The GW Mobile Learning Center: Mixed-Reality within an Immersive and Interactive Learning Setting

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Abstract—The Community Medi-Corps Program—designed and implemented by the George Washington University (GW) School of Medicine and Health Sciences (SMHS) faculty with Growth and Opportunity Virginia funding (GO Virginia)—is aimed at leveraging the power of community, educational institutions, mentors, industry, and business partners to close the opportunity gap, transform student learning, and enrich the regional workforce. This program transforms educational experience through innovative virtual reality, augmented reality, and a mix between the two that is the enhanced reality (e-REAL). Students will be better prepared in the pathways they choose for high demand health and life sciences industry jobs that will help grow the economy.

Keywords—immersive experience, interactive visualization, STEM education

1 The Community Medi-Corps program

Talent is everywhere, but opportunity is not. The Community Medi-Corps Program—designed and implemented by the George Washington University (GW) School of Medicine and Health Sciences (SMHS) faculty with Growth and Opportunity Virginia funding (GO Virginia)—is aimed at leveraging the power of community, educational institutions, mentors, industry, and business partners to close the opportunity gap, transform student learning, and enrich the regional workforce.

The Community Medi-Corps Program (Medi-Corps) is a $1.6 million project made possible by a $700,000 grant from GO Virginia. The program will augment curriculums and enhance health sciences education in the Alexandria City (Virginia) Public Schools (ACPS), Arlington (Virginia) Public Schools (APS), Fairfax County (Virginia) Public Schools (FCPS), and Loudoun County (Virginia) Public Schools (LCPS) The centerpiece of Medi-Corps is a mobile Immersive Learning Center (ILC)—a 45-foot-long classroom/lab on wheels that provides students with cutting-edge technology, simulation, and immersive virtual reality and augmented learning experiences [1].

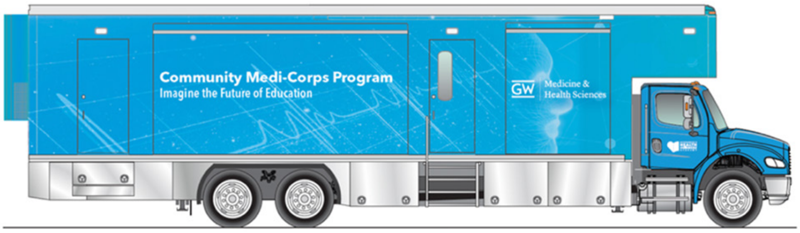


Fig. 1. Rendering of the mobile immersive learning center

Fig. 2. Internal view of the mobile immersive learning center

Fig. 3. Another perspective on the mobile immersive learning center

Medi-Corps and the ILC allow students to engage and work together to problem-solve, use virtual technology, and interact with experts in the life and health science fields. Faculty and staff members from SMHS and the four partnering school systems are supporting the project. The ILC incorporates the latest immersive learning technologies to support critical thinking and applied learning, and to maximize student learning and engagement. Our vision is for this initiative to serve as a best practice for other areas in Virginia and the region. We feel strongly that this innovative model, linking secondary education and four-year institutions, will benefit students in numerous ways and better prepare them in health sciences.

Although virtual reality (VR), augmented reality (AR), and mixed reality (MR) simulation training has gained prominence, review studies to inform instructors and educators on the use of these technologies—usually grouped under the name of extended reality (XR)—in science, technology, engineering, and mathematics (STEM) are still scarce. We found interesting references in Pellas, Dengel and Christopulos that analyzed various VR-supported instructional design practices in K-12 (primary and secondary), as well as higher education, in terms of participants' characteristics, methodological features, and pedagogical uses in alignment with applications, technological equipment, and instructional design strategies [2]. For the design of both the mobile ILC and the learning experiences, we decided to implement the guidelines from Salvetti, Bertagni, Wieman, Waldrop, and Brenner that are summarized by the title of the book Learning 4.0: Advanced simulation, immersive experiences, flipped classrooms, mentoring and coaching [3].

Fig. 4. An e-REAL interactive content: virtual patient

Our project emerges from a large-scale collaborative effort supported by a large number of professionals and institutions. Our colleagues provided support for this initiative at multiple levels. The commonly shared goal is to inspire youth to explore and connect as we create tomorrow's next generation of health sciences leaders.

Students are expected to be able to engage and collaborate, thanks to state-of-the art opportunities for students to learn STEM-H subjects interactively.

The Medi-Corps program is aimed at further bridging the gap between academics and the workforce by offering internships and mentorships with experienced health professionals.

The Medi-Corps team envisions the project to serve as a best practice that can be replicated in other areas in Virginia and the region. The innovative model, linking secondary education, community colleges, and four-year institutions, will benefit students in numerous ways and better prepare our future workforce in health sciences.

Medi-Corps is based at the Governor's Health Sciences Academy (Academy) at Alexandria City High School. Academy, APS, FCPS, and LCPS students are expected to experience interactive learning in the ILC, starting in the 2022–23 school year. Community events that showcase immersive learning and opportunities in the health and life sciences fields are also planned.

2 The mobile immersive learning center and the vision behind the program

The ILC was designed by the GW SMHS Community Medi-Corps grant team in collaboration with LifeLine Mobile, a vendor from Columbus, Ohio, and with the Logosnet Instructional Design Team, and the e-REAL Technology Team. The ILC features a 45-foot mobile immersive learning center that bridges the gap between the classroom and the field.

Fig. 5. Exterior view of the mobile immersive learning center

The ILC transforms educational experience through innovative virtual reality, augmented reality, and a mix between the two that is the enhanced reality (e-REAL). It raises student aspirations and attracts students to postsecondary education, provides summer programs, job fairs, and community outreach events.

The main issues addressed by the Medi-Corps Program are:

- Limited diversity in the life sciences and health professions workforce has significant consequences for access to health care services, health outcomes, and health equity, especially for underrepresented minority patients and underserved communities.
- Youth who identify as racial or ethnic minorities are less likely to be exposed to and less prepared for a range of STEM-H careers.

A long-term demand exists for skilled and credentialed health and life science workers: the field is growing at a faster rate than others with 7–26 percent growth forecast through 2028.

The Community Medi-Corps program strives to:

- Provide summer programs, job fairs, and community outreach events.
- Engage professionals in STEM-H fields to serve as student mentors.
- Shape future leaders essential for a healthier society.
- Champion equitable excellence and robust academic opportunities.
- Enrich the diverse communities it serves.
- Promote equity, diversity, and inclusion in practice.
- Influence future workforce needs for high demand jobs.
- Contribute to the region's economic growth and resilience.

To learn more about the program and the STEM mobile lab please view this video: https://youtu.be/1UL51zFq_bM.

Experts in postsecondary education agree that the center can provide students with hands-on learning experiences and encourage them to stay in STEM and health care fields after graduation.

According to William Corrin—the director of K-12 education at MDRC, an organization that researches social policy—high school and university partnerships are beneficial because they smooth the transition for students, making it less of a gap and more of a bridge. "Those transition points are usually the places where there's the greatest risk for students to experience some kind of disruption to their educational trajectory," Corrin said.

Max Milder, the director of research at EAB, an education research organization, said partnerships between higher education institutions and high schools can create a pipeline of leading new students to the institution. "Universities are always interested in how they're going to continue to attract future students or enrollments in the coming years," Milder said. "There's a part of this that is getting George Washington University in front of high school students as early as possible, even before they're going into that decision-making process for enrollment."

Milder said exposing high school students to high-level technology that is common in medical education familiarizes students with what they'll be using throughout their medical careers. "Experiential learning is really critical," he said. "And that's true in K-12. That's true in higher education as well. And so part of the effort here is to bring some of these scientific or medical concepts to life and do so in a way that is really engaging and hopefully fun for the students as well" [3].

The most innovative virtual, augmented, and mixed reality technologies are on board into the mobile ILC. Reality in the digital age is becoming more and more virtual, augmented, and mixed. These technologies offer options to improve learning methods. Sharing and mixing up the latest trends from digitization and virtualization, neurosciences, artificial intelligence, and advanced simulation allows us to establish a new paradigm for STEM-H education.

3 The learning setting and the main educational outputs

The learning setting of the mobile Immersive Learning Center is designed according to the STEAM approach: It's the extension of an acronym that originally stands for science, technology, engineering and math, with the arts added because STEM alone misses several key components that many employers, educators, and parents have voiced as critical to thrive in the present and rapidly approaching future. The STEAM approach refers to a movement that has been taking root over the past several years and is surging forward as a positive mode of action to truly meet the needs of a 21st century society.

STEAM uses science, technology, engineering, the arts and mathematics as access points for guiding learner inquiry, dialogue, and critical thinking. The end results are learners who take thoughtful risks, engage in experiential learning, persist in problem-solving, embrace collaboration, and work through the creative process. STEAM is a way to take the benefits of STEM and complete the package by integrating these principles in and through the arts. STEAM takes STEM to the next level: it allows learners to connect their learning in these critical areas together with arts practices, elements, design principles and standards to provide the whole pallet of learning at their disposal. STEAM removes limitations and replaces them with wonder, critique, inquiry, and innovation [5].

Designing a program that includes active learning requires more content knowledge, not less, than teaching in the classic lecture mode. If a teacher uses active learning techniques, they are still telling students information, but it's in response to their questions, their needs to solve a problem, and so they learn much more from it [6]. So, a teacher has to work hard to use active learning in the class and has to carefully structure problems and activities to get students to think like a scientist, mathematician, or, in our case, as a healthcare professional.

In active learning methods, students are spending a significant fraction of the time on activities that require them to be actively processing and applying information in a variety of ways, such as answering questions using electronic clickers, completing worksheet exercises and discussing, and solving problems with fellow students. The instructor designs the questions and activities and provides follow-up guidance and instruction based on student results and questions. Also, good active learning tasks simulate authentic problem solving and therefore teaching with these methods typically demands more instructor subject expertise than does a lecture [7].

The setting of the mobile Immersive Learning Center is designed around 3 key-words: visualization, interaction, immersion. It is a fully immersive and multitasking environment, designed to present challenging situations in a group setting, engaging all participants simultaneously. The e-REAL instructional design and technology make possible teaching and learning with motion pictures, as well as with 3D visualizations and augmented reality tools. These tools are fully interactive and "talkative"; avatars or digital humans are a key-component of the setting.

Effective visualization is the key to help untangle complexity: the visualization of information enables learners to gain insight and understanding quickly and efficiently. Examples of such visual formats include sketches, diagrams, images, objects, interactive visualizations, information visualization applications, and imaginary visualizations in scenarios [8]. Visualizations within e-REAL show relationships between topics, activate involvement, generate questions that learners didn't think of before, and facilitate memory retention. So visualizations act concept maps to help organize and represent knowledge on a subject in an effective way.

Half of the human brain is devoted directly or indirectly to vision, and images are able to grab our attention easily. Humans process images very quickly: on average, a person processes visuals 60,000 times faster than text. This is why we, as humans, are confronted with an immense amount of images and visual representations every day: digital screens, advertisements, messages, information charts, maps, signs, video, progress bars, diagrams, illustrations, etc. If we have to warn people, symbols and images are excellent: they communicate faster than words and can be understood by audiences of different ages, cultures, and languages. Images are powerful: people tend to remember about 10% of what they hear, about 20% of what they read, and about 80% of what they see and do [9].

Also, contextual factors have tremendous importance because they are key to learning. Learners practice handling realistic situations, rather than learning facts or techniques out of context. Context means "related factors" that can be influential and even disruptive. The most effective learning occurs through being immersed in context. Experience is lived and perceived as a focal point and as a key crossroad [10]. Much like being immersed within a videogame, people are challenged by facing real cases within complex scenarios that present a more than real wealth of information. This is because the many levels of the situation are made available simultaneously, by overlaying multisource information on the projected walls and inside a number of augmented reality displays made available within the setting.

The e-REAL setting and technology submerges learners in an immersive reality where the challenge at hand is created by sophisticated, interactive computer animation in three dimensions and holographic projections. Multi-surface environments require users to be "physically" engaged in the interaction and afford physical actions like pointing to a distant object with the hand or walking toward a large display to see more details. Based on a body-centric paradigm, the e-REAL setting is well-adapted to device- or eyes-free interaction techniques because they account for the role of the body in the interactive environment. Very large interactive wall displays do not lend themselves to use with traditional interaction modalities such as mice and keyboards. It is a multi-surface environment that encourages users to interact while standing or walking, using their hands to manipulate objects on multiple displays. Within the e-REAL setting, the body itself is used for input: Users can interact by moving the body, or with a flick of the hands and some other gesture [11–13].

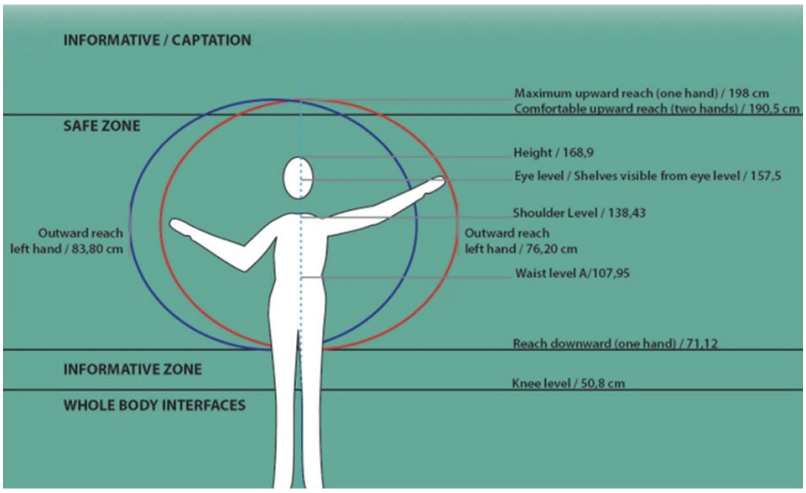


Fig. 6. Ergonomic reference table for e-REAL gesture shaping and body interaction

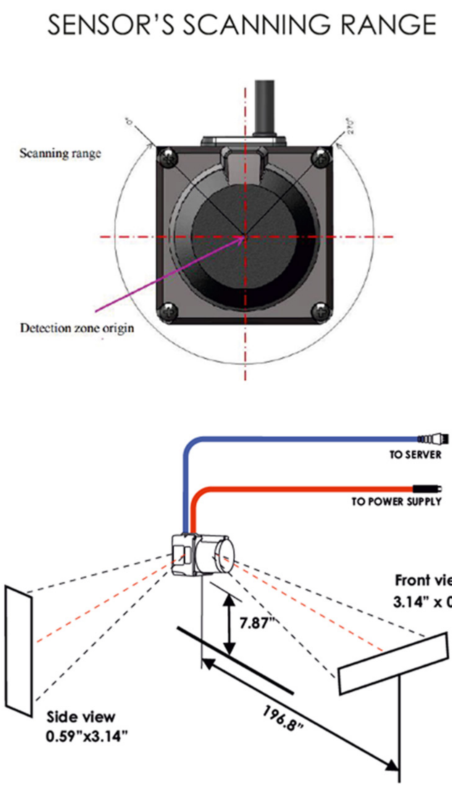
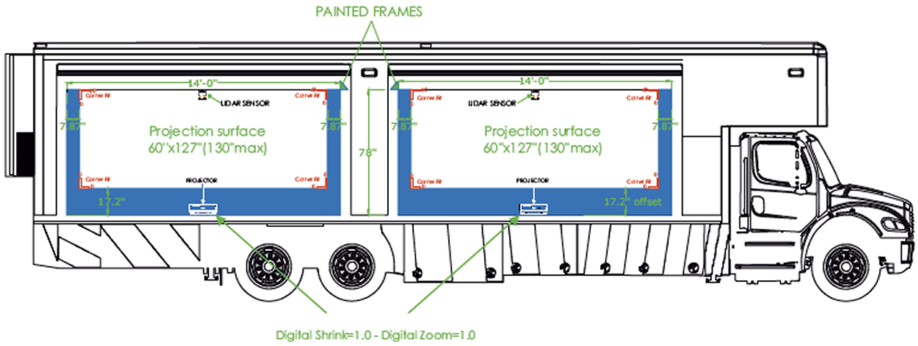


Fig. 7. The e-REAL sensor enabling gesture shaping and body interaction



- Projection rapport: 16:9
- Projection surface: 60"x127"-130"
- Projection area will be surrounded, onto the same wall, by a frame painted like the side walls
- Projectors' settings (Corner Fit, Digital Shrink and Zoom) are displayed into the above image.
- Projections' height from the floor is expected to be 85'': the visible projection's height will be reduced to 78'' from the floor by an electronic "black strip" with parametrized height (approx 7''), adjustable at runtime.

Please notice that there is a 3% tolerance regarding projection's expected performance, due to optical component variations. It is recommended to physically test the projection size and distance before permanently installing the projector.

Fig. 8. Projection surfaces and details about the e-REAL immersive setting

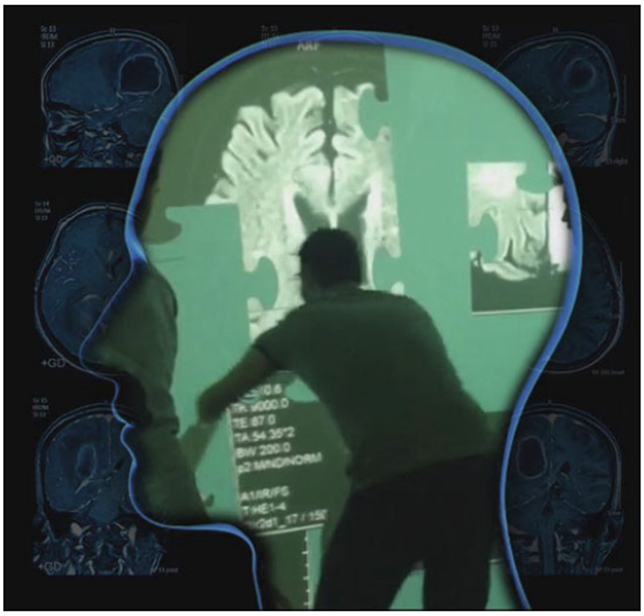


Fig. 9. A learner facing an e-REAL interactive image showing a brain cancer, divided in 8 pieces, during an experiment aimed at determining whether cognitive retention improves when visualization is broken into multiple smaller fragments first and then recomposed to form the big picture

Using the body enhances both learning and reasoning and this interaction paradigm has proven effective for gaming [14], in immersive environments [15], when controlling multimedia dance performances [16] and even for skilled, hands-free tasks such as surgery or emergency medicine [17]. Smartphones and devices such as Nintendo's Wii permit such interaction via a hand-held device, allowing sophisticated control. However, holding a device is tiring [18] and limits the range of gestures for communicating with co-located users, with a corresponding negative impact on thought, understanding, and creativity [19].

Advances in sensor and actuator technologies have produced a combinatorial explosion of options that do not require hand-held devices. The e-REAL interaction design team, since 2011, has tested and selected various options in order to combine them in a coherent, powerful way based on specific guidelines (like the ones displayed in Figure 6). A few simple and intuitive gesture options are the solution, enabling the learning experiences within the mobile Immersive Learning Center. In such a way, learners are physically engaged in the interaction and afford physical actions like pointing to a distant object with the hand or walking toward a large display to see more details [20], listening to and interacting with one or more digital humans.

Fig. 10. e-REAL representative avatars programmed to perform as digital twins of the learning facilitators

Fig. 11. e-REAL representative digital human, programmed to perform as an athlete student expected to be injured and to start a healthcare rehabilitation program

Fig. 12. e-REAL avatar programmed to perform as an injured lady, able to call for help and to interact dialogically with learners and simulation instructors

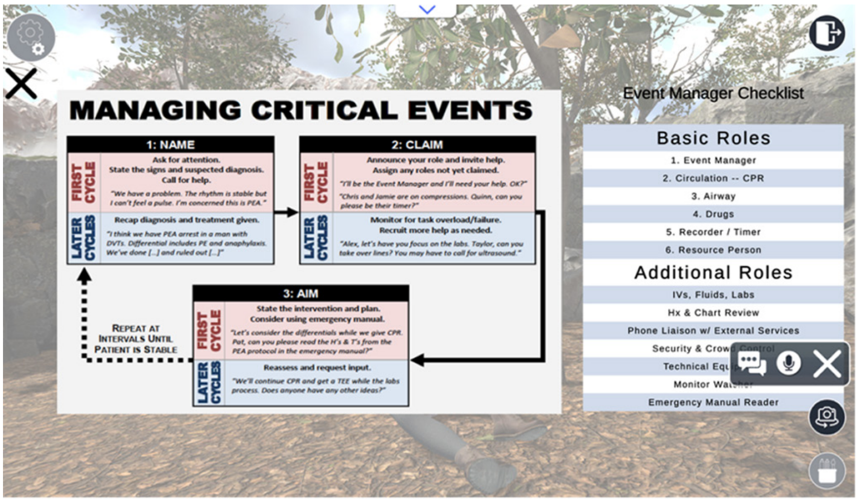


Fig. 13. Name-Claim-Aim©: A mnemonic and checklist developed by faculty at the center for medical simulation (Boston, Massachusetts), that encompasses a strategy to help health care professionals effectively organize a team for managing critical clinical events

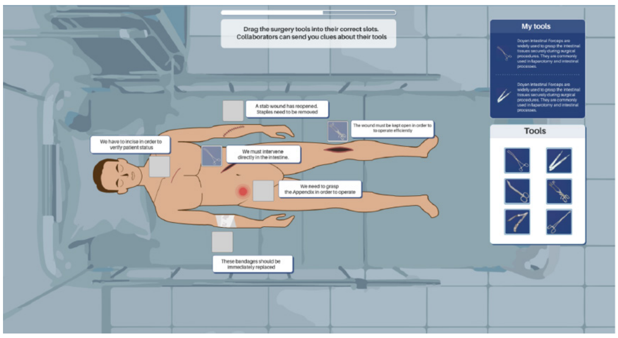


Fig. 14. e-REAL representative gamified healthcare activity designed to challenge the learners with a cooperative game aimed at understanding selected surgical procedures and to place surgery tools in the correct slots

The e-REAL learning setting encourages students to learn by doing with the help of simulation or game-based tools. This setting allows learners to experience abstract concepts in three-dimensional space based on visualization, enhancing at the same time an active learning mindset by encouraging cooperative work among students. Visual storytelling techniques are essential to represent a realistic context where learners are proactively involved to analyze scenarios and events, to face technical issues, to solve problems. The most effective learning occurs when being immersed in a context: realistic experience is lived and perceived as a focal point and as a crossroad [21].

A context related experience within an e-REAL setting is similar to being immersed within a video game with our entire bodies. Characteristics of games that facilitate immersion can be grouped into two general categories: those that create a rich mental model of the game environment and those that create consistency between the things in that environment. The richness of the mental model relates to the completeness of multiple channels of sensory information, meaning the more those senses work in alignment, the better. The richness also depends on having a cognitively demanding environment and a strong and interesting narrative. A bird flying overhead is good. Hearing it screech is better.

Cognitively demanding environments in which players must focus on what's going on in the game will occupy mental resources. The richness of the mental model is good for immersion because if brain power is allocated to understanding or navigating the world, it's not free to notice all of its problems or shortcomings that would otherwise remind them that they're playing a game. Finally, good stories—with interesting narratives, credible because intrinsically congruent as much as possible—attract attention to the game and make the world seem more believable. They also tie up those mental resources. Turning to game traits related to consistency, believable scenarios, and behaviors in the game world means that virtual characters, objects, and other creatures in the game world behave in the way in which learners expect.

The process of learning by doing within an immersive setting, based on knowledge visualization using interactive surfaces, leaves the learners with a memorable experience. From an educational perspective, learners are not assumed to be passive recipients and repeaters of information but individuals who take responsibility for their own learning. The trainer functions, not as the sole source of wisdom and knowledge, but more as a coach or mentor, whose task is to help them acquire the desired knowledge and skills. A significant trend in education in the 19th and 20th centuries was standardization. In contrast, in the 21st century, visualization, interaction, customization, gamification, and flipped learning are relevant trends. In a regular flipped-learning process, students are exposed to video lectures, collaborate in online discussions, or carry out research on their own time, while engaging in concepts in the classroom with the guidance of a mentor. Critics argue that the flipped-learning model has some drawbacks for both learners and trainers. A number of criticisms have been discussed with a focus on the circumstance that flipped learning is based mainly on video-lectures that may facilitate a passive and uncritical attitude towards learning, in a similar way to didactic face-to-face lectures, without encouraging dialogue and questioning—within a traditional classroom.

The e-REAL setting is a further evolution of a flipped classroom, based on a constructivist approach. Constructivism is not a specific pedagogy, but rather a psychological paradigm that suggests that humans construct knowledge and meaning from their experiences. From our constructivist point of view, knowledge is mainly the product of personal and interpersonal exchange. Knowledge is constructed within the context of a person's actions, so it is "situated": it develops in dialogic and interpersonal terms through forms of collaboration and social negotiation. Significant knowledge—and know-how—is the result of the link between abstraction and concrete behaviors.

Knowledge and action can be considered as one: facts, information, descriptions, skills, know-how and competence—acquired through experience, education and training. Knowledge is a multifaceted asset: implicit, explicit, informal, systematic, practical, theoretical, theory-laden, partial, situated, scientific, based on experience and experiments, personal, shared, repeatable, adaptable, compliant with socio-professional and epistemic principles, observable, metaphorical, and linguistically mediated. Knowledge is a fluid notion and a dynamic process, involving complex cognitive and emotional elements for both its acquisition and use: perception, communication, association, and reasoning. In the end, knowledge derives from minds at work. Knowledge is socially constructed, so learning is a process of social action and engagement involving ways of thinking, doing and communicating [22].

The Community Medi-Corps Program is currently at its beginning and we will be able to research for and analyze its educational inputs in the coming years. So far, we can say that the program's first execution into the mobile Immersive Learning Center is reaching the expected outcomes.

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