



Revitalizing innovation management courses through Art and Design thinking

How to encourage students to become responsible citizens thanks to STE(A)M education

Berthinier-Poncet, Anne

LIRSA, Cnam Paris

Anne.berthinier-poncet@lecnam.net

Kirkels, Yvonne

Fontys University (NL), y.kirkels@fontys.nl

Khairullina, Iulduz & Podmetina, Daria

LUT (Finland), Iulduz.Khairullina@lut.fi; daria.podmetina@lut.fi

Petraite, Monika

KTU (Lithuania) monika.petraite@ktu.lt

Résumé :

Malgré un engouement croissant pour les approches pédagogiques STE(A)M, leur application dans l'enseignement du management, et en particulier de l'innovation et de l'entrepreneuriat, est encore mal renseignée. L'objectif de ce papier est de fournir un cadre conceptuel intégrateur permettant de développer plus facilement ce type d'enseignement. Pour cela, nous proposons d'appliquer les cinq étapes du processus de *Design Thinking* et de les enrichir par *l'Art Thinking*, un style de pensée qui emprunte des attitudes et des stratégies créatives aux arts. Au travers d'une démarche de recherche-action dans le cadre d'un projet européen Erasmus + ArtIST, nous évaluons, à l'aide de ce cadre intégrateur, trois ateliers spécifiques développés pour ce projet : théâtre, arts visuels et musique. Les premiers résultats donnent des clés aux enseignants-chercheurs en management, sans formation artistique préalable, pour intégrer une approche STEAM et contourner les obstacles inhérents à de telles innovations pédagogiques, dans un contexte multi-culturel et pluri-disciplinaire.

Mots-clés : art-thinking, design-thinking, STEAM education, innovation management



Summary

Despite a growing interest in STE(A)M pedagogical approaches, their application in management education, and in particular in innovation and entrepreneurship, is still poorly understood. The aim of this paper is to provide an integrative conceptual framework to facilitate the development of such teaching. To this end, we propose to apply the five steps of the Design Thinking process and to enrich them with Art Thinking, a style of thinking that borrows attitudes and creative strategies from the arts. Through an action research approach in the framework of a European Erasmus + ArtIST project, we evaluate, with the help of this integrative framework, three specific workshops developed for this project: theatre, visual arts and music. The first results give keys to management teachers-researchers, without previous artistic training, to integrate a STEAM approach and to circumvent the obstacles inherent to such pedagogical innovations, in a multi-cultural and multi-disciplinary context

Key words : art-thinking, design-thinking, STEAM education, innovation management



Revitalizing innovation management courses through Art and Design thinking

INTRODUCTION

The global need for innovation and developing 21st century skills induces a change in teaching practices, but also creates a change in the vision of learning, asking for more responsible approaches. Following the global trends and needs to put more focus on students' future employability, but also students' engagement and responsibility as world citizens, universities and higher education institutions are looking for new methodological approaches and innovative teaching methods to sustain creativity, innovation, divergent thinking and collective problem-solving skills (Perignat & Katz-Buonincontro, 2019). STEAM approaches to education (Science, Technology, Engineering, Art and Maths) unpack learning and teaching innovation with their focus on experiential and transversal learning, transdisciplinary approach and project-based work encouraging students' autonomy, creativity and self-control (Chien & Chu, 2018; Conde et al. 2020). STEAM is getting more popular (Conner et al., 2017), but still lacks conceptual clarity in terminology, pedagogy and research (Perignat & Katz-Buonincontro, 2019). Most importantly, it still remains unclear how to effectively integrate the Arts into the current educational curricula, especially in innovation management and entrepreneurship education.

Following the lack of research on effective integration of Arts in STEAM education at the university level and the necessity to develop online STEAM based teaching, this research aims at exploring new STEAM teaching approaches based on design and art thinking for developing teaching formats for students and teachers skills development and guidance by answering the following research question: *How can we integrate arts-based methods to build innovative STEAM higher education modules for innovation management and entrepreneurship and to develop effectively students' skills?*

To overcome the various barriers hindering the development of STEAM education and to create a way for teachers to view the internal functioning of their education design, we propose to build a framework based on the insights brought by the Design Thinking process. However, as the A in STEAM stands for Arts, we discuss the limitations of the Design Thinking approach



for developing STEAM workshops and we introduce elements of Art Thinking, an arts-based style of thinking that has been recently developed to enhance the Design Thinking approach and transcend common approaches to innovation management and entrepreneurship. Our literature review on STEAM, design thinking and art thinking allows us to develop a more comprehensive and integrative framework that could be further used as a building tool for STEAM management courses. We then empirically test the framework by analyzing three innovative teaching practices – Music, Visual Art and Theater workshops – for innovation management education courses. These workshops were developed by a consortium of seven European universities in the case of an Erasmus + program, ArtIST. We end this paper with a discussion on the main outcomes and limitations of this framework.

1. THEORETICAL FRAMEWORK

1.1. STEAM EDUCATION: A PEDAGOGICAL INNOVATION?

Modern education aims to promote creativity among students and develop their creativity skills in order to prepare graduates to think creatively at work, in personal life, and in society (Craft, 2010; OECD, 2008). The complex future of higher education tends to mix fields and disciplines to create new professions as “astronautic geologists or biomimicry analysts” (Land, 2013). By integrating Arts into STEM, hence suggesting a STE(A)M methodology, the pedagogy is further developed in a more complex learning system that permits the desired business vision value and capabilities (Land, 2013). Using STEAM education increases students' interest and understanding of STEM disciplines individually, boosts student creativity, encourages unique ideas and develops 21st century skills such as engagement, perseverance, communication skills, team working. Moreover, with a meaningful integration of art into STEM, students grow self-motivation by building their own learning path. STEAM complements other student-centered pedagogical models like challenge-based education and develops creativity (Stehle & Peters-Burton, 2019).

Innovation, and more specifically open innovation (Chesbrough, 2006), encompasses the creation, adoption and dissemination of new (technological) knowledge through collaborative activities between organizations and other stakeholders. The domain is inherently interdisciplinary in which challenges are not new, but in which the context is ever-changing (Tidd & Bessant, 2018). Thus, pedagogy approach and course objectives should reflect the



development of craftsmanship, arts-based methods and application of new technologies on one hand and competencies like communication, teamworking, relationship-building, creativity and divergent thinking on the other hand. The aims of the STEAM pedagogy highly correlate with the learning objectives of innovation management education. However, there is little empirical research in higher education regarding the relation between these fields and how they can be integrated. As creativity, empathy, customer-oriented approaches, co-creation, problem-solving, rapid prototyping are key elements of both innovation management education and Design Thinking process, we suggest to take a closer look to a design-based thinking approach for building our framework.

1.2. DESIGN BASED THINKING

With regard to the design of management education modules, teachers often do not know what to teach and how to implement STEAM. A first understanding can be provided by the TPACK framework (Rosenberg & Koehler, 2015) that combines content-related knowledge (covering ‘what’ to teach) with pedagogical and technological knowledge (focusing on ‘how’ to teach). The heart of this model contains the elements content, pedagogy, technology, teacher and student background. Using this framework can help to better understand the relation between arts and innovation management education. However, a number of studies agree that just adding some crafts, drawing or music to a lesson does not create a STEAM lesson and avoids the deep process-based and problem-solving learning that is a distinctive characteristics of STEAM education (Stehle & Peter-Burtons, 2019). More attention must be paid to the active role played by the diverse stakeholders of the education process, and in particular the students and their ability to identify the problem(s), propose a solution for the specific situation, test the solution, and share their ideas (Stehle & Peters-Burton, 2019). Traditional educational model such as the TPACK framework might be insufficient to design complex STEAM-based management education modules, especially for integrating Art into innovation management or entrepreneurship courses.

Therefore, we suggest adopting a design-based thinking process to develop specific STEAM modules for innovation management education. While Design-thinking has most often been used in business or product/service design, it has increasingly received attention in education (Henriksen et al., 2017). Koehler and Mishra (2005) suggest teachers need experiences that place them overtly in designer roles, to develop their knowledge for solving problems and



creating learning experiences. As stated by Jacobs (2018), design and arts have been historically connected in higher education at a philosophical as well as an operational level. Mootee (2013, p. 32) defines Design-thinking as “the search for a magical balance between business and art, structure and chaos, intuition and logic, concept and execution, playfulness and formality and control and improvement”. In innovation management, Design-thinking is increasingly used both at the business and education level (Jacobs, 2018; Robbins, 2018; Schimpf et al., 2021). This staged process model of creativity has been mainly developed as a “human-centred problem-solving methodology” (Jacobs, 2018), focusing on understanding the needs of others, rapid testing and iterating, and bringing out each one’s inner creative genius. For Robbins (2018), Design-thinking clearly emphasizes the importance of problem definition, including customer, consumer or “end-user” perspectives to refine the problem for a better comprehension of the issue and a solution based on higher ground rather than common ground. It contradicts the design process of traditional teacher-centered education.

Problem-solving and process-based learning are the most distinctive characteristics of STEAM approach (Stehle & Peters-Burton, 2019): focus on the central question of the lesson and the process of exploration. A third characteristic of STEAM modules is the development and use of both divergent and convergent thinking. For Perignat and Katz-Buonincontro (2019), Arts in STEAM create and confront abstract reasoning (or convergent thinking) and divergent thinking at the same time; the first one to find the solution and the second to apply it to real world uses or problems. Design-Thinking involves both types of thinking: divergent thinking to enhance the creativity of thinkers and explore multiple solutions, and convergent thinking to come up with a correct solution. Adopting a Design-thinking approach can therefore enable teachers in innovation management or entrepreneurship to successfully elaborate STEAM education modules.

Depending upon the authors, Design-thinking processes generally include between three and seven phases. For the development of the STEAM methodology, we will consider the **five-phase descriptions** from the d.School Hasso Plattner Institute of Design at Stanford University as it is one of the most used in management education (Schimpf et al., 2021; Henriksen et al., 2017). The process starts with *empathizing* with the customer or the end-user and *defining* the problem to be solved. The process then moves to *ideate* on solutions using divergent thinking. The *prototype* is developed after convergent thinking and then the design-thinkers resort to



testing the prototype. Although described as sequential, design thinking is actually an iterative process with constant back and forth between the different phases.

In the following section, these five steps are further explained and enhanced with elements of Art-thinking for developing an integrative STEAM framework for management education.

1.3. ART-THINKING AND DESIGN-THINKING: TOWARDS AN INTEGRATIVE FRAMEWORK FOR BUILDING STEAM-BASED MANAGEMENT EDUCATION

As stated by many scholars (Bureau, 2019; Sandberg, 2019, 2021; Jacobs, 2018; Robbins, 2018; Schimpf et al. 2021), Design-thinking and Art-thinking are closely linked and complementary. For Robbins (2018), Art-thinking brings a new perspective and enables to go beyond the limitations of Design-thinking, leading to more radical innovation and, instead of offering an improved solution, creating an *optimal* solution. Sandberg (2021, p.3) defines Art-thinking as “an arts-based style of thinking and a multi-step method for exploring visions of the future while questioning the impact of cutting-edge, technology”. Integrating an artistic mindset and artistic practices into education will better prepare students for a complex and uncertain future as well as help them to become more responsible citizens (Jacobs, 2018). As stated by Adler (2015, p.481), “*art offers a unique perspective with which to confront the chaos and unpredictability that surround us*”. Perignat and Katz-Buonincontro (2019) confirm that the arts improve cognitive skills such as: spatial reasoning, abstract thinking, divergent thinking, creative self-efficacy, openness to experience and curiosity. For Sandberg (2021), Art-thinking is mainly about “sensemaking”, at the individual as well as at the collective level, where sensemaking is seen as the process of interpreting and constructing reality. For Purg and Sutherland (2017, p.382), the fundamental value of the arts for developing tomorrow’s manager-leaders is also the *meaning* it brings to them: “*the arts afford reflection, conversation, and challenge to the meanings and purposes of what we do*”. They, therefore, advocate the necessity for “management education to engage the arts in order to revitalize meaning-full praxis in organizing, managing, and leading.”

The Art-thinking mindset relies on three main principles – *emotional engagement, intuition and tolerance of ambiguity* – managers should cultivate in order to generate more creative solutions (Jacobs, 2018). *Emotional engagement*, with oneself and with others, is a strong characteristic of artists as compared to scientists, designers or managers (Feist, 1999). However, by



developing a more conscious emotional engagement with oneself, one's intuition or one's work, innovation managers might become truly empathic and more human-centred, self-aware (Jacobs, 2018). Connected to the personal and emotional engagement of artists, *intuition* is another key point of emphasis in art thinking. Most successful artists are strongly intuitive as might be experienced designers. Jacobs (2018) advocates for allowing more emotional and intuitive stages in the education, developing strategies and techniques to foster intuitive and associative thinking. Concerning the last feature, *tolerance of ambiguity*, Jacobs (2018) underlines the importance of accepting ambiguity and uncertainty throughout the creative process because it enables innovation managers to take more risks and generate more creative solutions and innovations. Artists are genuinely tolerant of ambiguity which allows them to better accept iteration and failures.

Moreover, as a specific form of sensemaking, Art-thinking highlights five key features we also integrate in the different phases of the design-thinking process for STEAM education: *bifocality*, *multivalency*, *ambidexterity*, *improvisation*, and *embodiment* (Sandberg, 2021). Enhancing the Design-thinking process with Art-thinking elements allows for a more integrative framework for management education that resolves around the five following phases: *Empathize*, *Define*, *Ideate*, *Prototype* and *Test*.

- **Phase 1 - Empathize**

This first phase is based on the ability to “walk in the users ‘shoes’” and to understand their pains and gains in order to develop ideas that would be most likely to resonate with them (Robbins, 2018). Empathy is at the foundation of human-centered design as an essential starting point for any design work (Henriksen et al. 2017). Teachers need to set aside their preconceptions about the course they want to develop. Drawing a parallel with the artistic creation process of the Bauhaus, Schimpf et al. (2021) observe that empathy is a real fuel for innovation and creativity: from drawing exercises to express holistic experiences and visualize invisible aspects to excursions or photography that develop learning and observation of users in their real environments. At this stage, Sandberg (2021) also emphasizes the *bifocality* and *multivalency* characteristics brought by artists: the first implies the ability to switch between multiple visual ranges, going from detail to holistic perception and back, and to take another perspective, when the latter establishes a participatory process as a play with ideas and interests of different actors. Robbins (2018) suggests adopting an “ethnographic approach” with very



close observation in the form of participant diaries, video diaries, vlogs, photos, etc... While describing his Art-thinking method for “creating the improbable with certainty”, Bureau (2019) insists on one preliminary step inspired from the art world: *donate* that can be seen as complementary to the first stage. Artists give without knowing what exactly they will get in return, without being able to calculate, but they give with the hope of creating links, meaning and materialities. To *donate* creates links that structure new universes of resources and is useful for the empathizing phase. On top of that, encouraging and developing *emotional engagement* of the students facilitates a more human-centred approach of the process.

- **Phase 2 - Define**

The better a challenge or a problem is defined, the better it can be addressed. Defining the problem statement from the user’s perspective enables us to focus on unanswered and specific areas. It requires the examination of its complexities and variables from multiple perspectives (Henriksen et al., 2017). This stage is particularly important for STEAM education modules as they are centered on problem-solving and process-based learning. Many creators and researchers have noted that finding the right problem is far more important than solving the problem. Unlike designers, artists are more comfortable creating and reframing the original problem and less focused on a solution. Rather than immediately focusing on solving a problem as quickly as possible, art thinking encourages people to take the time to think more deeply about the problem itself (Jacobs, 2018). In the Bauhaus movement, this stage is achieved through a methodological work with collag details or pairs of opposites, and is meant to get better insights into characteristics of the subject at hand (Schimpf et al. 2021). Defining the problem in art thinking requires *ambidexterity*, “a dynamic ability to simultaneously explore novel and unconventional solutions and exploit proven concepts” (Sandberg, 2021; O’Reilly & Tushman, 2008). By combining different learning processes, from existing curricula based on previous experience to radically new education concepts, ambidexterity emphasizes a constant challenging of the *status quo* while facilitating the definition of the main challenge to be addressed in the module creation process.

For Tim Brown (2008), inspirational father of the Design-thinking approach, both phases 1 and 2 participate in the *inspiration* phase that motivates the search for solutions.



- **Phase 3 - Ideate**

Ideation is the process of generating, developing, and testing ideas that may lead to solutions (Brown, 2008). The objective of this phase is to come up with a broad range of different ideas with a high variety that enables solutions beyond previous existing references (Schimpf et al. 2021). As an essential element of design thinking processes, ideation also reflects the divergent thinking aspect of creativity (Henriksen et al. 2017). The divergent and convergent thinking highlighted by STEAM approaches are therefore highly encouraged at that stage. As Bason and Austin (2019) underline it, the aim of divergent thinking is to get beyond easy answers and find options that might be truly innovative. “*Going sideways*” for the purpose of generating more ideas, even crazy ones, can make goal-oriented people uncomfortable as it generates ambiguity. In art thinking, Bureau (2019) highlights the importance of *deviation* that consists in using an existing creation (ideas, symbols, objects) from a context A in order to (re)create an original proposal in a context B. After deviating, the next step is to *destroy* in order to further challenge the status quo of generated ideas as “*every act of creation is first an act of destruction*” (Pablo Picasso). However, creative work relies on both processes of divergent and convergent thinking where people think divergently to generate a large range of ideas and then phase back into convergent thinking to focus and develop an idea with attention and craft (Henriksen et al. 2017). For artists, *intuition* is key in the ideation process as their ideas usually stems from life experience and knowledge of their medium: the “Wahoo” magical idea that occurs during the process is more often based on the connections and associations that artists make intuitively between embedded knowledge. Strongly relying on this intuitive mindset, the *improvisation* skills highlighted by Sandberg (2021) take here on their full meaning. During the artistic process, diverse perspectives on a variety of different alternatives are processed simultaneously: “*actors, dancers and musicians do not only use improvisation as a performing practice but as a form of inquiry*” (Sandberg, 2021, p.8). In Art-thinking, improvisation builds not only on expertise and framework but also on impulse, intuition, evolving responses to each collaborator and creativity connections.

- **Phase 4 - Prototype**

Prototypes are tools to have a conversation around, they are a key aspect of design thinking. They physically/materially represent the ideas that emerged from the previous phase and that were selected through convergent thinking. A prototype can be anything that takes an experienceable form: a role play activity, a storyboard, a sketch...the main purpose of this



step is to refine ideas together with the user and gain deeper empathy, by allowing people to interact with a tangible version of your vision. For students, it is a way to recognize the link between *thinking* and *doing* and involves at the same time *taking a risk* and accepting the *willingness to fail* (Henriksen et al. 2017). In their study of the *Bauhaus* movement, Schimpf et al. (2021) highlight the importance of this stage as a “mission of unity between art and technology”. Prototyping is a new preliminary stage for industrial production, creating models for the productive implementation work of the factories. In her creative method of Art Hacking, Sandberg (2019) insists also on the key aspect of *materials* as intermediary function: “*visualizing situations and organizational procedures can lead to a more profound understanding of the problem at hand*” (*ibid.*, p. 3). Playing with material and its potential symbolic power opens a different view of reality. More generally, there is a strong physical quality about art thinking. Sandberg (2021) evokes *embodiment* as one of its five core characteristics, the artistic act of creation being described as a “*mode in which one thinks with one’s body, not just with one’s brain or mind*” (Rajchman, 2013, p. 198).

- **Phase 5 - Test**

This phase is inextricably linked to the former one as whatever a designer creates must be tested by users. Prototypes will be shared with an audience of stakeholders or users in order to retrieve their feedback. Testing these tangible artifacts generates conversations much more detailed, concrete and useful than hypothetical discussions (Bason & Austin, 2019). In the *implementation* phase of his design thinking model, Brown (2008) highlights the crucial steps of prototyping and testing that need to be repeated as many times as possible, internally as well as with external users, before engineering the final experience. For theater, dance, music or any other live performances, the *rehearsal* phase is a key element. Drawing a parallel between theater play and business, Austin and Devin (2003) emphasize the importance of this last phase for building a *collective mindset* that will ease the execution of a common vision (Brown, 2008). Through repeated iteration, actors transform conflicting action into a coherent and unified collective form: it is a powerful coordination as well as creative tool that enables successful final implementation. After the rehearsal, comes the crucial moment of the performance before an audience: every artistic output will be confronted to the reaction of a public that is equivalent to the test phase. Bureau (2019) emphasizes the necessity of



displaying the result of the artistic work to an audience during an event because, in order to build and develop a creation, it needs to be confronted to a constructive dialogue.

Figure 1 below summarizes the integrative framework we developed from our literature review on Design-thinking and Art-thinking processes applied to the field of STEAM and innovation management education. We propose now to apply this framework to the analysis of the development of three STEAM workshops for a course on innovation, creativity and arts.

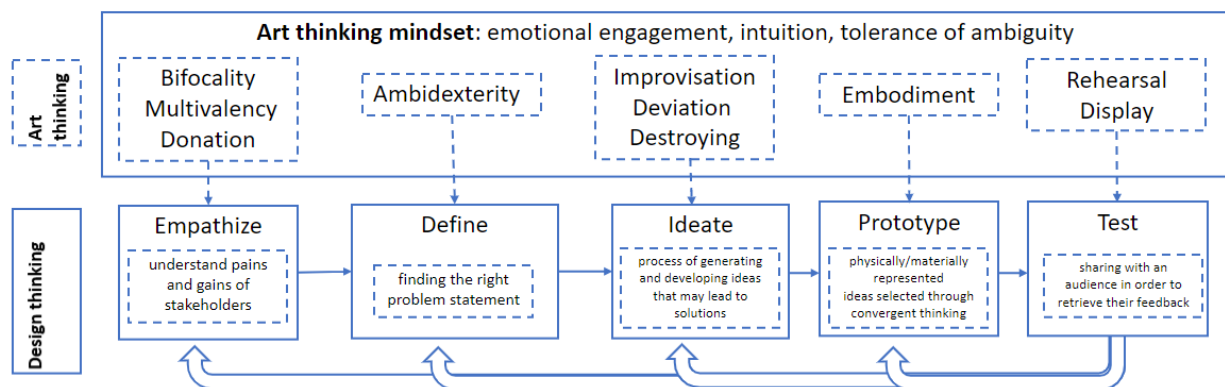


Figure 1 - Integrative framework for designing STEAM management education module

2. RESEARCH DESIGN

This exploratory study follows *action research* to develop, implement and evaluate online workshops. Action research is an iterative and collaborative/ participatory process and is rather “research in action than research about action” (Coghlan & Brannick, 2014, p. 4) as it develops solutions for real organizational problems and applies different knowledge sources from participants. (Saunders *et al.*, 2016). Action research includes 5 themes: *purpose, process, participation, knowledge and implications*.

The main *purpose* of our research is to develop and improve STEAM workshops for innovation management education at the Master level and promote pedagogical innovation based on STEAM approaches. The *context* of the research is defined by the larger objectives of an EU funded-project and focuses on interdisciplinary teaching for innovation management and entrepreneurship. The *process* of action research was initiated in the specific context of teaching practices and started with research questions. The action research process included three workshops integrating music, theater and visual arts in innovation management teaching. As



action research works through several cycles of iterations of planning, taking action, evaluating and diagnosing, - it can be expected that research questions are transformed during the research. The *participation* in action – as a compulsory condition of action research – was ensured by active involvement of teachers, students and peers on all stages of the process. The cooperation requirement was ensured by cooperation of teachers / researchers and all other stakeholders of the process. The process and participation were documented by video recordings of three 3 hour-workshops. Three main teachers and several other teachers participated in development, teaching and evaluation. The cooperation around the course development was ensured by regular online meetings and feedback loops. Student interaction was achieved with multiple rounds of reflections and feedback.

The research process incorporated different forms of *knowledge*: *theoretical* knowledge, *empirical* knowledge through the daily observation of the participants' experiences, diaries (experiential knowledge) and *experiential* knowledge – in our case from teaching practices, performances and final evaluation. These forms of knowledge, encouraged by collaboration among participants, were incorporated into stages of the action research process to generate “actionable knowledge” (Coghlan, 2011, p. 79) which has practical purpose for participants and organizations and further implications. In addition to analyzing workshop videos, the knowledge was generated from teachers' diaries, teaching materials and students' videos and presentations, the evaluations of the three main teachers and two attending / participating teachers per workshop, the reflection of over 40 students per workshop and overall feedback from students.

45 master and doctoral students participated in the workshops. They originated from ten different countries and had backgrounds in business administration, industrial engineering and management and various engineering fields. The main teachers were all PhD trained in the field of innovation management and had no professional background in arts. The three workshops – *Theater, Visual Arts and Music* – were initially developed for a Master course on “Innovation, Creativity and Arts” in the context of an Erasmus + project ArtIST. This project, which started in January 2020, gathers partners from seven European higher education institutions: Finland, Italy, France, Lithuania, Netherlands, Austria and Hungary. Each workshop included a theoretical part and a practical/ experiential artistic part, but they differed in their overall structure. For two of them (theater and visual arts), students received pre-course work and



homework, which are also part of the empirical materials (e.g. recorded theatre performances of students).

The description of the workshops including learning outcomes, format of teaching and content (knowledge, skills and attitudes) is presented in Table 1.

Title	Music	Theatre	Visual arts
Learning outcome	Student is able to combine arts (music) and innovation by creating distinctive ideas; the first step in the creation/innovation process	Developing creativity but also to better understand the potential reactions of all stakeholders in order to validate or modify the different stages of the innovation process.	Developing visual arts inspired perspective on viewing and solving innovation challenges, while applying entrepreneurial behavior, and creativity techniques.
Skills developed	Insights into creative and design thinking skills (analogy from music) and collaboration in (interdisciplinary) teams; Dare and willingness to step outside your comfort zone and explore creative thinking in unfamiliar working conditions	Openness, self-confidence, creativity, learn the power of collective work; Storytelling and performance -tell a story that will captivate an audience (useful for startup pitches); improvisation, communication, leadership and creative thinking; curiosity	Opportunity recognition, recombination of existing resources, Creativity across domains, entrepreneurial behavior, acting under limitations, creativity
Knowledge gained	Types of music arts and roles/activities performed by music professionals. Process of music arts thinking and product development and business models (music development exploration and exploitation process)	Different types of theatre; Storytelling and play writing (storyboard). Brainstorming and creating a collective piece. Sustainable / responsible innovation as the main topic of the plays	Role and history of fine arts in societal development and arts driven innovation techniques. Basic principles of artistic discovery, its application, the role of visual arts in innovation and progress. Opportunity recognition, recombination of existing resources, and acting under limitations while engaging with modern techniques of visual arts, while addressing innovation challenges.
Format of teaching included	Traditional, interactive lecture and masterclass. Content is due to Covid restricted to creating insights / awareness	Introductory lecture defining Innovation theatre and how the workshop will be done. Preparatory homework by the students BEFORE coming to the workshop: group work, inventing, writing and rehearsing their own, original short theatre play. During the workshop: a) Icebreaker sessions in small groups in breakout rooms ; b) Forum theatre play with all the class x2 Short group reflection AFTER the workshop	Preparation instructions for homework BEFORE the workshop: study a favorite artist or visit a fine arts exhibition + prepare materials for the class. During the workshop: Theory lecture: learn from the experiences shared by the artist about his work, and reflect on the entrepreneur, who has integrated visual art inspired solutions in the customer value proposition. Tool: engage in a hands-on development of the artistic work, while using easily accessible techniques of collage.

Table 1- Description of the three STEAM workshops



3. FINDINGS

Applying the integrative framework on Design-thinking and Art-thinking as described in Figure 1, we analyzed the development of the three workshops we developed for STEAM-based innovation management education in the context of the Erasmus+ project ArtIST. We followed the five phases identified in the integrative framework to highlight our main results.

Table 2 gives a summary of our main findings for the 3 workshops according to the 5 + 1 stages.

	Theater	Visual Arts	Music
Empathize	Curricula collection Interviews with stakeholders Co Creation workshop (CCW) Meetings with artists Students feedback		
Define	Theater workshop	Visual arts workshop	Music workshop
Ideate	Forum theater or theater of the oppressed, improvisation, stakeholder meeting topic with dilemma and conflict and science friction startup idea, warm up exercises (Storytelling, improv), Responsible innovation: use of UNO SDG topics	Empathy map, user personas, concept map, customer journey design	Music creation, instrumentation, playing and performing from idea to a final product; examples of innovation in music; scalability challenge; tools for musicians; collab. music creation in class; guest expert; musical quizz
Prototype	Canvas for creating a theater play, introductory video, performance video	Preparatory task, construction of the art work, presentation and individual reflection	Presentation of the theory and guest lecturer
Test	Online theater performances Group reflection after the workshop	Display of artworks, presentation, Group reflection	Individual reflection
Art thinking	Emotional engagement Multivalency; Embodiment Improvisation; Rehearsal Display & Dialogue	Emotional engagement Intuition; Embodiment Display	Emotional engagement Bifocality; Multivalency Ambidexterity

Table 2 - The design thinking of the 3 STEAM workshops



3.1. PHASE 1 - EMPATHIZE

Multiple criteria influence the design of an educational program and defining learning objectives such as level of education, requirements and educational background in the STEM disciplines or business management. Moreover, while building a STEAM course multiple stakeholders perspectives need to be taken into consideration: students, teachers, business, entrepreneurs, artists (musicians, dancers, coaches, theater directors, actors...), administration for discussing appropriate spaces and materials, etc. In the case of this research, students were from different countries, had different ages, educational backgrounds, and were not particularly familiar with arts.

During the *Empathy* step, we initially got inspiration from analyzing data of existing STEAM courses' university curricula, conducting interviews with STEAM teachers, and in organizing co-creation workshops with artists, experts in the field. Also, teachers' participation in creativity workshops (i.e. Mosaïc at HEC Montréal, Canada) was very inspirational for competencies development and ideas for new courses. This preliminary exploration leads us to further questions or problems to solve: how to effectively increase art-based knowledge in the module, how to collaborate with artists, how to teach arts to non-artists, how to reduce the reluctance of management or scientific students regarding artistic experiences, how to make them accept it as a valid education method.

Design-thinking is an iterative process and it is possible, even encouraged to reflect and ameliorate between each phase, without waiting for the outcomes of the final stage. For instance, during the *prototyping* phase of the theater workshop, students came back to the teachers with concerns and misunderstandings about the workshop preparation as it was going to be online. In addition to the difficulty of performing online, the remote location of all students, the additional time spending for video making and the lack of understanding of the link between theater and innovation, developed anxiety, misunderstanding and some initial resistance amongst students.

"we have lockdown in Austria, so I'm not allowed to meet more than two people from another household" (Student, Austria)

"preparing and doing something like that in a virtual mode might generate frustration and increase the already largest amount of time needed" (Student, Italy)



Empathy at that stage helped teachers to offer a solution to postpone the workshop and give more time to prepare with additional Q&A sessions to clarify all the questions from students. A video as well as a more precise template, with step-by-step indications, were then developed (back to the *prototyping phase*) to provide additional guidance to the students to create their original theater play. As a result, 8 of 9 groups performed their play online or video recorded and reflected positively which was surprising even for themselves.

Artists as stakeholders of the project reported difficulties in connecting their Art experience with the course and discipline: while they might have had useful insights, it was not clear how and what should be presented for the students. However, they were glad to introduce themselves, their field, company or product. Some of them invited students to collaborate on their artistic work or provided them with trial versions of their product.

3.2. PHASE 2 - DEFINE

The *Define* phase was settled by several preconditions addressing the TPACK model elements of content, pedagogy, technology, teacher and student background. First, the frontlines of the EU project call: to develop 21st century skills by creating innovative Master-level modules in innovation management and entrepreneurship integrating Arts. Thus, workshops were chosen as a pedagogical method to deliver the art-based practices as a problem-solving approach and experimental and practical way of learning and a safe environment to live through the real-life situation or problem. Secondly, due to complexity of the subject, teachers chose artistic fields familiar to them and where they already had a background, knowledge or experience. In addition, existing practices were explored and merged together with target discipline needs.

Incorporating arts into education doesn't necessarily mean that the teacher needs to be an arts professional. However, they need to be able to explain how arts professionals think, act and work and how their industry is organized. Translating their interests and experiences into a workshop content is difficult. Where to start, how can the subjects of arts and STEM be integrated? In order to create 'big ideas', they decided to take an open innovation approach in which teaching materials are not worked out in detail, but space is left for others, students in this case, to co-create. Furthermore, colleagues from art academia were asked to provide expertise and support via a music masterclass and guidance. Due to Covid, teachers were forced to use technology; all classes and guidance was (re)designed for online purposes.



3.3. PHASE 3 - IDEATE

The workshops were part of a Master course “Innovation, creativity and arts”. In the *ideate* phase, also at course level, strategy issues caused the most uncertainty. Since planning and teaching was done only online, there was little content-related input for the workshops and content alignment was teacher dependent. The ideation phase was done separately by each responsible for the workshop teacher(s) based on the background, aims of the practice and available settings.

The pedagogical design of the theater workshop emphasized the content aspects of problem-based delivery and problem-solving skills. The innovation theater workshop aims to help students understand the relations between diverse people, how people with different backgrounds and intentions relate to each other and interact which is a part of collaborative and open innovation. The ideation phase brought together different variants of the theater such as forum theater or theater of the oppressed, improvisation, stakeholder meeting topic with dilemma and conflict and science friction startup idea which all together makes it really interactive and participative for all students. Forum theater allows every human being to write a play or be an actor as well as address significant topics changing the world. Science friction, startup idea, stakeholder meeting and dilemma/conflict provide the frame on innovation management for the preparation. Improvisation includes the audience into the play and provides a safe trial practice of unpredictable behavior of stakeholders and in some cases externally invented solutions to the problem raised. Besides, based on the *Empathize* phase where the problem of student engagement was detected, the main activity of the workshop was supplemented with warm up exercises and up-to-date topic of SDG (Sustainable Development Goals) as a main direction of startup idea. Online mode of the course also provided an additional challenge of preparation and performing the play: in addition to play creation, students had to record their theater play on videos.

The main idea of the music workshop was to demonstrate the process of music creation, instrumentation, playing and performing from idea to a final product, familiarize students with tools musicians use, examples of innovation in music and scalability challenge and as a practice collaborative music creation in class. The theoretical material was composed by an experienced musician and a professor of innovation and included inspirational and diverse examples from a variety of musical fields. To ease the student’s perception of the new art-based method several



music-based quizzes were added in the lecture as well as popular and well-known musicians as examples supporting the theory. Due to limited internet bandwidth in the online mode, planned collaborative music creation practices were replaced by the guest lecturer presentation. Based on the empathize phase and the difficulty of artists to link their field with discipline, teachers supported guest lecturer preparation and helped to find interconnections as well as students were allowed to ask questions from the guest at any time during the lecture.

For the visual workshop, the collage technique was chosen as it is the one allowing the most democratic choice of materials and fusion of visual art techniques. This final choice was done after identifying, collecting and analysing various curricula of innovation management that integrated visual arts practices. Visual art-based tools for innovation were also extracted as supporting tools for students such as empathy map, user personas, concept map, customer journey design.

3.4. PHASE 4 - PROTOTYPE

The phase of prototyping was conducted separately as well due to different approaches in the workshops, for instance, theater and visual workshop required flipped classroom approach where students prepare their homework beforehand and demonstrate and reflect on the results on the workshop, while music workshop was planned as a traditional, interactive lecture.

For the theater workshop, the prototype initially corresponded to an introductory seminar that was supposed to be followed by step-by-step in-class exercises to help the students to create, write and play a short theater play within a week during the Innovation, Creativity and arts course. The search context was narrowed by giving a 'big idea' to be explored, *i.e.*, the development and launch of sustainable innovation by a startup and the stakeholder meeting. At the conclusion of the workshop, the student was able to develop personae, invent, write and play a small piece of theater together with his/her peers. According to the teachers, “the theater method helped to develop creativity, but also to better understand the potential reactions of stakeholders in order to validate or modify the different stages of the innovation process.” As we had to move online, the prototype evolved to a kind of reverse-course with the display of an introductory video explaining the main frame and issues of “Innovation Theater” and presenting the newly developed step-by-step canvas that was sent to the students. An intermediary synchronous online session was offered to the students to discuss their difficulties and misunderstandings regarding the development of their theater play according to the written



canvas. An additional modification to the initial prototype emerged because of the online mode as the students were eventually asked to pre-record their theatre performance as the online “final performance” session could not allow all groups to play in front of the others.

Mainly due to latency issues, collaborative and real time, music online is hardly possible, even with experienced musicians. Hence, the pedagogy of the music workshop had to be modified into a more traditional lecture plus masterclass emphasizing the content aspect of discipline integration. It showed the multiple ways in which art is and can be part of STEM and innovation. In music as a product the similarities of music creation and selling with innovation and innovation management were shown. Links were made with concepts like convergence and divergence explained in previous lessons of the course. Music was also depicted as a metaphor or tool for improving innovation, communication and STEM transdisciplinary. In music as a business, the relations between the music industry and (innovative) business models were highlighted. This broad overview was chosen to inspire the target group. According to the teachers, “bachelor and master students in non-arts educational programs very often consider themselves to be creative. This is for instance experienced in entrepreneurship teaching when students are quite well educated to develop a business or marketing plan but lack distinctive ideas to start their business. To some extent creativity starts with curiosity and observation of the inside or outside world”.

Visual workshop preparation task included a short introduction of the workshop objectives and visual art integration with innovation topic, main sections of the workshop, preparation task and finalizing task after the workshop, therefore, the distributed task presented the main instructions and workshop description for students. The online session itself was represented by an interactive student led workshop, where the instructor inspires, provides with the examples, and defines the steps of artist work: ideate, prototype, and establishes guidelines for reflection and presentation of the work. The workshop was designed as based on the ideas coming from visual arts and design professors, the way of artist work studied, as well as core elements of the artist journey in creating the artwork. The learning outcomes defined with the focus on broadening the perspective and changing the approach.

3.5. PHASE 5 - TEST

The test of the three workshops’ prototypes were done online. For theater and visual arts workshops, the online course session was dedicated to the display of their final “oeuvre”, i.e



the short theater play with the interaction of the audience for the former and the presentation of the different collages for the latter. We also used the daily individual or group reflections that we asked our students to deliver for all the courses of the whole program.

Despite only online teaching being possible, students actively participated in all workshops and demonstrated the ability to use Innovative Theater. All workshops only provide frames within which they could express their own interests within and after the workshops. This positively influenced personalization and collaboration. For example, the group with the most nationalities took advantage of the various backgrounds and took the music businesses in their home countries as theme for their final assignment. In the theater workshop the students took advantage of the online environment and used it as a stage. However, the online setting was not easily compatible with theatre play. The specificity of innovation theatre is to enable the evolution of the collective play and the resolution of conflicts thanks to the involvement of the audience. The online setting made it more difficult to engage into a collective discussion.

For the music workshop students were requested to submit their individual reflections. Most of the students gave positive feedback to the session highlighting musical quizzes, interesting examples and dynamics of the lecture. Some used the music topic for their final course assignment. Students also shared their insights after the lecture:

“What I found really intriguing is the use of music as a metaphor: it is possible to build an analogy between a manager and a conductor of a full-size Philharmonic Orchestra”

“The interesting part is that you can do music for different reasons, and people that do music at high level have a huge range of different skills, mindset, and ability to use differently.”

As a way to develop the workshop, further students proposed a variety of topics they are interested in and many of them underlined that they got inspired by the lecture to look at things in a different way and dig deeper into the topic.

The Theater workshop was oriented towards group reflection as a final part of the action sheet; however, some recorded videos already mentioned some basic positive feedback in themselves. In the collective reflection, students mostly underlined their doubts and hesitations at the beginning and surprising outcomes after the workshop. The difficulty of online mode was also repetitive in the reflections as well as lack of audience engagement for the presenting groups.

“performing it live for the second time in a virtual environment (on zoom) and not being in the same physical space increased the complexities”



“The added value of this workshop was to share different views in a safe scenario setting and, in this way, we will be able to realize a more complete overview of a potential negotiation”

“We would have liked more people on the stage and interacting, but we recognize the online form being not so representative of the true power of this workshop. It’s really a pity.”

Visual arts workshop also requested collective reflection on the individual collages and interconnection of them to the selected topics. Some students mentioned difficulties in collaborative work due to online mode, while others admitted online options as appropriate and highlighted refreshing handmade approaches in the traditional education activities. Students also reflected on the difference of the resulting work even with the common topic, great opportunity to learn from each other during the workshop and expressive power of visual art:

“Our initial skepticism - an evident symptom of the Zoom-related frustration after one year of pandemic - has immediately been replaced by enthusiasm and positive vibes”

“Very often it is harder to try to explain an idea with words, so visual arts are powerful tools of communication and co-creation, especially in early stages of a project when not all the aspects of the idea are very clear”

In addition to daily reflection on conducted activities, the course had a final reflection where the majority of the students reported positively on the workshops. Figure 2 highlights our main empirical findings and applies them to our theoretical integrative framework to enrich it.

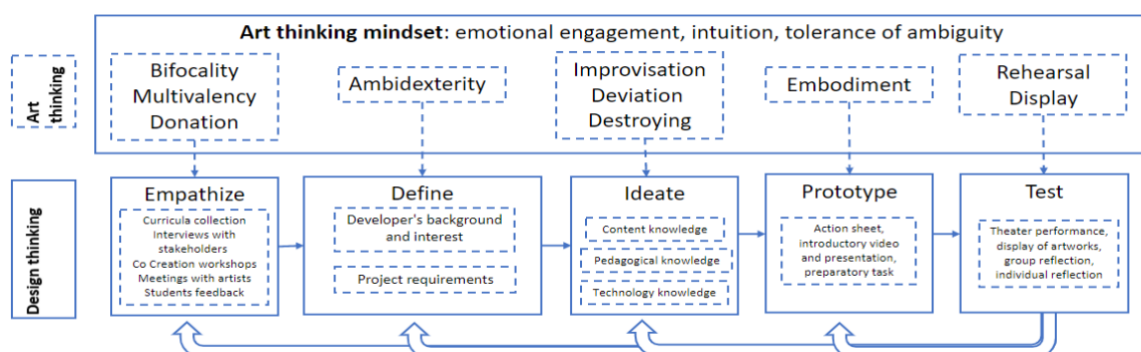


Figure 2 –Enriched integrative framework for designing STEAM education module in innovation management



4. DISCUSSION AND CONCLUSION

The proposed integrative theoretical framework based on design thinking principles augmented with art thinking elements (Figure 1), allows the evaluation and development of new teaching formats, like STEAM courses. The framework can be applied by teachers and pedagogy specialists to evaluate and design new STEAM courses and courses targeting development of 21st century skills of students. After reflecting on the use of our framework for designing STEAM-based management courses, we will highlight the challenges as well as the limitations that arose from the confrontation of our framework to the reality of designing a management course integrating art.

4.1. REFLECTION ON THE ART & DESIGN-THINKING FRAMEWORK FOR MANAGEMENT EDUCATION MODULES

In the *Empathy* phase the role of different stakeholders (teachers, students, artists) in such course's development was higher than initially expected by the researchers, even if we might take more into consideration the expectations / fears of the students regarding arts for ameliorating our course. However, the collaboration with the stakeholders ensures the knowledge transfer, skills development and overall satisfaction of the teaching and learning process. In terms of Art-thinking, sensemaking plays an important role among the stakeholders (Sandberg, 2021) as it facilitated a common understanding and interpretation of the reality we aimed at building through these workshops. The level of involvement of different artists in the workshops was different in our context, along the workshop objectives. In overall the objectives of the teaching format should be defined clearly, which would make effect on the roles of participants and stakeholders.

The *Define* and *Ideate* phases show that STEAM education in higher education is still in the exploring phase. With regard to content, teachers need to invest in codifying the tacit knowledge they have and make the intentional content connections themselves. Generating the 'big idea', a central problem-related question of the lesson, then follows naturally. However, as the teachers were no artists, they should also develop and rely much more on typical art-thinking characteristics such as intuition and tolerance of ambiguity in order to unleash their divergent thinking (Jacobs, 2018). In our first versions of STEAM workshops, no teachers dared to *destroy* (Bureau, 2019) what had been ideated, a process that could be rich of innovative



outcomes. However, *deviation* was partly used, in particular for the theatre and the music workshops.

In the *prototype* and *test* phase, we noticed that, pedagogically, the learning objectives were met. All workshops provided the students with insights; into strategies how to use music for their own interests and insights how to use theatre and fine arts in future innovation trajectories. However, the move to online mode impacted the pedagogy of the workshop as we had to rethink how to develop the practical and experimental parts that were initially prototyped for in-class performances. Moreover, this research shows that students who never dealt with arts before especially struggle with Art-thinking elements. When designing STEAM courses special attention should be given to this.

The test phase also highlighted encouraging development of an art-thinking mindset amongst the teachers as well as the students: emotional engagement, intuition and a higher tolerance of ambiguity (Jacobs, 2018) were observed in the three workshops. Thus, participants of innovation theater were able to learn the process of creation and develop creativity, respect and treasure mistakes made in the process, build improvisational capabilities, better understand the potential reactions of stakeholders, and improve their understanding of a team as an “ensemble”. In the visual arts workshop, students recognized the importance of parallel thinking, complexity and transfer of concepts into new settings. By using empathy, emotional engagement and improvisation, the students deepened their understanding of the problem.

4.2. CHALLENGES

Based on the overall assessment of teaching and learning experiences during workshops by teachers and students, we spotted numerous challenges of such teaching formats that were not expected. Teachers organizing art workshops for the ICA course noticed that students required more support than usual, especially for the realization of final performances such as theatre plays or the display of the visual art final “oeuvre”. Non-art students exposed to arts courses obviously step out of their comfort zone and need support and guidance from mentors and a safe environment. They all expressed anxiety and misconception when first confronted to the teaching guidelines (notably for the theater and the visual arts workshops). Teachers also mentioned the challenge and stress caused by the time constraints imposed by the format of the course (3-hour workshop).



The Covid 19 pandemic challenged education globally (Hamilton et al., 2020), forced the massive digitalization and called for an experimentation with teaching approaches and adaptation of teaching methods (Bozkurt & Sharma, 2020). The pandemic and digitalization added on another layer of challenges on how to teach art thinking and arts courses online. Among all disciplines, arts courses suffered the most from forced online education due to pandemic. STEAM, aiming at developing creativity and transdisciplinary problem-solving skills of future entrepreneurs and managers, also had to adapt teaching techniques, to reinvent group co-creation and to provide new ways of teaching and guidance online. The need to rapidly adapt to an online course module resulted therefore in modifications of the content as well as the pedagogy and limited the skills training for the music workshop. The theater workshop online transformation was even more challenging as the specificity of innovation theatre is to enable the evolution of the collective play and the resolution of conflicts thanks to the implication of the audience. Online setting made it much more difficult to engage a collective discussion as well as normal interaction. However, despite these constraints, it has to be said that emotional engagement was very strong amongst all participants, and in each workshop.

4.3. LIMITATIONS OF OUR FRAMEWORK

The design thinking model application to the course development is successful when it comes to educational process design and implementation. However, we found out that the model has significant limitations in the STEAM context. Our findings revealed the necessity to better address the development of teachers' and instructors' competencies and knowledge in terms of art teaching methods, practical arts, new technologies applications, abilities to monitor and mentor interactive teaching. Teachers need to develop skills to create a safe environment for students in order to help them coming out of their comfort zone when learning arts or performing in a theater play. After conducting the course, the teachers mentioned that their competences in the STEAM areas increased and they would feel much more comfortable to do a similar course again.

These limitations as well as the challenges observed during the development of these STEAM workshops for innovation management underline the necessary evolution of our framework, in particular in integrating the needed competences and observing how they might vary alongside the different phases.



4.4. CONTRIBUTIONS AND FUTURE RESEARCH

Notwithstanding these limitations, our research highlights a main theoretical contribution regarding the development of STEAM education in the field of innovation management in online mode. The development of a framework for designing STEAM-based education courses in the field of management while integrating Design thinking and Art thinking is new and might be very useful. As a matter of fact, STEAM education has recently gained tremendous popularity (Carsten Conner et al., 2017) and is backed by the European community through the funding of many STEAM related projects. However, STEAM pedagogy still lacks conceptual clarity (Perignat & Katz-Buonincontro, 2019), the main confusion being related to how effectively integrate the Arts into the current educational curricula. This is even more crucial for education at the Master level as many studies and experiments have been conducted at lower level of education (primary and secondary schools mainly), and very few of them have been investigating the field of innovation management and entrepreneurship.

At a practical level, STEAM enthusiasts both from academia and industry were brought together and developed, launched and implemented Art and Innovation courses following STEAM approach to education. The STEAM teaching model of Quigley et al. (2017) includes the dimension of instructional content, divided into problem-based delivery, discipline integration and problem-solving skills. The intentional connections and content alignment are probably the most complicated part of STEAM lessons. Our research contributes to shedding empirical light on this aspect.

In this research we aimed to find the connection between STEM standards, innovation and arts to develop the different units and teach the necessary fields content harmoniously and meaningfully. Since the involved main teachers have a background in teaching innovation, they were familiar with creativity and problem-solving teaching activities. Deciding on how to implement the big idea at the level of the workshop was no real issue. It seems that the field of innovation and its teachers could enhance STEAM education from an intermediate perspective. Future research could focus on how innovation and entrepreneurship education can bridge the space between arts and STEM education. In addition, innovation and entrepreneurship literature in the areas of open innovation, alliances and effectuation (Read et al., 2016) can offer various insights for the education domain.



REFERENCES

- Adler, N. J. 2015. Finding Beauty in a Fractured World: Art Inspires Leaders—Leaders Change the World. *Academy of Management Review*, 40(3): 480–494.
- Austin, R. D., & Devin, L. 2003. *Artful Making: What Managers Need to Know about how Artists Work*. FT Prentice Hall Press.
- Bason, C., & Austin, R. D. 2019. The Right Way to Lead Design Thinking. *Harvard Business Review*, 97(2): 82–91.
- Bozkurt, A. and Sharma, R.C., 2020. Emergency remote teaching in a time of global crisis due to CoronaVirus pandemic. *Asian Journal of Distance Education*, 15(1), pp.i-vi.
- Brown, T. 2008. Design Thinking. *Harvard Business Review*. 86(6), 84.
- Bureau, S. 2019. Art Thinking: A method for creating the improbable with certainty. *Entreprendre & Innover*, 42-43(3): 88–103.
- Chalmers, C., Carter, M. L., Cooper, T., & Nason, R. (2017). Implementing “big ideas” to advance the teaching and learning of science, technology, engineering, and mathematics (STEM). *International Journal of Science and Mathematics Education*, 15(1), 25-43.
- Chesbrough, H. 2006 Open innovation: a new paradigm for understanding industrial innovation. *Open innovation: Researching a new paradigm*, 400, 0-19.
- Chien, Y.H. and Chu, P.Y., 2018. The different learning outcomes of high school and college students on a 3D-printing STEAM engineering design curriculum. *International Journal of Science and Mathematics Education*, 16(6): 1047-1064.
- Coghlan, D. and Brannick, T., 2014. Understanding action research. *Doing action research in your own organization*, 43-62.
- Coghlan, D., 2011. Action research: Exploring perspectives on a philosophy of practical knowing. *Academy of Management Annals*, 5(1): 53-87.
- Compen, B., De Witte, K., & Schelfhout, W. (2019). The role of teacher professional development in financial literacy education: A systematic literature review. *Educational Research Review*, 26: 6-31.
- Conde, M.Á., Rodríguez-Sedano, F.J., Fernández-Llamas, C., Jesus, M., Ramos, M.J., Celis-Tena, S., Gonçalves, J., Jormanainen, I. and García-Peñalvo, F.J. 2020. Exchanging Challenge Based Learning Experiences in the Context of RoboSTEAM Erasmus+ Project. In *International Conference on Human-Computer Interaction* (pp. 442-455). Springer, Cham.
- Conner, L.D.C., Tzou, C., Tsurusaki, B.K., Guthrie, M., Pompea, S. and Teal-Sullivan, P. 2017. Designing STEAM for broad participation in science. *Creative Education*, 8(14): 2222.
- Craft, A. 2010. *Creativity and Education Futures: Learning in a Digital Age*. Trentham Books Ltd. Staffordshire, UK.
- Ellis, R. A., & Goodyear, P. 2016. Models of learning space: integrating research on space, place and learning in higher education. *Review of Education*, 4(2): 149-191.
- Feist, G. J. 1999. Personality in scientific and artistic creativity. In R. Sternberg (Ed.), *Handbook of Creativity*: 273–296. New York, NY: Cambridge University Press.
- Gardner, M., & Tillotson, J. W. 2019. Interpreting integrated STEM: Sustaining pedagogical innovation within a public middle school context. *International Journal of Science and Mathematics Education*, 17(7): 1283-1300.



- Guyotte, K. W., Sochacka, N. W., Costantino, T. E., Walther, J., & Kellam, N. N. 2014. STEAM as social practice: Cultivating creativity in transdisciplinary spaces. *Art Education*, 67(6): 12-19.
- Hamilton, L.S., Kaufman, J.H. and Diliberti, M., 2020. Teaching and Leading through a Pandemic: Key Findings from the American Educator Panels Spring 2020 COVID-19 Surveys. *Data Note: Insights from the American Educator Panels*. Research Report. RR-A168-2. RAND Corporation.
- Henriksen, D. 2014. Full STEAM ahead: Creativity in excellent STEM teaching practices. *The STEAM journal*, 1(2): 15.
- Henriksen, D., Richardson, C., & Mehta, R. 2017. Design thinking: A creative approach to educational problems of practice. *Thinking Skills and Creativity*, 26: 140–153.
- Jacobs, J. 2018. Intersections in Design Thinking and Art Thinking: Towards Interdisciplinary Innovation. *Creativity. Theories – Research – Applications*, 5(1): 4–25.
- Kelley, T. R., & Knowles, J. G. 2016. A conceptual framework for integrated STEM education. *International Journal of STEM education*, 3(1): 1-11.
- Knochel, A. D. 2018. An object-oriented curriculum theory for STEAM: Boundary shifters, materiality and per(form)ing 3D thinking. *International Journal of Education Through Art*, 14(1): 35-48.
- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, 9(1): 60-70.
- Koehler, M. J., & Mishra, P. 2005. What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research*, 32(2): 131–152.
- Köppe, C. 2020. *Workshop Report: Hybrid Learning Spaces–Data, Design, Didactics*.
- Land, M. H. 2013. Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science*, 20: 547-552.
- Lütjen, H., Tietze, F., & Schultz, C. 2017. Service transitions of product-centric firms: An explorative study of service transition stages and barriers in Germany's energy market. *International Journal of Production Economics*, 192: 106-119.
- OECD. 2008. *Innovating to learn, learning to innovate*, Paris, France, OECD
- Perignat, E. and Katz-Buonincontro, J., 2019. STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, 31: 31-43.
- Purg, D., & Sutherland, I. 2017. Why Art in Management Education? Questioning Meaning. *Academy of Management Review*, 42(2): 382–396.
- Quigley, C. F., & Herro, D. 2016. “Finding the joy in the unknown”: Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, 25(3): 410-426.
- Quigley, C., Herro, D., & Jamil, F. 2017. Developing a STEAM classroom assessment of learning experiences. *School Science & Mathematics*, 117(1-2): 1-12.
- Rajchman, J. 2013. Art as a Thinking process: New Reflections. In M. Ambrozic & A. Vettese (Eds.), *Art as a Thinking process: Visual forms of knowledge production*: 194–204. Berlin: Sternberg Press.
- Reason, P., 2006. Choice and quality in action research practice. *Journal of management inquiry*, 15(2): 187-203.



- Robbins, P. 2018. From Design Thinking to Art Thinking with an Open Innovation Perspective—A Case Study of How Art Thinking Rescued a Cultural Institution in Dublin. *Journal of Open Innovation: Technology, Market, and Complexity*, 4(4): 57.
- Rodrigues, F. & Mogarro, M.J. 2019. Student teachers' professional identity: A review of research contributions, *Educational Research Review*, 28, 1-13.
- Rosenberg, J. M., & Koehler, M. J. 2015. Context and technological pedagogical content knowledge (TPACK): A systematic review. *Journal of Research on Technology in Education*, 47(3), 186-210.
- Sandberg, B. 2021. *Art Thinking: Turning an Ill-defined Phantom into a Paradigm for Intrapreneurship*, 15p. Presented at the ISPIM Innovation Conference, Berlin, Germany.
- Read, S., Sarasvathy, S., Dew, N., & Wiltbank, R. (2016). *Effectual entrepreneurship*. Routledge.
- Saunders, M., Lewis P., and Thornhill, A., 2016. *Research methods for business students*, Pearson Education Limited, England.
- Schimpf, S., Wussow, K., & Zeh, M. 2021. Back to the roots and into the future: Applying Bauhaus Methodologies in Design Thinking. Presented at the *R&D Management Conference*, Glasgow, UK.
- Shulman, L. S. 2005. *Signature pedagogies in the professions*. Daedalus, 134(3), 52-59.
- Simpson, M., and Anderson, B. 2009. Redesigning Initial Teacher Education. In: Stacey, E., and Gerbic, P. (Eds.) *Effective Blended Learning Practices: Evidence-based Perspectives in ICT facilitated Education*, Hershey, NH: Information Science Reference, 62-78.
- Stehle, S. M., & Peters-Burton, E. E. 2019. Developing student 21st Century skills in selected exemplary inclusive STEM high schools. *International journal of STEM education*, 6(1): 1-15.
- Tidd, J., & Bessant, J. 2018. Innovation management challenges: From fads to fundamentals. *International Journal of Innovation Management*, 22(05), 1840007.
- Trentin, G. 2016. *Always-on Education and Hybrid Learning Spaces*. Educational
- Yakman, G. 2008. STEAM education: An overview of creating a model of integrative education. In Pupils' Attitudes Towards Technology (PATT-19) *Conference: Research on Technology, Innovation, Design & Engineering Teaching*, Salt Lake City, Utah, USA.
-