WeMake: a Framework for Letting Students Create Tangible, Embedded and Embodied Environments for their own STEAM Learning

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Objective

- WeMake proposes a series of steps in order to combine different **opportunities**, the different **theoretical frameworks** and the various **technological and pedagogical enablers** in order to trigger students and teachers to construct their own **STEAM learning tools**

- ***Science, Technology, Engineering, Arts and Mathematics***

- a) how learners can be involved in and take the responsibility of the construction of their own learning devices, rather than in the mere use of pre-given learning devices,
- b) how teachers can be stimulated to enhance learners' con-constructive activities
- c) how effective embodied learning environments can be disseminated in schools sooner than later
- d) how to create a community of sharing resources about embodied learning environment with the participation of researchers, teachers and students

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Motivation

- Designing learning activities that promote conditions for embodied learning is an emerging and not yet systematized area of research
- Further research is required for researchers to learn how to cue the body to enact certain actions and create physical representations that facilitate conceptual understanding

- Existing research on embodied learning technologies has been disparate, driven largely by specific technical innovations and constraints, and often lacking a clear focus on establishing their efficacy in educational contexts
- The design space for ideating relevant interactive learning environments is chaotic and most of the proposed environments are polarized either towards the technological or the pedagogical view on the basis of the team members that produce each learning environment
- How can we combine all these different opportunities, the different theoretical frameworks and the various technological enablers, the various scientific perspectives, the experience in each separate learning domain in order to construct effective, efficient and enjoyable embodied interactive environments?

Motivation

- Another significant drawback of current embodied interactive technologies is that their mass deployment in schools seems infeasible since they are usually
  - developed only for research purposes,
  - are customized with expensive technologies,
  - do not follow the curriculum
  - while teachers also do not have confidence in using them

- STEAM happens to coincide with the recent enthusiasm for the “maker movement”
  - Low cost rapid prototyping together with the uprising trend of arts and crafts fairs, tinkering and inventing, can enable students to recreate such embodied interactive technologies and concurrently empower creativity and problem solving, brainstorming, sustained perseverance and a lot more.

WeMake: students create tangible, embedded and embodied environments for their own STEAM learning

- WeMake is based on two pillars:
  - it underlines the need to create an interdisciplinary team of experts that together with students/teachers and a new participatory design methodology adapted to embodied interactions, will develop low cost and easily reconstructable embodied interaction environments for STEAM learning domains;
  - and secondly, to invite students, teachers and schools across the world to build, exploit, share and assess their own versions of these embodied learning environments

- Expertise is needed in the learning domain (STEAM learning domains), child-computer interaction, cognitive psychology, educational technology, interactive installations, arts, prototyping and participatory design.

- The development of a new participatory design methodology that will leverage this symmetry of ignorance and help the participants negotiate their different perspectives of embodied interactions and also enable them to develop common externalizations of embodied performances that will mediate their collaboration

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- In order to explore systematically the design space of interactive embodied learning, the design team will focus on three widely exploited types of interactive embodied learning environments for STEAM:
  - *mixed reality spaces* where physical and digital objects co-exist and where the body is situated in the environment and interacts with it. Mixed reality environments offer a large vivid and immersive audiovisual interface for eliciting body activity (interactive floors, interactive walls etc.).
  - *tangibles*, digital manipulatives that become objects to think and act with (building bricks and balls, interactive physical objects, tools, etc.).
  - *e-textiles* are wearables at the intersection of physical, digital and artful media and which will help students to “embody” new conceptualizations and representations

- The three different interfaces have been selected as they provide multiple means of engagement, multiple means of representation, and multiple means of action and expression.

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- However, the design products of the interdisciplinary team must comply with two design constraints
  - they must be low-cost by using mainstream prototyping hardware and software
  - they should be easily reconstructable by students and teachers. In order to be highly populated, the products should be accompanied by construction guides and learning scenarios in order to help students to create them and teachers to embrace them.

- Afterwards, all the products will be shared through an online STEAM makerspace platform which will enable researchers, teachers and students to share designs with each other and more specifically to
  - to present new embodied interactive learning environments
  - to provide learning scenarios and instructional guides for the proposed learning environments
  - to present personal variations and improvisations on the proposed learning environments
  - to view anonymous learning usage data for each learning environment

- The online STEAM makerspace will promote the maker culture which provides an effective mechanism for K12 students, particularly women and multicultural students, in pursuing STEAM fields.

Embodied STEAM learning and MR environments

- Mixed Reality (MR) environments merge the digital with the physical and offer a vivid and immersive audiovisual interface for eliciting body activity.

- In these environments, authentic and expressive physical activity can be augmented with digital displays that emphasize the metaphor and tools for feedback and reflection

- Mixed reality technologies allow students to become part of the system they are trying to familiarize with, and give them the advantage of the insider who can monitor and evaluate the mechanisms and relationships that define the domain

- Up to this point, there has been little research examining outcomes for students learning the same content in the same simulation environment, differing only in the degree of immersion and physical interaction with the interface.
- Also, the duration of the interventions in the various studies is limited (from 20mins up to 1 week) while relatively few empirical studies have investigated learning in authentic classroom settings

- **WeMake framework suggests to focus on large interactive floors and will try to exploit varying degrees of sensorimotor activation, gestural congruency and immersion and also explore the collaborative perspective of mixed reality spaces since it is of paramount importance for realistic classroom settings**

Embodied STEAM Learning and Tangibles

- Tangibles are frequently used to teach children abstract concepts, in STEAM

- Tangibles are able to offer a natural and immediate form of interaction that is accessible to learners, promote active and hands-on engagement, allow for exploration, expression, discovery and reflection, provide learners with ‘tools to think with’ and offer opportunities for collaborative activity among learners
- In order to achieve the goal of designing efficient and effective learning tangibles, designers and researchers have to bring together specific knowledge about children’s cognitive, physical, emotional, and social skills, the idiosyncratic characteristics and prior experience on each field domain and the opportunities provided of tangibles environments

- **WeMake suggest to investigate the cueing possibilities of tangible representations by exploiting a range of material properties (e.g., size, shape, texture, temperature, weight), by putting emphasis on multiple output modalities of the designed products and by identifying ways to transfer performance from physical to symbolic representations of problems**

Embodied STEAM Learning and E-textiles

- Wearable technologies can incorporate a wide variety of sensors for measuring mechanical information (i.e. position, displacement), acoustic information (i.e. volume, pitch), biological information (i.e. heart rate, temperature), optical information (i.e. refraction, light wave frequency) and environmental information (i.e. temperature, humidity) but they can also offer multimodal output by providing haptic feedback, integrating screens, producing sounds
- E-textiles address excellently the challenge of designing STEAM activities which must authentically engage participants in both STEM fields and the arts.
- E-textiles have already demonstrated its capacity in the professional realm to invite and sustain participation from women
- Electronic textile (e-textile) toolkits have been successful in empowering users to engage in meaningful design that is creative, self-expressive, and personal and concurrently seem to offer greater transparency into STEM disciplinary content i.e. for exploring physiology

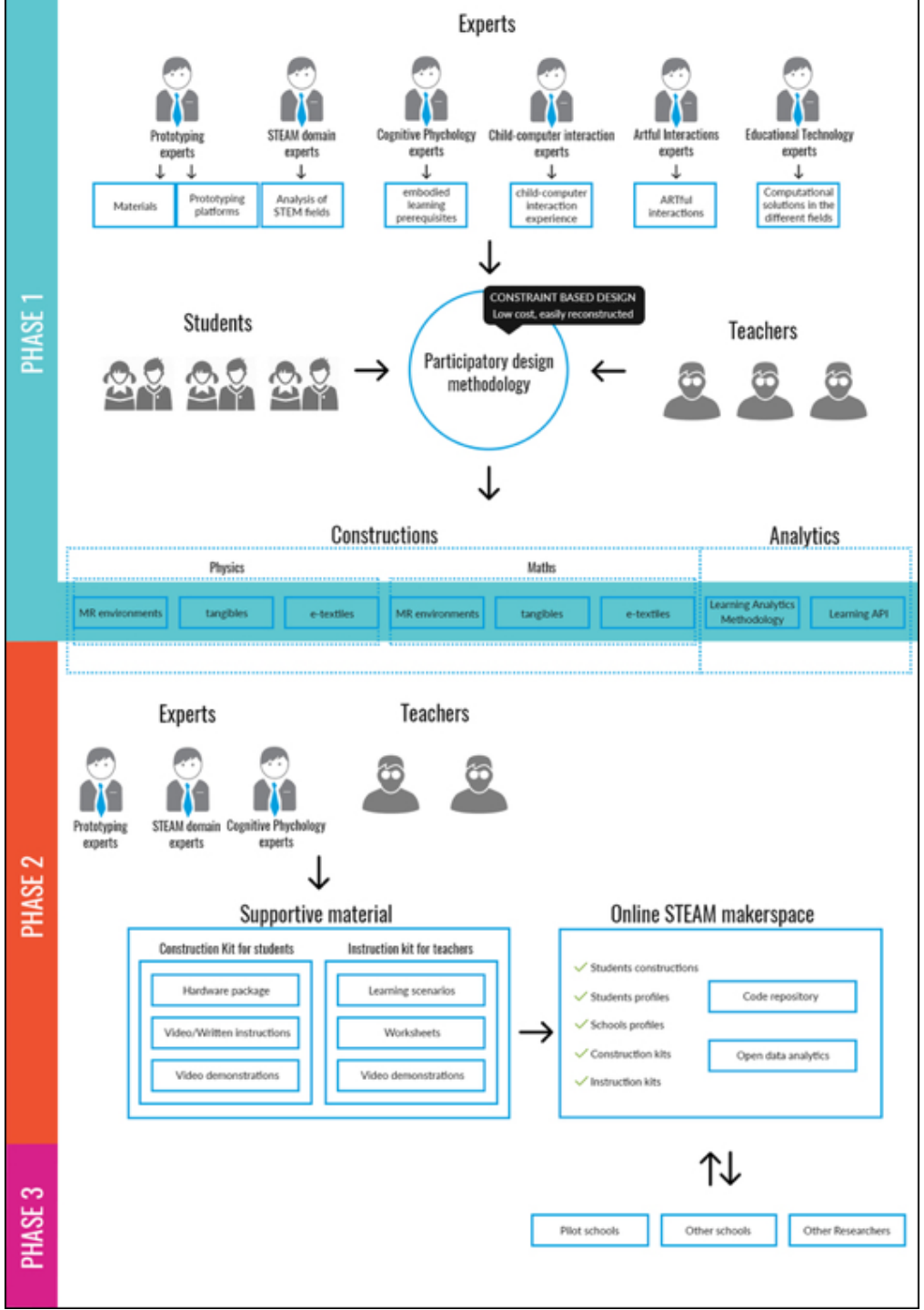
- **WeMake recommends the wearables to be designed by an extended multidisciplinary team of experts together with students and teachers, with the aim of exploring different ways of creating representations with the body. The design of wearable interfaces should identify the preconditions for delivering open-ended exploration, a high degree of personal expression, and aesthetically compelling possibilities with the e-textiles**

The WeMake phases

- WeMake aim is to enhance STEAM educational practice by applying interdisciplinary embodied interaction/learning paradigms and by inviting students and teachers to design, develop and exploit their own mixed reality spaces, learning e-textiles, and learning tangibles

Its structure has been developed having in mind the following goals:

- To develop and study innovative embodied learning artifacts that address significant STEAM learning obstacles
- To provide playful and effective learning interactions to students by integrating museum-inspired digital installations, wearables and learning tangibles in the daily learning practice inside the school
- To make accessible such learning experiences to all schools by exploiting the new wave of low cost prototyping platforms, by addressing curriculum needs and by providing teachers the necessary deployment tools
- To enable students to become the creators of their learning tangibles, mixed reality spaces e-textiles of their schools
- To motivate creativeness and handcraft mentality and to disseminate the maker culture in schools
- To offer synergies between schools of different areas/countries
- To provide personalized embodied interactions by exploiting the wealth of data collected from different schools
- Offer incentives to researchers, companies, learners and teachers for the continuous design, development, application and research analysis of similar embodied learning environments beyond the projects' lifespan.



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The Design Methodology

- WeMake requires the development of a new participatory design methodology since the interaction in such embodied learning environments is not the only the mean but also the goal.

- The act of interacting should also be an embodied act for learning; students are asked to act with their bodies, learn and interact with the environment.

- The new methodology should emerge from tailoring and mixing existing participatory design methods (e.g. cooperative inquiry, future workshop), techniques (e.g. play-back theater, bodystorming) and ideation tools (e.g. ideation decks, technological probes) after making them suitable
  - a) for the three types of embodied interaction: mixed reality spaces, tangibles and wearables
  - b) for facilitating multi-stakeholders preparation and collaboration (from students to researchers),
  - c) for sharing creative practices, purposes and reaching common understanding when negotiating about embodied representations
  - d) for the STEAM domains

- A direction for the development of the participatory design methodologies seams to be a research through design (RtD) approach, an approach also known as design-based research

Future work

- The ultimate goal of learning and teaching is the acquisition of adaptive rather than routine expertise or competence i.e. the ability to apply knowledge and skills flexibly and creatively in a variety of contexts and situations (as opposed to simply completing stereotype school tasks without understanding)
- STEAM learning has to be conceived as an active, constructive and self-regulatory process of sense-making, understanding, and problem solving within a community of learners.
- There is ample evidence that instruction that endorses such a view needs to promote, from the very beginning, learner autonomy. This will create the necessary affective climate for the development of intrinsic and autonomous incentives for and authentic interest in the STEAM domains.

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