives and challenges – The example of Chatalhöyük. *Journal of Eastern Mediterranean Archaeology & Heritage Studies, 2*(1), 1–29.

Graham, A. M. (2007). Art, ecology and art education: Locating art education in a critical place-based pedagogy. *Studies in Art Education, 48*(4), 375–391.
Greenstein, S., Leszczynski, E., & Fernández, E. (2017). 3D Designing for Mathematical Learning. *Mathematics Teaching in the Middle School, 23*(1), 50–53.
Hargittai, E. (2010). Digital na(t)ives? Variation in Internet skills and uses among members of the 'Net generation. *Sociological Inquiry, 80*(1), 92–113.
Hegedus, T., Segarra, V. A., Allen, T. G., Wilson, H., Garr, C., & Budzinski, C. (2016). The Art-Science Connection: Students create art inspired by extracurricular lab investigations. *The Science Teacher, 83*(7), 25–31.
Helsper, E. J., & Eynon, R. (2010). Digital natives: where is the evidence? *British Educational Research Journal, 36*(3), 503–520.
Jacobson, S.K., Seavey, J. R., & Mueller, R.C. (2016). Integrated science and art education for creative climate change communication. *Ecology and Society, 21*(3), Art. 30. http://dx.doi.org/10.5751/ES-08626-210330
Kárpáti, A., Freedman, K., Heijnen, E., Kallio-Tavin, M., & Castro, J. C. (2016). Collaboration in Visual Culture Learning Communities: Towards a Synergy of Individual and Collective Creative Practice. *International Journal of Art & Design Education, 36*(2). 164–175. https://doi.org/10.1111/jade.12099
Knochel, A. (2013). Assembling Visuality: Social Media, Everyday Imaging, and Critical Thinking in Digital Visual Culture. *Visual Arts Research, 39*(2), 13–27.
Lucero, J. (Ed.) (2016). *Mere and Easy*: *Collage as a critical practice in pedagogy.* Illinois: University of Illinois Press
Milgrom–Elcott, T. (2019). When STEM becomes STEAM, we can change the game. *Forbes*, Retrieved November 7, 2019, from https://www.forbes.com/sites/taliamilgromelcott/2019/11/07/when-stem-becomes-steam-we-can-change-the-game/?sh&329676736905
People for Education (2020). To grade or not to grade: Assessment in a Pandemic. *Blog entry*, Retrieved April 29, 2020, from https://peopleforeducation.ca/our-work/10745-2/
Plonczak, I., & Zwirn, S. G. (2015). Understanding the art in science and the science in art through crosscutting concepts. *Science Scope, 38*(7), 57–63.
Schramm, S. L. (2000). Genetic Robots: An Integrated Art and Biology Curriculum. *Art Education, 53*(3), 40–45.
Sanders, D. H. (2014). Virtual Heritage. Researching and visualizing the past in 3D. *Journal of Eastern Mediterranean Archaeology & Heritage Studies, 2*(1), 30–47.
Stokrocki, M. (Ed.) (2014). *Explorations in Virtual Worlds: New Digital Multi-Literacy Investigations for Art Education.* Reston: National Art Education Association
Wood, J. (2004). Open minds and a sense of adventure: How teachers of art & design approach technology. *International Journal of Art & Design Education, 23*(2), 179–191.