STEM+ARTS=STEAM Skills: Innovation Management and Scratch Programming for Year 4 Students

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Abstract: Nowadays, world economic success and well-being require new industries to appear. Technology, Engineering, and Mathematics (STEM) provide tangible solutions towards this direction with STEM introduced in cross-curriculum activities. However, when working in Primary Education, STEM is not enough; Arts and Design (STEAM) can introduce fun, surprise, curiosity, teamwork, co-creativity and innovation. STEAM intervention was conducted with Year 4 students at the 6th Primary School of Patras for one year. Initiated within the Flexible Zone hours, STEAM skills development was anchored in Bruner’s proposition: anything can be taught at any age if delivered correctly. STEAM advanced concepts were taught for Innovation Management and Programming with Scratch using metaphors and practical examples. Art was approached via Design Thinking within the Zone of Proximal Flow. The creative classroom activities were orchestrated based on Computer Supported Collaborative Creativity and Learning (CSCC/L) The 10 years old students produced innovations and a Scratch game by having fun, innovating and learning together.

Keywords: STEAM, Design Thinking, Zone of Proximal Flow, Scratch, Innovation Management

Design Thinking + Hybrid Synergy
Teachers play a significant role stimulating children's curiosity, imagination and willingness to experiments, helping them develop the transversal competences required for creativity and innovation, such as critical thinking, problem-solving and initiative-taking. Following Piaget (1988), the principle goal of education in the schools should be creating men and women who are capable of doing new things, not simply repeating what other generations have done; men and women who are creative, inventive and discoverers, who can be critical and verify, and not accept, everything they are offered. Be one with the universe, and so very identical to it that he does not even feel the need for two terms. The purpose of education is to facilitate thinking and problem solving skills so to be transferred to a range of situations, also developing symbolic thinking by discovery learning; students construct their own knowledge for themselves (constructivist approach) (Bruner, 1960, 1961). According to Csikszentmihalyi (1996, 1990), the secret to happiness is to be in the creative flow state. Hence, there can be an interdisciplinary field where students can be creative and happy achieving the optimal experience in education.

This field is STEM (Science, Technology, Engineering, and Mathematics); but STEM is not enough. It is also essential to support young students’ group experience, fun, creativity, curiosity and innovation. Such elements exist in STEM with Arts and Design via collaborative learning environments. STEAM skills development stands on Bruner’s proposition that anything can be taught at any age if delivered correctly. Design thinking is a
method for creative action and was adapted for solution and user driven approaches. Design thinking employs creativity techniques for idea generation (Eureka moments) and evaluation.

Anchored in Design Thinking, 26 Year 4 students were introduced to advanced concepts in Innovation Management and Scratch Programming. Time was essential in both activities as innovation management requires scheduling and as the students entered a competition with Scratch with deadline the end of March 2015. Hybrid Synergy creativity technique activated both left and right brain hemispheres (LBH, RBH). LBH is objective, analytical, logical and classical; RBH is more informational, holistic, continuous, patterns, gestalt capturing and subjective. In reality, both L/RBH functionalities make our abilities and competencies move from an individual self-perception to a more unified perception of our world (Kounios & Beeman, 2015). Hybrid Synergy (Lambropoulos et al., 2008) is a creativity technique that synthesised De Bono’s thinking hats (2000) and critical thinking levels.

Hybrid Synergy is a 5levels non-linear analytical framework that facilitates and enhances e-learners’ metacognitive awareness. Hybrid Synergy levels enhancing critical thinking are: information provision; social inferences; ideas exploration; ideas evaluation; and overviews, summaries and task allocations. These levels are nonlinear and not predetermined. Both parts of our brains can function as a unity much faster providing more accurately perception of reality so to respond to a need or a problem. In this way, cognitive plasticity and flexible learning embraces ambiguity, requiring creativity competencies on-the-spot dealing with rapid changes in information, knowledge, signification and meaning. Furthermore, the students were acquiring new competencies as the projects were developing.

Art + Creativity in the Zone of Proximal Flow (ZPF)

Innovation and learning can be collaborative experiences mixing ‘older’ and more experienced with ‘younger’ students. Knowledge acquisition and symmetry in groups
converge and align asymmetrical interactions between learners and more capable peers, the Zone of Proximal Development (ZPD, Vygotsky, 1978; Dillenbourg, 1999). Creativity is a combination of personal interest and a sense of discordance in the environment, and thus the creative process is a search for interest and novelty by changing the environment to reduce discordance (Martindale, 1990). Flow happens when a person in an activity is fully immersed in a feeling of positive energized focus, full involvement, and success in activity. Ultimate individual or group performance occurs when harnessing the emotions and positively enhanced, channeled, energized, and aligned with the task to promote ultimate learning and performing. Creative flow is a crucial source of internal rewards for humans; it is the self-engagement in activities which require skills just above their current level. Thus, exploratory behaviour is explained by intrinsic motivation for reaching situations with a learning challenge. Internal rewards are provided when a situation which was previously not mastered becomes mastered within an optimum amount of time: the internal reward is maximal when the challenge is not too easy but also not too difficult. There are 10 factors to promote the creative flow (Csikszentmihalyi, 1996, 1990):

1. Clear goals where the challenge level and skill level should both be high
2. Concentration and focused attention
3. Loss of feeling
4. Distorted sense of time as in immersion
5. Direct and immediate feedback
6. Balance between ability level and challenge (the activity is neither too easy nor too difficult)
7. Sense of personal control over the situation or activity
8. The activity is intrinsically rewarding, so there is an effortlessness of action
9. Lack of awareness of bodily needs, and
10. Absorption into the activity.

The Zone of Proximal Flow (ZPF, repenning, 2012; Basawapatna et. al, 2013) is the area where Creative Flow occurs within ZPD. Learners’ interest and engagement counteract the anxiety experienced; however, for learners to experience ZPF for an enhanced learning experience, immersion is required. Thus, capturing attention for deep engagement facilitates students’ involvement in mental creative flow states. In this case, Design Thinking and ZPF needed an innovative pedagogical approach: Computer Supported Collaborative Creativity and Learning (CSCC/L). Individualised learning based on talent management (Robinson, 2009; Coyle, 2009) with direct observation of the students was also a major part of such study as the +U approach: adding own talents, characteristics and personality traits as complementary skills in each team.

**Computer Supported Collaborative Creativity + Learning for STEAM**

Collaborative learning (by UNESCO n/d )takes place when learners work in groups on the same task simultaneously, thinking together over demands and tackling complexities. Collaboration is here seen as the act of shared creation and/or discovery. Anchored in constructionism, Computer Supported Collaborative Creativity and Learning (CSCC/L,
Lambropoulos & Romero, 2015; Dillenbourg et al., 1996) different group members work on different parts of the project that are brought together, also working all together in all project parts for coherency. CSCC/L provided the learning convergence techniques for orchestrating the educational activities: the macro script related to the Jigsaw Puzzle technique and teaching styles; and the micro script for team communication with Hybrid Synergy dialogues, revolved around generative topics; in this case, Innovation Management and Scratch Programming. The target was to enhance students’ STEAM competencies in action. Teaching by generative topics is open without strict use of resources so both the students and the teachers can explore the subject to their interest. Thus, different techniques and methods were tried out for the best practices to appear for the specific context and situation, also expanding it to students’ own context such as programming in their own time for their own purposes. Such synthesis of formal and informal learning, and also, onsite and online simultaneously, occurred within the IT Room, donated by Niarchos Foundation.

The combination of real life projects requires STEAM inter-being, evident in the necessity of a range of disciplines and capabilities. The students were organised in small teams to build specific and common purposes and targets, share responsibility, measure their progress, synthesize their complementary skills, agree on the norms and rules, agree on practices and processes to follow for a successful project to mention a few. Specific theoretical and onsite team building approaches were employed as leaving the students decide the teams on their own failed dramatically. Team projects were built on: (a) team culture, the leverage of expertise of others based on everyone’s expertise and advance on others; (b) the shared desire and meaningful ideas to each member; (c) each member’s significant contribution; (d) a wide spectrum of expertise; and (e) students’ full brain utilisation and imagination in a very short period of time. Team creative flow also required the students to resolve any conflicts, work towards team project realisation, acknowledge each other’s abilities and skills, build relationships of trust and support; otherwise they realised the projects would fail.

**Generative Topics for STEAM**

**Innovation Management**

Innovation Management is the process of implementing an innovative idea in the real world. Briefly, the stages are: idea generation, idea evaluation and selection, recognise opportunities and challenges, idea realisation and evaluation, innovation product for display. More specifically:

1. Idea Generation: The students utilised the Hybrid Synergy technique. They worked in groups following the creativity process (Wallas, 1926): (a) Preparation: problem identification, gathering relevant information and their analysis (b) Incubation: positive treatment of the problem, quantity and originality of ideas, suspension of critical process, cross-fertilization of ideas, stimulate new ideas, enthusiasm and acceptable mental status (c) Illumination: maturation of an idea after a reasonable period of time and through the subconscious ideas as the Eureka moment; (d) Verification: evaluate and verify the best idea for implementation.
2. Idea evaluation and selection: The students, working in teams, had to choose the best idea for implementation based on specific quality criteria they had to settle for the project.

3. Recognising opportunities and challenges: The ideas the teams agreed were: Trojan Horse (play and clean the floor simultaneously to help your mum), Flying City (an ecological city above the ground), Robotokton (a robot that gathers and kills rubbish in the neighbourhood), Recycle Ship (a ship that recycles rubbish in the sea), Lancer Evolution (a robot that waters the plants on the earth or the house), and the Mechanic Animal (Μηχανόζωο, robot that protects all plants and animals from extinction).

4. Idea realisation and evaluation: The students finalised their innovations and team-to-team evaluation took place, exchanging ideas and comments for improvement.

5. Innovation product for display and marketing: The students produced posters and flyers about their innovations. They also presented them in front of the school block of the 6th and 19th Primary School students and teachers, and also parents. Lastly, there were presentations into different classrooms and YouTube recordings.

Some students comments were: ‘Almost from the beginning of the school year we were dealing with innovations, it was about time to create three-dimensional ones. I was surprised with our fantastic and great innovation! Nothing went wrong because we worked nicely together.’ (Eftixia, Flying City). ‘I was impressed when we constantly disagreed and agreed again so we finally created a very beautiful building. It is small and simple, but I believe it will teach others to love the nature! (Diana, Flying City). ‘I was impressed we built a big robot. I was very happy we managed such a big project and I hope to do again so we have perfect time and also show our abilities!’ (Dora, Robotokton). We created incredible innovations for environmental protection together! With my team, we made a horse that cleans the environment while playing. Our materials were simple, glue, wood, wheels, glass for the eyes, sensors and a sponge for the horse tail. (Nicholas, Trojan Horse).

**Scratch Programming**

Education today cannot be separated with the ICT based activities. Teaching programming languages to kids influences their way of thinking while personal fulfillment and development is achieved. Code Club volunteers were all students in the Department of Computer Engineering in University of Patras (Anyfanti et. al, 2015). For each lesson the teachers showed all the pupils what they would do next - on a whiteboard - or playing it at the front of the class. Then they go to work in pairs at the computers, trying to achieve the same task using Scratch. By the end of the educational year, the students could create their own games and debug their own programs utilising technology safely and respectfully. The Jigsaw Puzzle technique. This game development led the slitting of the class into 4 teams: Coding, Drawing, Sound and Script Creative Writing. Concerning programming as such, the students successfully identified, solved and implemented a number of increasingly complex logical, organizational and even cross-specialty problems. They worked on some core values of programming (both serial and object-oriented), from loops and if clauses, to objects working in parallel and event send and handling. Theory was explained via examples both in-code and using little games. Spatial representation was also played onsite following the classroom axes.
to explain x and y axes on Scratch. The steps on the floor represented the coding numbers on the interface.

During the first meeting with the Code Club volunteers there were team building techniques such as 'catch the ball' and introducing themselves, what they do and interests. Also, an agreement on norms and behaviours was established. As for a class project in order to participate in a major national competition on Scratch in March 2015, the students agreed to participate. During the first class project meeting the students were split into two groups selecting a different project game, the circus and the cemetery. Such division created a major competitive climate in the classroom so we, the teachers, decided to change methodology. For this we utilised the Jigsaw Puzzle CSCL technique build upon the game development real expert roles as in the industry.

A new project called The Mystery House combined the previous teams’ ideas. Students’ complementary and successful participation was ensured, also targeting at the acknowledgment that one groups cannot work without the other. In the initial Game development stages, the decision was upon a haunted house in which the player has to follow clues in hopes of finding the hidden treasure. The students were voluntarily participated in 4 teams: Code-Programming, Visual-Drawing, Music-Audio and Script-Writing. When the basic game outlines, structures and designs were in place, each team created workflow diagrams, furniture sketches, creepy ghostly laughs and riddles. The students were taught advanced concepts’ in mathematics taught in High school in Greece. For this we used spatial metaphors and role play games to represent the temporal and special connection in space as with the computer interface. Close to the deadline, they realised that after all this hard work they were not there yet, and some decided to quit. The teachers inspired and encouraged them to continue beyond the breaking point. The deadline day was chaotic, however, the Mystery House was finalised and tested. Finally, year 1 students with their teacher came for the first user testing. Then, the game was submitted for the competition.

The students were really surprised from their game result: "I liked that we all worked together" (Diana). "It was perfect..!" (Nicolas). "We made a game!!" (Dionysius). "I drew and others were speaking in microphones and others were using computers and others were writing riddles and we all worked as a team" (Charalambos). "I solved many problems it was very fun!!" (Eftixia). Many students created their own games at home, visited the CodeClub website to download more advanced learning material and collaborated between them for more games.

**Conclusions + Future Trends**

An important factor for the current crisis and future development, is the provision of innovative opportunities and prospects to young students who may feel threatened and without sustainable future. Group thinking, fun, creativity and production, can provide a completely different viewpoint for school activities. By incorporating Arts and Design in STEM, a STEAM initiative was introduced to Year 4 (10 years old) Primary School students. Computer Supported Collaborative Creativity and Learning (CSCC/L) was the pedagogical
methodology to orchestrate an educational environment so to support and enhance STEAM knowledge, skills and competences in practice. Design Thinking and the Zone of proximal Flow, a combination of the creative flow and ZPD were the macro scripts for small groups CSCC/L convergence for: diverse students’ learning styles; teaching and learning for left and right brain functionalities; techniques to enhance imagination and creativity, concentration and attention; digital skills development; close cooperation between the teachers and the students with the teachers; and cooperation with the Parents’ Association so the students will continue to practice and develop their skills beyond the initiatives. Taking part in a challenging creative flow enhanced by interactive collective intelligence, the interplay between reasoning and curiosity brought dreams to reality. Human creativity is to dream, to imagine, to feel and create together, to change a youngster’s behaviour, and thus, his/her own destiny.

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- Flying City http://youtu.be/WZ8wPE3ePMc
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