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Σχεδιάζοντας τη μάθηση στα μουσεία: Μια διαδικασία επαγγελματικής ανάπτυξης

Maria Xanthoudaki

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Design for Learning in Museums:

A professional development exercise

Maria Xanthoudaki[a]
National Museum of Science and Technology Leonardo da Vinci

Abstract

The paper discusses the role of educational research and reflective practice in the design of a learning methodology in a museum education context. Educational research and reflective practice are addressed for their role in visitor-centred experiences and in the professional development of museum educators through the case of the National Museum of Science and Technology Leonardo da Vinci. The paper first examines the research questions by looking into the work of the Education Department of the Museum in order to contextualize and justify certain choices and directions in the development of visitor learning and experience. It then analyses one of the education projects of the Museum, "Future Inventors", as the context for the learning design and reflective practice processes in order to question traditional epistemological stances in visitor learning and to stress the importance of professional development for museum educators to enrich their knowledge in the field and the competences necessary to stand as the audience advocates within the museum institution.

Περιληψη

Το άρθρο εξετάζει τον ρόλο της εκπαιδευτικής έρευνας και της αναστοχαστικής πρακτικής στον σχεδιασμό μιας μεθοδολογίας μάθησης στο πλαίσιο της μουσειακής εκπαίδευσης. Η εκπαιδευτική έρευνα και η αναστοχαστική πρακτική εξετάζονται για τον ρόλο τους στην εμπειρία με επίκεντρο τον επισκέπτη και στην επαγγελματική ανάπτυξη των μουσειοπαιδαγωγών μέσα από την περίπτωση του Εθνικού Μουσείου Επιστημών και Τεχνολογίας Leonardo da Vinci. Η εργασία εξετάζει αρχικά τα ερευνητικά ερωτήματα μέσα από το έργο του Εκπαιδευτικού Τμήματος του Μουσείου προκειμένου να πλαισιώσει και να δικαιολογήσει ορισμένες επιλογές και κατευθύνσεις στην ανάπτυξη των εκπαιδευτικών προγραμμάτων. Στη συνέχεια, αναλύεται ένα από τα εκπαιδευτικά προγράμματα του Μουσείου, το "Future Inventors", ως πλαίσιο για τη συζήτηση της διαδικασίας σχετικά με τον σχεδιασμό της μεθοδολογίας και την αναστοχαστική πρακτική, προκειμένου να αμφισβητηθούν παραδοσιακές επιστημολογικές θέσεις που αφορούν στη μαθησιακή εμπειρία των επισκεπτών και να τονιστεί η σημασία της επαγγελματικής ανάπτυξης των μουσειοπαιδαγωγών για τον εμπλουτισμό των γνώσεών τους στον τομέα και των ικανοτήτων που είναι απαραίτητες για να σταθούν ως 'συνήγοροι' των επισκεπτών εντός του μουσειακού ιδρύματος.

Key words: museums, education, STEM, professional development

Contact person: Maria Xanthoudaki, xanthoudaki@museoscienza.it

URL: http://ejournals.epublishing.ekt.gr/index.php/hjre/index

Introduction

If you ask anybody among those who work in and for learning in museums, they will certainly reaffirm the importance of its educational and social role and that of fostering visitor-centered experiences and meanings. Whichever the type of museum – science, art or other – educators belong to, they will all argue that museums (need to) evolve "from talking about something to being for somebody" (Weil, 1999).

Such stance implies the need to ‘broaden what counts’ in/as learning, that is, to redefine learning as a process of ‘being, knowing, becoming’ acknowledging the value of the personal and social spheres (Petrich M. et al., 2013). This means create supportive and inclusive environments in which all visitors feel they can contribute from their own lived experiences and that these are valid and valued (Harris E. et al., 2018). Consequently, all this calls for, first and foremost, a museum learning context – a combined set of contents, methodologies, spaces, materials and facilitation – that fosters the personalization of the learning experience, and invests in participation, open-ended, creative exploration and dialogue as ways through which people can play an active role in constructing (their) meanings, stories, knowledge and skills. In this context, museum educators (should) act as “the audience advocate” (Hooper-Greenhill 1991) suggesting means through which museum learning and experience can be fostered and enriched for every visitor.

To act such a role, museum educators need to invest in ongoing professional development and most importantly in ongoing research and pedagogical reflection. Our work is not static, it evolves along with the museum; therefore, it is only through research and reflection that we can grow capable and prepared to make a difference in the quality of learning in and through the museum.

The paper addresses the role of educational research and reflective practice in the design of learning experiences that contribute to enrich, potentiate, expand visitor experience in museums. In addition, it highlights the value of pedagogical research and reflective practice as fundamental professional development tools for museum educators contributing to building their knowledge in the field and the competences necessary to stand as the visitors’ advocates within the museum institution. To do this, it discusses learning design processes at the National Museum of Science and Technology Leonardo da Vinci, taking one of its most recent and strategic education projects, “Future Inventors,” as case study.

The arguments are presented in the five parts: The following part illustrates the history and identity of the Education Department of the Museum, which contextualize and justify certain choices and directions in the development of visitor learning and experience. Paragraph 3 analyses the research and development process leading to learning innovation and reflective practice. Paragraphs 4 and 5 present the phases of structuring and testing of the project approach in order to question traditional epistemological stances in terms of both visitor learning and museum educator professional development. Concluding remarks are included in the last part of the paper.

Education and Learning at the National Museum of Science and Technology Leonardo da Vinci

Ever since its foundation on 15 February 1953, the National Museum of Science and Technology Leonardo da Vinci places education at the heart of its mission. Over the last 70 years, several pioneer events have helped shape today’s education mission and strategy (Museo Nazionale della Scienza e della Tecnica, 1958).

The first one is the institution of the ‘Centre for Physics’ in 1955 to offer the resources necessary for the study of physics via an approach that “fosters a direct and dynamic engagement of visitors with experiments developed for that purpose” (Ghezzi, 1966). The first users of the Centre were teachers attending demonstrations and directly experimenting with scientific apparatuses. Until the beginning of the ‘80s, the Centre devised and offered training courses, teaching materials and education exhibitions.

The 1980s constituted a period of important change following the evolution of the science communication field internationally. The influence of the science centre movement drew even more attention to the impact of direct experience, that is “from observation of objects to execution of experiences, in such a way as to awake attention and curiosity and to instill the desire and interest to know more” (Museo Nazionale della Scienza e della Tecnica, 1992). As a result, the second pioneer event was the birth of the first ‘interactive laboratories’ in 1993 inspired by the Exploratorium of San Francisco and the philosophy of Frank Oppenheimer.

The interactive laboratories (i.labs) were active learning spaces in which visitors encountered real phenomena and engaged in experiments directly; and, when opened, were the first of their kind at national level. The i.labs developed in line with the history and identity of the Museum. A conscious choice was made not to create a science centre (i.e., an open space with a range of interactive exhibits for free use by visitors supported by floor staff) but, rather, develop a type of context that can offer more structured learning experiences and facilitated activities to schools, primarily, and other audiences (Miotto, 2002).

Today, the labs have grown to a total of 13, dedicated to different STEM-oriented themes: Food and Nutrition, Biotechnologies, Genetics, Energy and Environment, Mathematics, Leonardo, Chemistry, Base Mars, Future Inventors, Tinkering Zone, Soap Bubbles, Sea Travels, Young children’s lab. The initial mandatory correspondence between the themes of the i.labs and those of the exhibitions is not anymore a prime criterion for the choice of contents, as currently the idea is to respond to current trends in the STEM fields, interpret science and technology in a more interdisciplinary way and bring societal issues into the narrative and learning experience.

Around the labs and the exhibitions, over the years the Museum has developed a precise and distinct learning methodology that characterizes all its programmes and activities. The guiding principle is that learning is built on visitors’ explorations, investigations, constructions, integrating their personal context and their backgrounds, age, learning modes and knowledge levels. ‘Something that occurs’ – a phenomenon, an object, an authentic question, an immersive experience – is used as a prompt and a tool to activate a personalized, open-ended learning flow in which visitors are actively involved. In this, situated learning and the learning process are more important than results; meaning making and skill development come before subject-knowledge; and active participation and the development of a ‘scientific stance’ are among the main goals (Bevan & Xanthoudaki, 2008).

For the Education staff, learning and learners themselves are at the centre of our mission; educational research and pedagogical reflection are integrated into our practice; labs are not merely spaces to learn, but also contexts for research for the development of new approaches and tools that help foster and strengthen visitors’ learning at the Museum. In this context, a third pioneer event has been the creation of CREI©, the Museum’s Centre for Research in Informal Education, in 2009. The Centre is part of the Education Department of the Museum and was founded to promote research into, and practice of, methodologies and resources for museum learning and to develop and deliver training and professional development courses for formal and informal educators.

Throughout the history of the Museum, research and pedagogical reflection have helped define the main interpretative and learning principles that characterize our education provision. Methodological choices, contents, tools and learning objectives have evolved, been shaped by different historical moments or changes in the field of museum education but have always been determined by the strong belief in the centrality of the learner.

Today, our work builds on the learning principles of Inquiry-based learning and Tinkering and is inspired by the philosophy of Science Capital and Public Engagement (Archer et al., 2015; Harris et al., 2020; McCallie et al. 2009; NFS, 2000). At the same time, we are constantly working on new approaches and resources as no museum should think that its mission is accomplished by simply opening its doors and waiting for people to visit. The following paragraphs analyze an example of defining a new learning approach with the aim to help reflect on the criteria, steps and complexities of learning design as well as on the role of educational research and reflective practice as tools for innovation and professional development.

Designing ideas

The case discussed is Future Inventors, an education project of the Museum carried out with the support of Fondazione Rocca that aims to contribute a new teaching and learning approach to STEM education in junior high school. The project was undertaken to respond to: the need for enriching STEM education at school, today still characterized by transmissive approaches and rigid teaching structures (Xanthoudaki, 2020); the need to support teachers in acquainting themselves with new technologies, often closer to the agendas of their own students than to their own ones; and the need to reinforce the stance that sees individuals as active constructors of knowledge (Papert S. 1980). To meet the project aim, the Education staff of the Museum created a new learning space (the Future Inventors lab) combined with a series of STEM-oriented activities, resources for work in the classroom and a programme of art residences as the context for the design and testing of an alternative way to STEM school education.

We knew that that defining anything new and capable of challenging traditional schooling meant allowing for time for change and raising the bar: not (merely) design stand-alone resources for teachers and students, but use the project as a context for research and for questioning fossilized attitudes; not think in terms of single experiences, but create a 'learning flow' that looks into learning as a value, "creating a synthesis of the individual and her context, in an affective relationship between those who learn and that which is being learned" (Rinaldi C. 2006, p. 141). But, even more, seize the opportunity to look into our practice with its idiosyncratic nature, history and identity through a process of reflection that would bring an understanding of how we can contribute to the transformation of STEM learning in a more structured way.

The work acquired thus an action research dimension in the sense of a self-reflective, research-oriented inquiry to enhance direct practice and improve the rationality and justice of our practices, our understanding of these practices and the situations in which the practices are carried out (Carr & Kemmis, 1986). The process of reflecting on practice was regarded as equally important as the process of designing for practice.

Reflective practice or, otherwise, "living ourselves in a permanent state of research" (Rinaldi, 2006, p. 137) is a requisite for pedagogical innovation and professional development through which practitioners engage with their own experiences, learn to appreciate, to be aware and to understand experience itself (Eisner, 1985; 1998). Such process, in the form of conversations among the team of educators, was dedicated to observing and problematizing, "thinking for themselves and making their own choices, asking themselves what they should do and accepting the consequences of their own actions" (Smith, 2017). It led to a rigorous examination of which pedagogical elements from our own existing methodological context we needed to maintain and which ones to question as a way to introduce change.

As a result, we chose to maintain some of the methodological principles that we knew worked well in our work. Those were: the combination of content, approach, materials, environment and facilitation in the design of our labs; the tinkerer's disposition, strong in our Tinkering activities, that state of mind of taking oneself through a process of exploring a problem rather than solving it (Petrich et al., 2013; Bevan et. al., 2015); our approach to professional development based on the notion of the teacher as learner and reflective practitioner (Tickle et al., 1999; Xanthoudaki et al., 2007); and, of course, inquiry-based (science) learning, constructivism, constructionism and project-based learning as the well-established, solid basis that help strengthen the idea of knowledge as experience through the creation of a "conversation with the material" (Shoen, 1983 in Resnick & Rosenbaum, 2013, p. 165) and the construction of artefacts as a way of understanding and learning (Vossoughi & Bevan, 2014).

But the goal of coming up with a new approach for STEM learning meant that we also needed to break the ground and introduce methodological elements and concrete ideas for practice that were new and original. The direction we wanted to take was towards a ‘STEM learning ecology’ according to which the learner constructs her personal STEM ecosystem and STEM identity through a range of educational experiences; and it is this ‘identity’ that gives a sense of ownership when it comes to engaging in STEM-oriented experiences. It meant that we, as educators, needed to “build on what young people bring to the learning experience—their interests, skills, and personal areas of expertise—and help youth see how their interests can extend into the future” (Bevan B., 2016).

In Future Inventors, we wanted to build on the fundamental importance of creative thinking as well as the plurality, complexity, thus the richness of learning which is continuously influenced by personal stories and interactions with stimuli from the world around us. Personal stories and interactions with the world were not only pedagogical tools to exploit, and foster, with learners but have also been a decisive factor in our own learning design process. The components of the growing Future Inventors approach were influenced by the pedagogical discourse and case studies from ours and other fields or professional practice, but were also shaped by some particularly inspirational moments that helped us see - aha! - a solution for what we were seeking, and thus take a decisive turn in the development of ideas (Irvine, 2015). We mention two of those:

The Ars Electronica Festival 2018 - one of the pivotal events for understanding the potential of the digital for blending a range of fields into rich experiences - was the opportunity to encounter artists that ‘converse’ with, and integrate the STEM fields into their work. Among those, Gerhard Funk and his ‘Cooperative Aesthetics’ represented a powerful inspiration for the conception of some of the fundamental components of the Future Inventors approach. Funk’s research and work focus on the creation of immersive spaces in which participants can live collective audio-visual experiences and in which bodily engagement, immediate feedback, collaboration and the negotiation of behaviors become fundamental components of what takes place. Cooperative Aesthetics, now part of the Future Inventors lab, offered the opportunity to explore the notion of immersivity and embodied cognition and their role in learning, and represented the first important stimulus to the team to design experiences around the theme of (digital and analogic) Image.

Following that, the visit of the team to the “CALDER-PICASSO” exhibition at the Musée Picasso in the summer of 2019 helped us reflect on, to later introduce, the notion of aesthetic experience. While in the exhibition, and in the following discussions, we realized once more the ever-lasting dialogue between art and STEM. The theme of the Void, or the absence of space, was explored with curiosity and intellectual challenge by Calder and Picasso; for us it represented a beautiful example of the power of art in (re)interpreting a STEM-related concept stimulating at the same time emotions, an appreciation of beauty, connections and new meanings, all of them qualities of the aesthetic experience (Knobler, 1967). How would it be, we wondered, if we tried to create a similar dialogue within a teaching/learning situation?

What was increasingly brought to the surface of our thinking were a series of qualities acknowledged for their role within an individual’s experience but unfortunately still not considered equally valuable in STEM learning: bodily engagement, emotions, self-expression and open-ended, creative exploration, all of which can be also seen as constitutive elements of the aesthetic experience (Girod, 2007; Claxton, 2015; Chemi et al., 2017; Vecchi, 2010).

Aesthetic experience is an overarching notion with great pedagogical potential. In our case it encompasses all the qualities we wanted to introduce into Future Inventors and, defined as follows, determined the nature of the learning activities and experience designed for the project:

- a way to interpret human experience, which a) recognizes our body as the means to encounter and understand the world around us, the body perceived as the unity of senses, gestures and words; recognizing thus the importance of the physical experience as learning tool; b) is guided by curiosity and awe and inspired by beauty to create new meanings; c) inviting the creation of connections, at both cognitive and affective level, among ideas, objects and experiences (Vecchi, 2010; Girod & Wong, 2002; Dewey, 1934/1980; Girod, 2007; Claxton, 2015; Xanthoudaki, 1997).

- a pedagogical tool, compelling, transformative and unifying, through which emotion and anticipation become the flywheel for change and for the desire to pursue similar experiences; and which mixes the value of creating knowledge with the value of exploration, joy and the expression of ideas, thoughts and emotions (Dewey, 1934/1980; Girod & Wong, 2002).

All the above stimuli, gathered into a gradually emerging methodological structure, worked on the idea that subject-knowledge across different fields is blended with a range of '*linguaggi*[1] to build situated learning experiences that could engage learners cognitively as well as emotionally - but this *only* if the learning flow can be addressed as a unique, evolving process. The Future Inventors approach was gradually emerging as such, a learning flow that can, ideally, help get deeper into the STEM contents through creative thinking and personal expression.

Structuring ideas

The notion of 'learning flow' was one of the most important ideas adopted in the process of designing the Future Inventors approach: instead of a series of stand-alone activities, we argued for a single and gradually evolving experience which invites learners to explore, and engage with, STEM-oriented situations, differently from one passage to the next, thus scaffolding their knowledge and skills and building a deeper and more meaningful relationship with STEM.

Our initial thinking was inspired by the 'attention-value model' of Bitgood (2010) conceived for museum exhibitions to examine and improve visitor attention. It suggests three levels of attention - capture, focus and engage - each distinguished by qualitative and quantitative types of attention and by the combination of psychological and physiological processes at work. The levels represent a progression from broad, unfocused attention to narrow, deep processing of exhibit information.

Although referring to a different context, what we liked in this model was the frame it offered for developing our learning flow to integrate both consolidated and new methodological elements into a progressive learning experience. We imagined the learning flow as going from *capturing* attention through a response to a powerful stimulus (Bitgood, 2010, p. 5); to *focusing* on a single aspect as a way to elaborate and deepen into concepts (Ibidem, p.6); to *engaging* through deep sensory-perceptual, mental and affective involvement and a personal interpretation that would lead to meaning making and a deep, emotional response (Ibidem, p. 10).

This frame allowed us to place, beside inquiry-based science and project-based learning, what we view as potentially pedagogically powerful methodological elements: art (as process and product), creativity, aesthetics, immersivity, bodily engagement, self-expression – in the form of arts installations, activities, tools, and materials – within a learning flow and a physical space (our Future Inventors lab).

The Future Inventors approach consists of three phases – Capture, Focus, Engage – that invite learners to be part of different types of experiences:

- *Capture* experiences build on digital art installations that powerfully integrate and explore science and technology. No explicit reference is made to STEM at that point, while encounters are of immersive nature and characterized by an interaction with immediate impact at emotional and aesthetic levels. Immersion and aesthetic experience help engage the senses, cognition, emotions, the body, often in unexpected ways and offer a series of meanings and insights that stimulate reflection among learners.

[1] The literate translation of 'linguaggi' is 'languages'. In the education field, the term has been widely used by Reggio Children to indicate the many ways children use to express themselves in addition to the spoken language. In this paper, we use the term to mean to the expressive, cognitive and communicative languages together with the many art-oriented expressive and interpretative means. www.reggiochildren.it/assets/Uploads/Rechild-24x34-MALAGUZZI-ESEC-taglio-low.p1.pdf

- In *Focus* experiences, STEM contents and digital tools, which lie at the basis of the installations, become the subject of experimentation that helps learners encounter and explore the science concepts and the technologies, understand their qualities and how they might connect, and build basic knowledge to enable reuse of learned concepts in other situations.
- In *Engage*, learners build on the knowledge, skills and experience developed in the previous phases to conceive and design their own project with a strong self-expression and storytelling dimension. A successful Engage project should be unique and reflect the learners' synthesis of the concepts and ideas they encountered in the Capture and Focus activities.

Capture, Focus, Engage became key terms for our own discussions, explorations and documentation, conceived in an inter-relation and as the *fil rouge* connecting everything that takes place in the lab. They became the 'containers' for continuously evaluating ideas, tools, for test our theory and understanding the rationality and justice of our practices. Collective conversations were full of analyses of our experience and reflections on the phenomena before us, helping to develop a new understanding of the constitutive characteristics of the Future Inventors approach.

Testing ideas

Following the initial creation of a theoretical basis and the prototyping of the learning flow, the lab, the resources and the activities became the subject of testing with schools – in two parts: the first testing phase involved 12 expert teachers with the aim to co-design and reflect on the characteristics of the approach and its transferability into the school practice; the pilot testing phase consisted of a series of collaborative professional development experiences with teachers and one of learning experiences with students, in the Museum and at school, across an entire school year. It is worth mentioning that for both co-design and pilot testing phases we asked for the participation of a team of teachers from each school – science, technology, and art or music teachers working together (rather than of a single teacher per school) – as a way to promote interdisciplinarity, mutual support and collaboration into a common project, something not habitual at junior high school level.

Our intention to involve teachers as co-designers was to give them agency in both the process and the product that is Future Inventors, for several reasons: the first is that teachers have intimate knowledge of context and practice, as well as relationships with the students, that museum educators do not. This was particularly significant because we were designing activities that should become opportunities for creative self-expression. Because each student is unique, they require enough freedom to orient their projects around their interests to meaningfully connect with their curiosity. Since museum educators are not in a direct relationship with the students for most of the time, they find it more difficult to maintain the relationship of curiosity, openness and respect for their ideas that is the best means of supporting their creative process. Only teachers, by virtue of their proximity, can do that. We thus stablished a relationship with the teachers that was similar to the kind of relationship we hoped they would create with their students during the project - one of acceptance, curiosity, and most of all open-ended. That is not possible without granting them agency, and indeed responsibility, in reinterpreting our design and intentions in their classroom. Such reinterpretations from the teachers were also one of the best ways we have of getting feedback to improve our ideas in both the short and long term.

During the testing phases, even more inspiring than the appreciation received were the discussions with teachers around the key concepts of the Future Inventors approach. Teachers acknowledged the potential of Capture-Focus-Engage, as well as of aesthetic experience and the other qualities (interdisciplinarity, bodily engagement, self-expression, etc.), if adopted directly into the school practice. For example, the experiences included in Capture could unfold their potential for students' learning in STEM but only under the condition that their unique qualities – the poetic and 'theatrical' nature, the physical and sensory engagement, the artistic aspect and the potential of triggering questions and new explorations – could be reproduced in the school context in a similar way as they were in the Museum. Engage was seen as the open-ended conclusion of the learning flow, totally influenced by the learners' own direction and choices, their knowledge, skills and previous experiences, both pre-acquired and those built during Capture and Focus. Although project-based learning is not new at school, Engage represented a way to interpret and express STEM-oriented ideas through a personal journey of creative exploration. In Engage, digital and analogic tools, *linguaggi*, encounters with art and all the experiences in Capture and Focus are mixed with the learners' personal context into a narrative that is meaningful to the learner. As is true for Capture, transferability of Engage at school could be of impact and benefit only if we can guarantee the possibility for open-ended explorations and authentic self-expression for the students, that can lead to realizing their own stories and ideas.

Teachers' contribution to the design of the approach was strategic. Their considerations enriched our work substantially and shaped the following phases of the project; but, more than that, it helped us become more aware of the place that traditional manifestations or more constructivist or situated instantiations hold in the spectrum of 'what counts as science learning' at school and the museum. We would still find many examples of transmissive models of "successful acquisition of bits of knowledge", or examples of "make-and-take" processes in teachers' practice (Bevan & Xanthoudaki, 2008); and we would still see science education considering only logico-mathematical learning qualities as relevant or valuable for what is to be learned or assessed (Bellocchi, Quigley & Otrel-Cass, 2017). Realizing this was fundamental for understanding the ground to keep working on: if we really want people to be self-confident, skillful learners, we need to create the conditions that invite them to develop a creative mindset. In Future Inventors, arguing for dialogue between STEM, aesthetics, self-expression and embodied cognition within a learning context meant yet another opportunity to challenge traditional STEM teaching practices. It meant pushing for more open-ended learning, in which the learner's own subjectivity, interests and sense of aesthetics become the foundational elements of their curiosity, motivation and inspiration. These in turn can guide and shape the choices the learner makes, become their means of navigating the near-infinite possibilities of open-ended problems to arrive at a meaningful outcome. In our view, subjectivity and aesthetics are indispensable to the creative process not only in the arts, but also in STEM.

Future Inventors is currently undergoing the Implementation phase through a long-term planning that aspires to reach teachers and students at national level. The Museum continues its effort in promoting a new way of approaching STEM not only through teacher training or the provision of resources for work in the classroom, but also with the continuation of reflecting on the above issues at methodological level: carrying out further research and extending the reach of the project to other contexts i.e., adopting the Future Inventors qualities in other labs or projects, involving policy makers, creating new programming that explores the dialogue between STEM and aesthetics, etc. Our idea is that this approach can contribute to the enrichment and strengthening of a positive personal relationship between individuals, science and technology.

Reflecting on ideas

Future Inventors represented a unique opportunity for professional development in the Museum, radically different from the more traditional how-to professional development experiences that immerse educators in activities that they can implement later with visitors (Bevan & Xanthoudaki, 2008). The project was taken as an important 'case' of informal learning and facilitation, a data-driven, real situation to review and discuss in terms of underlying theories, roles and interactions. Articulating, reflecting and debating over those situations provided opportunities to gain insights into our own assumptions about 'what counts' as science learning also in the museum context. The underlying, central idea in much of learning sciences research — that cognition is a profoundly cultural and social activity — is not new to the museum education field. By and large, theories that underpin the rhetoric of teaching and learning in the museum field have been constructivist, arguing that learning is a cognitive and affective process of exploration and experimentation integrating the experience, existing knowledge, and background of the individual learner. The contemporary museum seeks, therefore, a negotiation between the knowledge and culture sedimented in objects, exhibitions, spaces and tools, on the one hand, and the knowledge, memory, emotions, and socio-cultural background embodied in the visitor herself, on the other. Learning depends directly on the meaning that the visitor develops through her own experiences in the museum, and this should have an important impact on both learning design and facilitation.

Future Inventors allowed to work along these principles building an approach and related resources that could help broaden 'what counts as/in learning', at school as well as in the museum, and indicate a direction to take as far as our professional development is concerned. As Bevan & Xanthoudaki argue:

> "Professional development is a long-term investment: it takes time to change practices, not to mention changing epistemological stance. […] unless the fundamental epistemological underpinnings of transmission models are thoroughly, and constantly, re-examined, through ongoing professional development for museum educators/floor staff, our theories of learning cannot and will not inform our practices and vice versa" (2008, page 9).

As museums position themselves as active agents in today's learning societies, museum educators can be decisive professionals, the "audience advocates" who can help engage new and more diverse audiences and best articulate connections between visitors' learning needs and museum policies and practices.

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