Nafath

by Mada

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Inclusive Education

Mada ICT Accessibility and Inclusive Design ICT-AID Competency Framework

ICT-AID use cases by Mada partners in Qatar

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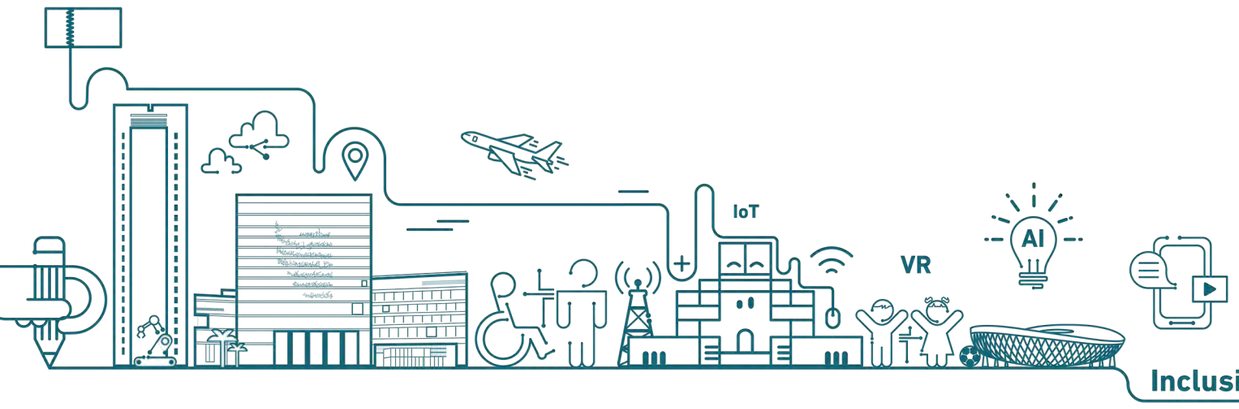


About Mada

Mada Center is a private institution for public benefit, which was founded in 2010 as an initiative that aims at promoting digital inclusion and building a technology-based community that meets the needs of persons with functional limitations (PFLs) – persons with disabilities (PWDs) and the elderly in Qatar. Mada today is the world's Center of Excellence in digital access in Arabic.

Through strategic partnerships, the center works to enable the education, culture and community sectors through ICT to achieve an inclusive community and educational system. The Center achieves its goals by building partners' capabilities and supporting the development and accreditation of digital platforms in accordance with international standards of digital access. Mada raises awareness, provides consulting services and increases the number of assistive technology solutions in Arabic through the Mada Innovation Program to enable equal opportunities for PWDs and the elderly in the digital community.

At the national level, Mada Center has achieved a digital accessibility rate of 90% amongst government websites, while Qatar ranks first globally on the Digital Accessibility Rights Evaluation Index (DARE).

Our Vision
Enhancing ICT accessibility in Qatar and beyond.

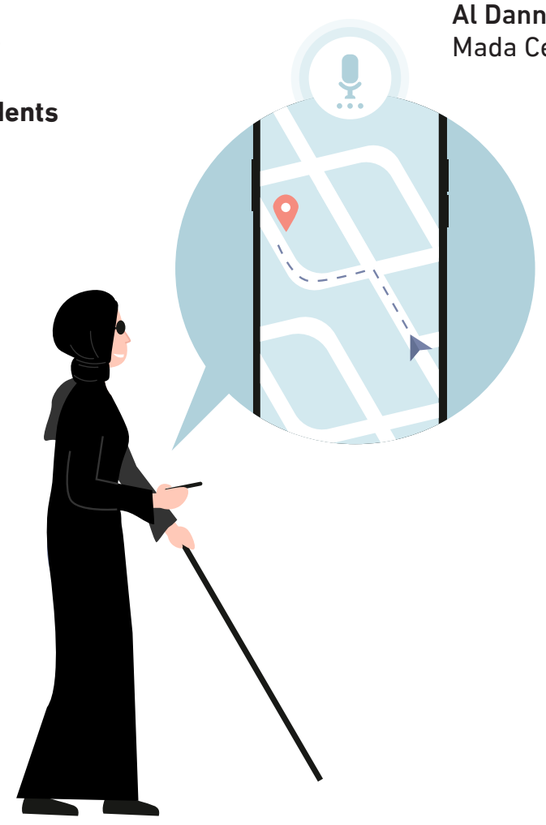
Our Mission
Unlock the potential of persons with functional limitations (PFLs) – persons with disabilities (PWDs) and the elderly - through enabling ICT accessible capabilities and platforms.

About Nafath

Nafath aims to be a key information resource for disseminating the facts about latest trends and innovation in the field of ICT Accessibility. It is published in English and Arabic languages on a quarterly basis and intends to be a window of information to the world, highlighting the pioneering work done in our field to meet the growing demands of ICT Accessibility and Assistive Technology products and services in Qatar and the Arab region.

Inclusive Smart City

Content Page



Open call for papers

Nafath, an open access journal, solicits original research contributions addressing the accessibility, usability and key information resource for disseminating the facts about latest trends and innovation in the field of ICT Accessibility to enable persons with disabilities and the ederly. Nafath is focusing on theoretical, methodological, and empirical research, of both technological nature, that addresses equitable access and active participation of potentially all citizens in the Information Society.

Topics of specific interest

Important aspects and topics to be discussed evolve around (but are not limited to):

- Accessibility guidelines
- Accessible games
- Adaptable and adaptive interfaces
- Alternative and augmented Input /Output techniques
- Applications of assistive technologies in the mainstream
- Architectures, development methods and tools for ICT Accessibility
- Design for All and accessibility education and training
- Evaluation of Accessibility, Usability, and User Experience
- Innovative Assistive applications and environments and ICT Accessibility solutions
- Localization
- Novel designs for the very young, the elderly, and people with different types of disabilities
- Novel interaction techniques, platforms, metaphors, and devices
- Personalization techniques and personalized products and services
- Smart artifacts, smart cities and smart environments
- Web accessibility

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ICT accessibility Research Capacity building in the State of Qatar

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The potential of information and communication technology (ICT) to promote economic growth, exradicate poverty, and assist the integration of emerging countries into the global economy has garnered widespread agreement. Accessible ICTs has become an obligation that as is governed by policies and procedures all around the world. Therefore, training the next generation of experts has now strategic aim of governments and institutes working toward inclusion and sustainable future. there also is a growing consensus that strengthening research capacity requires a concerted effort across multiple institutes. This paper discusses an overview of the ICT accessibility Research Capacity Building in the State of Qatar, including a Case Study on Our Experience at HBKU University and Working Together with the Mada Centre.

Introduction

In many countries around the world, accessibility has shifted from being merely an option to satisfy the design of Information Communication Technology (ICT) to a moral obligation and policy enforced by law. There are various means and methods to enhance accessibility in an ecosystem, however, the core and most fundamental aspect are to train the people designing and employing these technologies. Article 9 of the Convention on the Rights of Persons with Disabilities (CRPD) [1], in fact, has stressed the importance of providing training for stakeholders on accessibility issues facing persons with disabilities and promoting access to ICT through designing and developing ICTs.

ICT accessibility has started to gain interest in research and academic spheres since the mid-90s when the use of the internet started to take place on the global stage. During that time, the initial developments of guidelines related to web accessibility were the result of efforts by the civil rights of Americans with disabilities, ongoing work on telecommunications accessibility, and growing interest in using the web as the main source of modern-day information [2]. By the end of the 90s, the web accessibility initiative (WAI) of the world wide web consortium (W3C) released the first version of its infamous web content accessibility guidelines (WCAG) 1.0 [3]. This was followed by a number of Governments in the United Kingdom, United States, and Australia to consider accessibility to ICT in their legislation systems by either specifically implementing their own guidelines or by adapting the W3C guidelines. The interest continued to raise as technologies increasingly integrates into our daily lives. In 2008, the CRPD came to light and become the driving force behind many of the accessibility-initiatives including the teaching and research initiatives in academia, that we have today. Today many renewed research and academic institutes around the world established courses, research groups, and centres that focus on accessibility and assistive technology paving the way to more inclusive societies. In this article, I discuss ICT accessibility Research Capacity building in the State of Qatar, detailing our journey at HBKU university and collaboration with Mada center as a case study. This article is structured as follows; section 2 discusses the background of accessibility practice and research in the state of Qatar; section 3 details how ICT accessibility is integrated into the courses at HBKU; and ICT research training experiences are then discussed in section 4.

Background

The state of Qatar was among the first nations that ratified United Nations CRPD in May 2008, and in April 2015 the state adopted a law on persons with disabilities which covered all the rights contained in the Convention. In its effort to adopt the convention, in 2011 Qatar released the National e-Accessibility Policy [4], which aims to raise the level of accessibility across all digital platforms. Prior to that, in 2009, the Supreme Council for Information and Communication Technology established Mada (Qatar Assistive Technology Centre), a non-profit organization dedicated to connecting people with disabilities to information and communication technology. Today, Mada Center is the world's Center of Excellence in digital access in Arabic. Mada's center work is influenced by its core belief that persons with disabilities form an integral part of society and that if they are equipped rightly, they will play a vital role in the growth of Qatar's economy. To pursue this belief, Mada center has built a number of strategic partnerships with entities in Qatar and the world. Through these partnerships, the center works to enable the education, culture, and community sectors through ICT to achieve an inclusive community. Mada center supports technology initiatives in research, training, and innovation through its various program. our research group closely works with the Mada center on a number of initiatives.

Over the past two decades, Qatar has established solid foundations in education and has played a leading role in scientific research across the region, developing a number of world-class facilities and institutions, including QNRF, the first national institution to finance research on a competitive basis in the Middle East; Qatar, and several research hospitals, including Hamad Medical Corporation, Sidra Medical Center, as well as Qatar Biobank Medical Research and Qatar Genome Program. Qatar also has branches of a selection of major international universities, while Qatar University is ranked among the top five universities in the Arab world. At the same time, Qatar has increased the number of local opportunities available for postgraduate degrees through the launch of masters and PDD programs at Hamad Bin Khalifa University (HBKU).

In 2018, the Qatar Research, Development, and Innovation (QRDI) Council was established. This was a big step forward for Qatar's research, development, and innovation (RDI) agenda [5]. The first thing the Council had to do was come up with a national strategy that would make the best use of RDI activities and help the country reach its overall goals and aspirations. At the end of 2019, the Council launched the Qatar Research, Development, and Innovation Strategy 2030. Capacity building is the heart of the QRDI strategy thriving a knowledge-based society.

Our research group is based at HBKU, a member of the Qatar Foundation. HBKU was founded in 2010 as a research-intensive university that acts as a catalyst for transformative change in Qatar and the region while having a global impact. In our research group, which was founded in 2016 at HBKU, we believe each of us must play an active role in supporting access and use of technology. Designing technologies that suit different abilities and ages is critical in allowing individuals to achieve a smooth and undiminished ICT interaction. The aim is for this interaction to reach optimal levels of performance. Our research group is interested in addressing the issue of designing a comprehensive user experience and accessibility to create a more inclusive community in Qatar and the world. The group, therefore, experiments and design human-centered technologies that are sensitive to use in various contexts including education and health. To achieve this, we collaborate with world-renowned centres and experts in the field, engage with users with disabilities to understand their needs, design human-centered technologies by taking advantage of modern technological developments and artificial intelligence, and train the next generation of highly skilled researchers.

Research capacity building is referred to as “a process of developing sustainable abilities and skills enabling individuals and organizations to perform high-quality research” [6] In many research intuitions focus on capacity building as one of their most important pillars and tools of development and continuity. In the HBKU 2016-2026 strategic plan [7] capacity building is in its core four pillars. Mada’s mission implies that is aiming Unlock the potential of persons with functional limitations (PFLs), persons with disabilities (PWDs), and the elderly – through enabling ICT accessible capabilities and platforms [8].

Training

The aim of research capacity building is to strengthen the existing workforce with skills that will widen their understanding [6]. Through this, they are able to contribute to the development of high-quality research that improves their field's understanding, persuades funding authorities, and makes evidence-based practice possible. That is in addition, to enhancing practices currently taking place.

Training includes offerings a course on ICT accessibility in the Bachelor of Computer Programming and Engineering Course, embedding ICT accessibility, Universal Design, and Inclusive design fundamental in a Human-computer Interaction elective course offered for the master's and Ph.D. students at the College of Sciences and Engineering at HBKU, and engaging research student in active research grants related to accessibility, digital inclusion, and assistive technology. In the ICT accessibility, the Mada Accessibility and Inclusive Design Competency framework [9] was used to design and prepare the course outline. The course focuses on enhancing the student's capabilities in the domain of ICT accessibility. It provides a comprehensive review by covering diverse topics that advance the skills needed to develop, review and evaluate accessible digital platforms according to the international best practices and ICT accessibility standards. When completing the course the students will be able to understand the definition and the importance of ICT accessibility, develop accessible websites and Mobile applications including the creation of accessible digital content such as multimedia, and evaluate the level of accessibility of digital platforms, such as website, Mobile application and electronic kiosks, identify the uses of assistive technology, and demonstrate the application of universal and inclusive design principles in the development of user-center technology. During the course, the student gets the opportunity to visit Mada Center and its innovation lab, interact with the team, and know more about the work taking place in Mada. The course also involved students working on innovative projects addressing pressing accessibility problems. The students were engaged and should a real interest in the subject. In fact, a number of them express their interest in engaging in ongoing accessibility research in HBKU and Mada.

To build capacity on the research level, I offer a class on accessibility and inclusive design in collaboration with Mada Center As part of its Interactive Design for Healthcare course. In this class students who register in the course attend a workshop on digital accessibility at Mada – Qatar Assistive Technology Center. The workshop at Mada enhanced participants' learning experience, providing them with opportunities to engage with real-world applications and technologies. The workshop, entitled Introduction to Digital Accessibility, stressed the importance of inclusiveness and accessibility in technology-related innovations.

Research experience

Providing research experience is a crucial part of capacity building in a university setting. HBKU is a research-intensive university in which most of its programs are at the graduate level. Thus, research training is given the highest priority. In our research group at HBKU, we work on a number of projects related to accessibility and inclusive design in collaboration with the Mada Center. We also have a number of partnerships with local centers in Qatar such as Shafallah Center for Persons with Disabilities, Center of Empowerment and Care of the Elderly (Ehsan), Step by Step Center for Special Educational Needs, and iSpeak Rehabilitation Center. We have a number of international collaborations with research institutes and non-governmental organizations around the work such as Texas A and M University, University of Bristol, University of Ottawa, Autism Speaks, the National Autism Society in the United Kingdom, and Age–Well in Canada. Most of the research projects we currently work on are funded by the Qatar National Research Fund, Mada center, HBKU College of Science and Engineering, and HBKU innovation fund. Master's, Ph.D., research assistants, and postdoctoral fellows are hired in the projects to work alongside the Principal Investigators from both Mada and HBKU. They would be engaged in the different phases of research from ideations to data gathering, analysis, and dissemination. Two Ph.D. and three master's students working in areas related to inclusive design and accessibility have so far graduated from the team. We currently have 12 research team members in our group working on a number of active research grants that focus on technology design for the elderly, children with autism, and inclusion. The team actively publishes in reputable research venues and top-tier journals in the field of accessibility and human-computer interaction. The team also received a number of patents and is looking into the opportunity of technology transfer to feed into the innovation ecosystem in Qatar and the world.

When looking at my research work, it becomes evident that I have had a focus on supporting the design of inclusive technologies for people with autism spectrum disorder (ASD). There are a number of reasons for pursuing this research direction. Firstly, the incidence of ASD has increased significantly in the United States of America, as reported by the Center for Disease Control and Prevention (CDC). The increase in the number of children diagnosed with ASD is not limited to the USA, but is a global trend, including in Qatar. A recent study by the Qatar Biomedical Research Institute (QBRI) has found that one in 56 boys and one in 230 girls have been diagnosed with ASD in Qatar. The experience of families who have children with ASD shows that the children require a great deal of support from the parents and siblings, relatives, and friends. Sometimes, the support needed by children with ASD spans from childhood to adulthood, which is usually overwhelming and psychologically challenging. Thus, one of Qatar's 2030 visions is to meet the needs of individuals with special needs regarding development rights. This vision emphasizes Article 24 of the UN Convention on the Rights of Persons with Disabilities, which recognizes the right of persons with disabilities to education and opportunities without discrimination. Intellectual disabilities, such as ASD, have remained the most significant proportion of disabilities over the past decade in Qatar. Within this pillar, I have four active projects. The research in this pillar received several grants for projects in which I am a Lead PI. These grants are: (1) idea development from Hamad bin Khalifa Innovation Centre, (2) QNRF NPRP13S-0108-200027, (3) QNRF PDRA6-0611-20012, (4) QNRF RRC-3-010, and (5) NPRP10-0208-170408. I also received in-cash funds from Mada Assistive Technology Center and Shafallah Center.

Children with ASD are characterized by attention deficit and exhibit a range of attentional behaviours due to heterogeneity in the spectrum. The current state-of-the-art states that engagement assessment in ASD happens through subjective methods, requiring a long year of experience [10]. Our previous review [11] shows that researchers often focus on how technology innovations can improve the engagement level of children with ASD. However, the application of this technology for engagement assessment is still in its infancy. The commonly applied method is based on subjective evaluation, which requires high expertise and is time-consuming. However, few studies have explored objective assessment of engagement levels during learning by utilizing existing sensing technologies for typically developing individuals. Those few engagement assessments conducted to date are based on evaluating generalized attention, which is not suitable for children with ASD due to their heterogeneity. Our group applied a personalized engagement assessment that captures visual, auditory, and social attention for children with ASD during learning. Our study explored the effect of social and non-social visual stimuli on the attention of children with ASD and typically developing (TD) children in a simulated virtual classroom [12][13]. Using a webcam and eye-tracking, forty-six participants (ASD = 20, TD = 26) took part in a series of attention tests, in which social and non-social visual stimuli were used as target stimuli [14][15]. We proposed a face-based attention recognition model using two methods [16]. We showed that the geometric feature transformation [17] using an SVM classifier outperforms the CNN approach, emphasizing that the attention features are more generalizable in the TD group.

Our recent AR [18] review shows that researchers have targeted several skills related to ASD in the studies. However, the teaching of vocabulary or language is still underexplored despite its importance in academics. Working closely with local stakeholders (parents and their children, teachers, and centers), we conducted a detailed qualitative study to ascertain and understand their needs [19]. As a result, an AR app was developed using collected requirements in the classroom and at home. The app was then evaluated using a participatory approach [20]. Through feedback received from our sessions with teachers, we incorporated the concept of mixed reality into the app. Children with ASD can benefit from the app by regularly connecting with their teachers and performing a set of tasks within the app environment. However, in the absence of a teacher, a 3D humanoid talkative avatar would support a child and parents in a virtual environment. To the best of our knowledge, there is no educational platform that caters to the needs of children with ASD. The platform allows parents and teachers to view a child's performance, and teachers can create lesson plans according to the child's needs. The AR app would benefit children with ASD as it would allow them to become independent individuals and live better lives. The application will be available on the Apple app store, by the name of MARVoc, and it is now being used at Shafallah Center, which is a center that provides educational support for children Intellectual disabilities and mental disabilities associated with motor disability, ASD, and its spectrum.

In the realm of web accessibility for the blind, we investigated ways of generating overview web search results [21][22]. We amended these different approaches in a search engine which we called InteractSE. This search engine uses Formal Concept Analysis (FCA) to generate an overview of search results. InteractSE was evaluated with 16 users [23] and five HCI experts [24], showing a significant improvement in search efficiency and individual user experience for VI web users. The team continues to work on research projects related to accessibility and looking for aspiring scientists to join this journey. Our future research plan aims to strengthen and develop a local research team in the area of ICT accessibility.

Conclusion

Building research capacity can be targeted on three different levels, including foundational training on the topic of accessibility and the initial introduction of research in this field (such as understanding how to search, evaluate, and consciously apply research evidence to inform practice), active participation and gaining the research experience (such as assisting designing the research, and participating in the data collection and analysis), and finally leading research grants in this area. Building research capacity can be targeted on all three levels simultaneously. The collaboration between Mada and HBKU has gone a long way with a number of ongoing projects, and courses taught on both undergraduate and graduate levels. We hope that this fruitful is shared with institutes around the region to work towards building a strong foundation for ICT accessibility both in research and practice.

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Capacity Building and Advocacy to Promote the Digital Accessibility Rights of Persons with Disabilities

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The Global Initiative for Inclusive Information and Communication Technology (G3ICT) Digital Accessibility Rights Education - DARE Academy

Despite the progress that has taken place in the sector of technology, efforts of ensuring the inclusion of persons with disabilities remain limited. This is due to the limited opportunities of capacity building, weak awareness among engineers and industrialists, and the hindering of persons with disabilities' voices in Information and Communication Technology (ICT) policy development and decision-making.

Inspired by the disposition of the Convention on the Rights of Persons with disabilities regarding accessibility, the Global Initiative for Information and Communication Technologies have been playing a pivotal role in promoting the persons with disabilities' right to inclusive ICTs. Benefiting from the results of its Digital Accessibility Right Evaluation Index, G3ICT has realized the increasing commitment of CRPD States Parties to issues of ICT Accessibility. Nevertheless, The DARE index data show the remaining challenges encountered by governments' procurement capacity for offering actual support to inclusive ICT programs, products, and services. ICT accessibility continues to be absent from higher education and vocational training programs. Furthermore, advocacy efforts of persons with disabilities and their organizations remain limited within the realm of digital accessibility.

This paper discusses G3ICT's Digital Accessibility Right Education (DARE) Academy, and its role in tackling issues of digital divide through offering a platform of educational development and advocacy capacity enhancement for persons with disabilities around issues of ICT accessibility.

This essay presents the background and motivation behind the creation of the G3ICT DARE Academy. The following Paragraphs will offer an overview about the Academy's main programs that are aimed to help the enhancement of inclusion of persons with disabilities in the field of digital accessibility and its related policies and programs.

Background

The [1] recognizes the right of persons with disabilities to accessible physical, digital or technological environments. Many convention articles address this right in relationship with different sectors and life aspects.
While Article 9 of the convention sets forth the primary components of accessibility as a core principle, other articles of the convention highlight the position of ICT accessibility in relevance to other rights, inter alia: access to justice (article 13), independent living (article 19), freedom of expression and access to information (article 21), education (article 24), employment (article 27), political participation (article 29), and access to cultural material, programs, and facilities (article 30). The convention also realizes that ensuring the right of persons with disabilities to accessibility should be recognized through rather operational mechanisms pertaining to CRPD implementation monitoring and evaluation. Such mechanisms should also take into account the principle of accessibility, particularly through data collection and desegregation by disability, as well as the enhancement of international efforts of multilateral partnerships.

The establishment of this disposition has taken place in a timely manner, given the critical progress done in the field of technology, particularly digital accessibility. Such progress has been reflected through the development of technology dependent practices, such smart cities, e-governance, e-learning, remote employment etc.

As the world is shifting towards increasing reliance on technology, persons with disabilities remain left behind on many levels in terms of ensuring their accessible technology rights. States Parties compliance with the CRPD disposition on accessible technology remains limited to the commitment level i.e., the deployment of relevant legislations, regulations, and policies, as G3ICT DARE index shows. According to this Index, level of implementation capacity of States Parties in the arena of digital accessibility continues to be lagging behind. This matter significantly appears in areas, such as engaging persons with disabilities in decision-making around issues of digital accessibility. Another rather important area, where implementation capacity seems to be lagging behind, is the integration of special curriculum on digital accessibility in both academic and vocational training courses of computer sciences and programming and so on and so forth.

These two examples of areas of implementation capacity by States Parties reflect the perpetual exclusion of voices of persons with disabilities on the level of decision-making in national policy development regarding accessible technology. Furthermore, it rather questions the availability of capacity building opportunities for technology professionals, and primarily for persons with disabilities who are interested in technology. While these two factors would surely result in hindering persons with disabilities' chances of inclusion in technology dependent platforms and programs, it shall also have negative implications on persons with disabilities knowledge and advocacy capacity pertaining to issues of ICT accessibility on the national, regional, and global levels.

Why is the DARE Academy?

Based on its mission towards promoting the CRPD disposition on digital accessibility rights for persons with disabilities, and supported by its [2] data, [2] has been aware of the problem of lacking opportunities of capacity building and enhanced advocacy efforts by persons with disabilities around issues of digital accessibility. On June 14th, 2021, at its virtual side event during the [3] held by the United Nations Department of Economic and Social Affairs (UNDESA), G3ICT launched its [4]. In preparation of this launch, G3ICT reached out to major international organizations of persons with disabilities, including: International Disability Alliance (IDA), Disabled People's International (DPI), World Blind Union (WBU), World Federation of the Deaf (WDF), European Union of Persons with Hard of Hearing, in addition to disability and development organizations, including CBM Global Disability Inclusion, Leonard Cheshire, and Daisy Consortium. These organizations today form G3ICT DARE Academy Advisory Council.

To help filling the gap in programs of ability building and advocacy in the field of digital accessibility, G3ICT DARE Academy aimed at offering persons with disabilities a number of opportunities. Given its educational mission, DARE academy has been formed to provide means of capacity building for persons with disabilities around issues of digital accessibility. These means are primarily reflected through the Academy Scholarship program and online courses. To ensure that the knowledge gained through the scholarship program is going to be useful for potential candidates, the Academy strives to bring digital accessibility leaders and champions of persons with disabilities together through a global advocacy and peer-to-peer sharing of expertise network.

DARE Academy Scholarship

Sponsored by G3ICT, this scholarship is dedicated for all persons with disabilities interested and active in the field of digital accessibility. With the priority given to persons with disabilities of countries of emerging economies, and affiliated to representative organizations of persons with disabilities, this scholarship allows candidates to have free access to G3ICT International Association for Accessibility Professional's (IAAP) Certification for Professional Accessibility Core Competency (CPACC). This certification program is offered in partnership with Princeton University in the United States. The free Access to CPACC covered by the DARE Academy Scholarship entails that have access to the certification Course's body of knowledge and examination process.

The scholarship, so far, has been granted to forty candidates, who have been selected according to a rigorous application process, and the approval of the members of the Academy's Advisory Council. These scholarship recipients compromise two application cycles, with one year timeframe each. The first cycle was started in September 2021, while the second cycle was started in December of the same year. During this one year, each recipient is anticipated to access and study the CPACC body of knowledge and take and pass the CPACC exam. Upon their acceptance into the scholarship program, each student is granted a one-year IAAP membership. This membership will enable each student to have access to a broad network of accessibility professionals around the world and take advantage of IAAP online seminar series on different digital accessibility topics and issues.

DARE Academy Online Course on Digital Accessibility Best Practices

In addition to its scholarship program, DARE Academy is preparing the launch of an online course featuring digital accessibility best practices. These featured best practices will be selected based on the series of responses and data collected through G3ICT DARE Index. This online course will host experts, professionals, and leaders in the field of digital accessibility who will form each course session panelists or lecturers. The identification of course subjects will take into consideration the DARE Index set of variables and will take advantage of the extensive knowledge resources owned by G3ICT. Course sessions will be recorded and archived for future by demand access. While this course will require paid registration, DARE Academy Students will be granted free access to course sessions and archived materials.

Global Network for Digital Accessibility Champions

The Academy alumni and program participants constitute a global network that brings together persons with disabilities who have leadership roles at organizations of person with disabilities, particularly those that are active in the field of digital accessibility. This network aims at creating a space for these leaders to share their expertise and enjoy peer-to-peer support around issues of digital accessibility rights. This network is an open platform for leveraging advocacy efforts of these leaders, and to enhance their voices towards their governments and other digital accessibility stakeholders on the local, national, regional, and global levels. DARE Academy scholarship recipients are granted automatic membership in this network upon their graduation with their CPACC certificate.

Conclusion

As a pioneer initiative by G3ICT, the DARE Academy will hopefully be an aid to those who believe in the role of digital accessibility in transforming the lives of persons with disabilities through inclusion on all levels. Therefore, G3iCT hopes that this Academy will become a hub of knowledge and capacity building to help voices for persons with disabilities will be further heard at digital accessibility platforms of decision-making, and skills of persons with disabilities to be recognized for ensuring their participation and inclusion in society at all levels.

Acknowledgment

The author of this paper thanks the leadership of the Global Initiative for Information and Communication Technologies (G3ICT), and the International Association of Accessibility Professionals (IAAP) for its support to launching an important program of the DARE Academy. He also thanks the staff members of the DARE Academy on their excellent support for putting this paper together.
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Inclusion of STEAM Innovation Spaces

A Critical Issue for Learners with Disabilities

The fourth industrial revolution has provided a wide range of flexible physical and digital technologies that continue to enhance the teaching and learning of STEAM. Incorporating STEAM and building makerspaces, Fablabs (Fabrication Labs), and STEAM labs as part of the educational curriculum can serve as the right environment to empower learners to transform their ideas into tangible digital or physical solutions. However, the standards way of development of spaces such as FabLabs does not always guarantee accessible learning opportunities for learners with disabilities as they may require additional accommodations to be able to access and use the technology tools. This article confirms that children with disabilities face multiple challenges with inclusivity and accessibility. Creating inclusive innovation spaces that support, promote, and accelerate learning is essential and requires an understanding of the application of user-centered design, universal design, and utilization of local and global networks to create solutions that increase accessibility and create an inclusive environment.

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Ibtechar Digital Solutions

Introduction

According to a recent UNICEF report, it is estimated that there are 240 million children globally who suffer from a form of disability [1]. This report confirms that children with disabilities face multiple challenges with inclusivity and accessibility. Education is the most imperative subject when it comes to children's development, yet learners with disability are still falling behind as inclusive learning environments are not the norm in modern society.

STEAM is one of the most popular and fast-growing topics in the education industry. This is due to its unique approach and emphasis on innovation, problem-solving, and critical thinking. STEAM education stands out from other learning paths as it is centered around the individual's learning capability and interest which therefore provides an inclusive and accessible learning environment for students with varying abilities. This approach helps students develop 21st-century skills that are necessary to bridge the skills gap for future jobs. Unquestionably, access to STEAM education should be adopted by society, especially to students with disabilities as it possesses the right tools, and environment that empowers the individual to strive in education.

Did you know that the late CEO of Apple, Steve Jobs, and the founder of Virgin Group Richard Branson both had learning disorders growing up? Individuals with disabilities have greatly contributed to our world in STEAM fields. An example would be Kursat Ceylan who is a visually impaired engineer since birth. Kursat invented a smart cane that improves mobility for visually impaired individuals and is currently the co-founder of the WeWalk

Cane as well as being the CEO of the Young Guru Academy which is an international non-profit established to empower volunteers to develop projects that tackle challenges within their communities [2]. This indicates that students with disabilities or different abilities, can all get empowered by STEAM education and therefore contribute to society with products and services that develop different STEAM-driven fields such as Assistive Technologies.

Technology has been identified as the bridge between all the core subjects of science, engineering, arts, and mathematics and is very focused in STEAM learning environments. The fourth industrial revolution has provided a range of flexible physical and digital technologies that continue to enhance the teaching and learning of STEAM. Incorporating STEAM and building makerspaces, Fablabs (Fabrication Labs), and STEAM labs as part of the educational curriculum can serve as the right environment to empower learners to transform their ideas into tangible digital or physical solutions. These kinds of spaces are mainly developed with the purpose of creating accessibility within the community for fields such as manufacturing and makers technologies. Making spaces accessible and accommodating to individuals with different abilities and capabilities is important.

However, the regular development of spaces such as Fablabs in many countries somewhat follows a "One size fit all" approach in terms of design and build which does not guarantee to provide accessible learning opportunities for learners with disabilities as they may require additional accommodations to be able to access and use the technology tools. Hence, there have been recent efforts toward building an awareness of the requirement of building an accessible innovation space. The University of Washington conducted research in 2018 in which individuals with diverse disabilities participated in a series of activities to brainstorm means to make makerspaces more accessible and user friendly. Subsequently, the research concluded with a set of recommendations that can be considered when developing a makerspace that can be accessible to all [3]. Some of these recommendations revolve around the policy planning, space design, equipment, safety, training, and user testing [4] [5].

Simultaneously, Ibtechar Digital Solutions (a Qatari innovation consultancy and management firm) developed a unique approach towards creating the 'world's first' inclusive Fablab "Mada FabLab" which was designed with careful consideration to ensure the lab can be accessed and used by individuals with various abilities. The space layout is easily navigable, the furniture was locally fabricated to be customizable and adjustable to fully accommodate the different users. In addition, the technology equipment stations were designed to be accessed by different individuals while also ensuring that the technologies selected are user friendly. Most importantly, the staff were trained on how to utilize the furniture and the technology equipment to create inclusive learning experiences.

As a result, Ibtechar developed "Mini Fablabs" which is a local, economic, and accessible solution that can be used by any institution that would like to create an innovation space. It consists of a customizable mobile furniture unit that can be equipped with any technology equipment, basic tools, and materials. In the context of education, more institutions are adopting the STEAM education approach which greatly relies on having the right setting or environment. Yet, building a Fablab or a makerspace in an established educational building may require assigning

an appropriate space, extensive remodeling of existing infrastructure and many more constraints. Therefore, the Mini Fablab is a turnkey solution that can be utilized to empower the teaching of STEAM and can be easily customized to provide accessibility to all individuals with various abilities creating an environment that is empowering and inclusive.

Conclusion

In summary, research, evidence, and experience clearly prove that inclusivity and accessibility should be considered when it comes to providing quality and inclusive education for children as it gives value to the contributions of all students regardless of their abilities. Creating inclusive innovation spaces that support, promote, and accelerate learning is essential and requires an understanding of the application of user-centered design, universal design, and utilization of local and global networks to create solutions that increase accessibility and create an inclusive environment.

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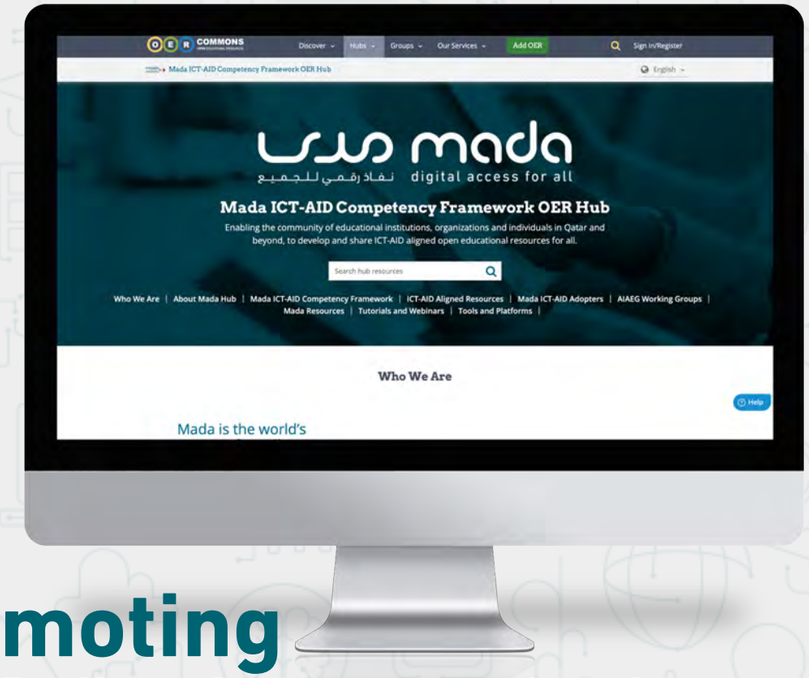

Promoting

ICT-AID aligned open educational resources

OER for all

Recognizing the pivotal role that Open Educational Resources OERi have, providing equally effective access to learning opportunities for all, Mada has joined the growing worldwide OER movement and pledges as such to promote OER accessibility harnessing the power of inclusive ICTs so that educational resources are accessible for all.

With this in view, Mada launches the "Mada ICT-AID OER Hub"[1] to be a Global knowledge hub featuring freely accessible resources toward closing the training and knowledge gap in ICT Accessibility.

Mada Hub contains collections of accessible open educational resources, which are aligned to the "Mada ICT Accessibility and Inclusive Design (ICT-AID) Competency Framework"[2]. These resources are aggregated, curated and managed by Mada and partners, through collections, and groups, and development tools available on the Hub.

The community of ICT accessibility professionals, experts, advocates, educators, and learners can discover, create, and share accessible quality open content, and connect with others to expand their capabilities and improve inclusive practices. The Mada ICT-AID OER Hub is meant to be a centralized and searchable repository of ICT-AID aligned educational and training materials to help the community in Qatar and beyond, locating and accessing appropriate OER related to ICT accessibility. In that vein, Mada ICT Accessibility and Inclusive Design competency framework is featured as a standard available to users of the OER Commons[3] digital library and collaboration platform. As a standard, Mada ICT-AID will be used to index and describe ICT-AID aligned OER providing accordingly ease of access and retrieval of these resources. As such, the ICT-AID competency framework will be used for searching, aligning and evaluating Open Educational Resources published on the Mada ICT-AID OER Hub, serving globally learners and educators.

1 https://oer.mada.org.qa/
2 https://ictaid.mada.org.qa/
3 https://www.oercommons.org/

iOpen Educational resources (OER) are "learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others" .

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Mada ICT Accessibility and Inclusive Design ICT-AID Competency Framework

The Information and Communication Technologies ICT -evolving into an integral part of everyday life, shapes profound changes in our societies. Consequently, everyone should access ICT in the same way as everyone else, which means that ICT should be accessible to everyone, regardless of his/her abilities, needs, or disabilities. This calls, among other effective measures, for developing skills in ICT accessibility, which includes a shared understanding of ICT accessibility and Inclusive Design ICT-AID, as well as acquiring necessary digital accessibility competencies for everyday life and work. Nevertheless, selecting appropriate accessible training and education materials aligned with specific ICT-AID competencies, especially in the Arabic language, remains a barrier to all, inhibiting aspirations and willingness to build capability and proficiency in ICT accessibility. This paper presents Mada ICT Accessibility and Inclusive Design ICT-AID Competency Framework, encompassing all core competencies required to effectively integrate ICT accessibility principles into training and educational curricula toward closing the training and knowledge gap in this field.

A wide range of challenges and barriers confront people with disabilities and the elderly [1], especially in the field of Information and Communication Technologies (ICT), reducing their access to various online services, educational, and employment opportunities [2]. Under such circumstances, there is a growing global recognition that accessibility is essential for individuals and organizations to help remove barriers hindering access to ICT and create high-quality products and services universally accessible and usable by a broad range of users [3]. Undoubtedly, ICTs play a crucial role in bridging the digital divide and fostering the development of inclusive Knowledge Societies, as was highlighted in the 2030 Agenda for Sustainable Development Goals SDG. On that premise, the United Nations member states have been required to implement the 2030 Agenda [4] and facilitate therefore access to ICT for persons with disabilities. Furthermore, according to the United Nations Convention on the Rights of Persons with Disabilities UNCRPD, access to information and communication technologies, emergency services, and the Internet is recognized as a fundamental human right. As such, signatory states are obliged to take appropriate measures to allow people with disabilities access to these services equitably and invest more in providing ICT products and services meeting their needs and requirements [3]. In particular, leveraging inclusive ICTs in education as well as integrating ICT accessibility within the capacity building, training, and education curricula and programs can enable all persons, including persons with disabilities, to access equitably to learning opportunities and to gain the necessary ICT accessibility and inclusive design ICT-AID competencies required for life and work.

Nonetheless, ICT-AID topics tend to be underrepresented in training and educational curricula specifically in the Arab region [5]. In addition, the availability of accessible digital educational content appropriate for different learning contexts and proficiency levels remains far short of expectations[6] [7]. This will undoubtedly lead to a lack of knowledge, and awareness, and expertise about developing accessible contents and services, contrary to what was stated in UN conventions. It is therefore extremely important to spread knowledge and awareness, and to develop skills around ICT accessibility, particularly, through fostering the integration of ICT-AID aligned courses in educational institutions and professional development services.

This paper presents Mada ICT accessibility and inclusive design ICT-AID competency framework defining a set of coherent relevant competencies in the ICT accessibility and inclusive design field, intended to serve as a training, and learning guide on the foundation in ICT accessibility and inclusive design [8]. The remainder of this paper is organized as follows: Section II investigates existing educational programs in ICT accessibility and discusses the need for a competency model as an instrument to guide training and learning in this sector. After this, section III describes Mada ICT-AID competency framework. Section IV then presents some results from a 2-round Delphi validation method of the proposed framework. Then, Section VI explores some of the ICT-AID use cases by Mada partners so far in Qatar. Lastly, Section V concludes the paper and suggests ways forward.

Developing ICT accessibility capabilities

As per Article 9 of the Convention on the Rights of Persons with Disabilities, states parties are required to take appropriate measures to enhance accessibility as well as to promote inclusive ICT use and access at a minimum cost [3]. Various surveys have shown that the lack of ICT accessibility skills represents a serious stumbling block to implementing accessibility on digital products, and contents, and services [9] [10]. In response, many organizations and educational and training institutions have rushed to offer capacity building and training programs aligned to their own knowledge and understanding of ICT accessibility [11][12] [13]. Among the most important, the World Wide Web Consortium W3C Web Accessibility Initiative WAI has provided the community with training materials to support individuals understanding and implementing accessibility [14]. The W3C WAI has also developed a curriculum on Web accessibility to be used as a framework for educators to build their own courses. The Curricula modules cover accessibility foundations that apply broadly, and specific skills for developers, designers, content authors, and others [15]. Additionally, the International Association of Accessibility Professionals (IAAP), which operates as a division of the Global Initiative for Inclusive ICTs G3ICT, provides professional resources and certification in digital accessibility in a bid to support accessibility professionals developing and advancing their careers and integrating accessibility into digital products and contents [10]. The W3C's Web Accessibility Initiative (WAI) and the UNESCO Institute for Information Technologies in Education (UNESCO IITE) cooperated to provide a free online course built on the open curricula of the W3C WAI. It is in this context that they launched an Introduction to Web Accessibility Massive Open Online Course MOOC on edX platform [16]. Learners can audit the course for free or choose to receive a paid verified certificate [17]. In the same way, ITU organization offers a self-paced online training on ICT accessibility with the aim to develop a good understanding of ICT accessibility among all relevant stakeholders [18]. Apart from above examples of organizations striving to achieve ICT accessibility through capacity building and training, several universities have also joined these endeavors and have integrated ICT accessibility courses into their curricula [19] [20]. In Qatar, Hamad bin Khalifa University HBKU [5] and Community College of Qatar CCQ have recently introduced courses dealing with digital accessibility in their curriculum. In the US, the University of Illinois at Urbana-Champaign in Illinois, e.g. has launched an ICT-AID MOOC on Coursera that allows learners to explore the fundamentals of accessibility and inclusive design. Learners can audit the course for free or choose to receive a paid verified certificate (University of Illinois at Urbana-Champaign, 2020) [21].

This is indeed a very important and beneficial effort towards fostering ICT accessibility in the region. It appears, however, that none cannot be effectively used as a holistic and comprehensive framework to cover all the knowledge, skills, and attitudes that learners need to acquire, nor can it be utilized as an instrument for describing and curating existing materials. Therefore, a dedicated competency framework, that specifies globally what stakeholders need in terms of ICT-AID capability development, training, and education towards achieving, is required more than ever before.

In fact, when well-defined ICT-AID competencies are spotted within a dedicated competency framework and adopted as a global standard, individuals and professionals from all over the world will be able to gain the same level of understanding and the same skill sets scaffolded by training professionals

and education providers. These latter, by availing such a common competency framework, can better define their curricula and training programmes and materials, and would accordingly drive globally their training offers addressing more accurately ICT accessibility jobs' needs. It is within this context, that Mada has developed the Mada ICT-AID competency framework, as part of its fully-fledged innovative Academy initiative toward fostering ICT accessibility proficiency in the region and beyond [22].

Mada ICT-AID Competency Framework

Mada has developed the ICT-AID Competency Framework [23] in order to guide training of students and workers on the foundation in ICT accessibility and inclusive design, which allows the intended audience to make a sense of the experience of disability related to the use of ICT, and to increase their accessibility awareness when using and creating electronic materials[24], and to apply accessibility standards and techniques [25][26], including W3C Web Content Accessibility Guidelines WCAG[27], so that they will be well prepared to excel in their accessibility professions and contribute in the creation of accessible products, contents and services.

With a view to fostering the integration of ICT Accessibility in education and training programmes addressing diverse audiences, Mada ICT Accessibility and Inclusive Design ICT-AID competency framework can be used as a tool to guide professional education services, universities and individuals on delimiting the required relevant competencies in ICT accessibility [28]. Mada ICT-AID competency framework, as an open framework available in open access under Attribution-ShareAlike 4.0 International (CC BY-SA 4.0), can be adapted for use in different learning contexts and modes, and availed to develop, describe and publish ICT-AID aligned resources in courseware repositories.

Among the audiences for Mada ICT-AID competency framework are decision makers, administrators, and teachers responsible for education and training policy formulation, policies, and programs, as well as business and industry experts. Education, training and certification programs developed according to the Mada ICT-AID competency framework are intended to cover a wide range of occupations and professions, such as digital content writers, Web content managers, web developers, designers, instructional designers, digital education specialists, teachers, project managers, ICT managers, marketing professionals, communications specialists, etc.

Mada ICT-AID competency framework features six key domains of competencies that follow a logical progression in mastering ICT accessibility (Table I):

- **D1.** Becoming familiar with Disability and Accessibility
- **D2.** Describing the legal landscape of Disability and Accessibility
- **D3**. Making a sense of Universal Design
- **D4**. Creating Accessible Digital Content
- **D5.** Creating Accessible Web Content
- **D6.** Making Digital Environments and Platforms Accessible

Each competency domain contains a set of competencies each of which is sub-divided into capabilities (Table II) that the intended audience should master to be able to develop, evaluate, and remediate accessible digital contents. The first four competency domains (from D1 to D4) represent the ICT-AID core competencies covering key capabilities required to developing a deeper mastering of the fundamental principles of digital accessibility. The fifth competency domain D5 encompasses required capabilities for the evaluation and the development of accessible

web content in compliance with international standards and best practices. At last, the sixth competency domain features the broad scope of accessible digital environments and platforms, including mobile apps, gaming, and future digital technologies.

Table 1 **ICT-Aid Competencies**

Competency Domains	Competencies
D1. Becoming familiar with Disability and Accessibility	D1.1 Distinguishing theoretical Models of Disability D1.2 Recognizing the major types of Disabilities and their impact on lives of PWDs D1.3 Demonstrating Understanding of Accessibility D1.4 Describing and following disability etiquette guidelines for interacting with PWDs
D2. Describing the legal landscape of Disability and Accessibility	D2.1 Identifying and characterizing main Laws, Declarations and Conventions on Human Disability Rights D2.2 Recognizing key ICT Accessibility regulations, policies and best practices D2.3 Identifying ICT Accessibility standards D2.4 Integrating ICT Accessibility across the organization
D3. Making a sense of Universal Design	D3.1 Describing the Universal Design paradigm D3.2 Demonstrating understanding of Universal Design for Learning
D4. Creating Accessible Digital Content	D4.1 Identifying major Accessibility considerations to common digital formats D4.2 Creating Accessible Word-processing documents D4.3 Creating Accessible Presentation documents D4.4 Creating Accessible PDF documents D4.5 Generalizing Accessibility considerations for different multimedia formats

Table 1 **ICT-Aid Competencies**

Competency Domains	Competencies
D5. Creating Accessible Web Content	D5.1 Demonstrating understanding of Web Accessibility D5.2 Designing and creating web content in accordance with the W3C Accessibility specifications D5.3 Testing and evaluating Web Accessibility D5.4 Remediating inaccessible Web documents
D6. Making Digital Environments and Platforms Accessible	D6.1 Identifying and applying the basic principles of Mobile Applications Accessibility D6.2 Evaluating Mobile Applications Accessibility D6.3 Identifying Accessibility considerations for improved game Accessibility D6.4 Ensuring the Accessibility of emerging digital technologies

Based on these competencies, ICT-AID specializations in Arabic and English languages are currently being developed. The specialization includes three courses aligned to the ICT-AID competency framework according to three skill levels: beginner, intermediate and advanced. These courses can be offered at universities and training institutions (Table 3), and certificates to be obtained accordingly to attest the acquisition of the necessary competencies for each level. As such, Mada is collaborating with partners in order to offer a joint accredited training programmes in Arabic and English languages including basically the following three key courses:

- An introduction to ICT Accessibility and Universal Design, aligned to the following competencies: D1, D2, D3, D4.1, D4,2, D4.3, D4.4, D4.5.1, D4.5.2, D4.5.3, D4.5.4, D4.5.5, and D5.1.
- Digital Accessibility, aligned to the following competencies: D4.5.6, D4.5.7, D4.5.8, D4.5.9, D4.5.10, D5.2, D5.3, and D5.4.
- Mobile and Environments Accessibility, aligned to the competency domain D6.

Table 2 **Capabilities Corresponding To The Competency Domain D1**

Competency Domains	Competencies
D1.1 Distinguishing theoretical Models of Disability	1. Identifying prominent theoretical models of disability 2. Describing Models' characteristics and understanding their strengthens and weaknesses 3. Defining Disability on your own words
D1.2 Recognizing the major types of Disabilities and their impact on lives of PWDs	1. Identifying basic categories of Disabilities and related demographics 2. Naming main characteristics of disabilities and associated barriers 3. Distinguishing how PWDs are impacted by different technologies
D1.3 Demonstrate Understanding of Accessibility	1. Describing the broad scope of Accessibility and technology 2. Identifying Benefits of Accessibility 3. Defining ICT Accessibility and related terminology on your own words 4. Exploring Accessibility barriers and Accessibility solutions 5. Identifying the use and application of AT and adapted Strategies 6. Identifying key professional organizations and networks in the area of Accessibility 7. Discussing your role in promoting digital inclusion through ICT
D1.4 Describing and following disability etiquette guidelines for interacting with PWDs	1. Identifying major misconceptions or stereotypes about PWDs 2. Applying disability etiquette to different life settings 3. Determining what your contributions could be to the Disability and ICT Accessibility movement

The first course corresponding to the first level can be integrated in education curricula at universities e.g. under the Common Core Program CCP. This course is intended to prepare for the first certificate level attesting the acquisition of core competencies in ICT Accessibility and Inclusive Design. The second and third courses are targeting intermediate and advanced levels and can be accordingly included within specialized computer science programs at universities. These latter levels allow students and trainees taking the certificate for digital accessibility specialists and then the certificate for digital accessibility experts:

- Level I Certificate: Core Competencies in ICT Accessibility and Inclusive Design
- Level II Certificate: Digital Access Specialist
- Level III Certificate: ICT Accessibility Expert

Table 3 **ICT-Aid Specialization Within Mada Accredited Training Programme**

Course	Title	Level	Certification
Course 1	An introduction to ICT Accessibility and Universal Design	Starter	ICT Accessibility and Universal Design Core Competencies
Course 2	Digital Accessibility	Intermediate	Digital Accessibility Specialist
Course 3	Mobile and Environments Accessibility	Advanced	Digital Accessibility Expert

On the other hand, in order to promote the development of accessible training and educational contents, particularly in ICT accessibility topics, taking advantage from the rise of education technology [29], Mada offers a dedicated accessible open educational resources OER Hub on OER Commons, where ICT-AID aligned accessible resources are aggregated, curated and managed through collections, and groups, and development tools. Mada ICT-AID OER Hub is intended to be a Global knowledge hub featuring freely accessible ICT-AID resources toward expanding capabilities for all in the realm of ICT accessibility [30]. Furthermore, Mada ICT Accessibility and Inclusive Design competency framework is now featured as a standard available to users of the OER Commons digital library and collaboration platform (Fig. 1). As a standard, Mada ICT-AID will be used to index and describe ICT-AID aligned educational resources providing accordingly ease of access and retrieve of these resources. As such, the ICT-AID competency framework will be used for searching, aligning, and evaluating Open Educational Resources serving globally learners and educators.

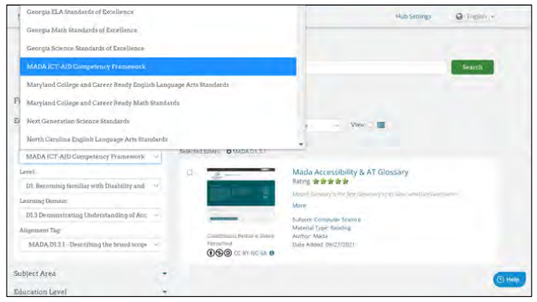

Figure 1
ICT-AID education standard on OER Commons

Expert survey on Mada ICT-AID Competency Framework

Generally, surveys are conducted to acquire expert opinions and recommendations in a particular field [31]. For a better understanding of the required relevant ICT-AID competencies and their inclusion and structure within a framework of competencies, Mada centre prepared and shared questionnaires with a group of experts, requesting their review and then validation on the proposed framework. In fact, two-round Delphi questionnaires were emailed to a selected group of experts in the region. Most of the reviewers came from academia with expertise in accessibility, education technology, and competency frameworks. In the first instance, experts were invited and contacted to gauge their interest in participating in the study. Then 22 experts (from 32 invited experts, about 70 % active responses) took part in the study. As part of the first round of the survey, experts reviewed and validated the structure of the proposed competency framework and checked if it has covered all the relevant competencies, and capability levels and related levels of proficiency. The first questionnaire covers three dimensions, namely: (1) Personal and professional Information; (2) ICT-AID competency domains; and (3) ICT-AID competencies per competency domain. For about half a month, experts were invited to add their detailed responses to the questionnaire sent via email. Following this, the response data were collected and analyzed, and the competency framework was updated and enhanced based on the most common suggestions. Among the 22 experts involved in the study, it is noteworthy that 10 out of 22 affirmed that ICT-AID courses (or similar courses) are not yet integrated into the curricula of universities in their countries, six do not know, and only 6 experts replied that it is or it would be integrated. As for the question on existing similar ICT accessibility and inclusive design competency frameworks, 15 out of 22 answered no and 7 referred mostly to the W3C WAI curricula on Web accessibility and IAAP professional certifications, which both don't cover comprehensively all required knowledge and capabilities on ICT-AID topics, and they are not structured and featured as a competency framework (Fig. 2). The remainder of the first questionnaire is dedicated to investigating the structure of the framework, and to check the spotted competencies and underlying capabilities. At last, 7 experts strongly agreed with the proposed structure of the framework, 12 agreed and 3 somehow agreed. After collecting and analysing inputs and feedbacks from experts, the ICT-AID competency framework was updated and enhanced. Then, the experts were requested in the second-round questionnaire to confirm the suggested updates and validate subsequently the final release of the proposed framework. The average rate of 9.05 on the interval [1, 10] was obtained to expressing the extent to which experts do agree with the current enhanced ICT-AID competency framework version. The promising average rate of 8.09 on the interval [1, 10] was obtained to expressing the potential readiness of experts' universities to be ICT-AID adopters [32].

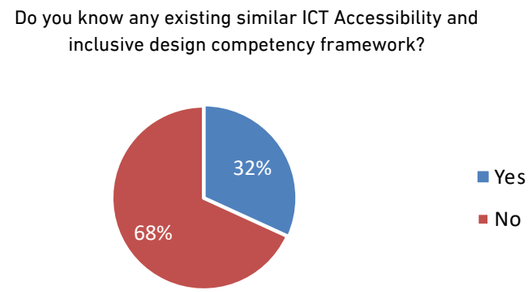

Figure 2
Investigating Similar ICT accessibility and inclusive design competency frameworks

ICT-AID use cases by Mada partners in Qatar

accessibility courses aligned with Mada ICT-AID competency framework. In Qatar, Hamad Bin Khalifa University HBKU for example, offers a course on ICT accessibility in the Bachelor of Computer Programming and Engineering. Additionally, master's and doctoral students at HBKU College of Sciences and Engineering have the opportunity to take a Human-computer Interaction elective course covering ICT accessibility and inclusive design topics. Accordingly, research students are engaged actively through active research grants related to accessibility, digital inclusion, and assistive technology. The Mada Accessibility and Inclusive Design ICT-AID Competency Framework was availed to design and prepare these courses with a view to expand the student's capabilities in the ICT accessibility area. By covering a variety of topics of interest, such courses provide a comprehensive review of the skills needed to develop, review and evaluate accessible digital content and platforms in compliance with international standards and best practices. Indeed, a student who has completed ICT-AID courses will have the capacity mainly to: understand the definition and the importance of ICT accessibility, develop accessible content, websites and mobile applications; evaluate the level of accessibility of digital content services, and platforms (e.g. documents, websites, mobile applications, electronic kiosks, etc.); identify the use and application of assistive technology; and apply universal and inclusive design principles to user-centered technology development. As part of the aforementioned ICT-AID courses, HBKU students visited Mada Center and its innovation lab and met Mada team, which has given them the opportunity to learn more about Mada's programs, services, and activities towards enhancing ICT accessibility in Qatar and beyond. It is also noteworthy that students were involved in ongoing innovative projects to address pressing accessibility issues. Throughout the entire process, students showed an intense interest and full engagement. There are many of them who were interested in participating in ongoing accessibility research and projects at HBKU and Mada. In addition, HBKU also offered a class on accessibility and inclusive design as part of its Interactive Design for Healthcare course in collaboration with Mada Center to build research capacity. A workshop on digital accessibility was conducted at Mada Center to all students who took this class. In the workshop, entitled: "Introduction to Digital Accessibility", participants learned about the importance of including people with disabilities and making sure they have access to technology related innovations. Participants were provided with opportunities to engage with real-world applications and technologies, enhancing thus their learning experience (to learn more about HBKU experience, please see the next paper in this edition entitled: ICT accessibility Research Capacity building in the State of Qatar).

The Community College of Qatar CCQ has also recently introduced an introductory ICT-AID course in Arabic language as part of its core curriculum program supported by Mada. This is indeed a very important and beneficial effort towards fostering ICT accessibility in Arabic in the region. This course, entitled : "An introduction to ICT accessibility and inclusive design" has been started in Fall 2022 with about 22 female students, mostly from the governmental sector in Qatar. The class is covered weekly in part as a theoretical lecture class and also as a lab. The course was designed and prepared by Mada in Arabic language based on Mada ICT-AID competency framework. Accordingly, the following ICT-AID competencies are targeted as per the framework: D1, D2, D3, D4.1, D4,2, D4.3, D4.4, D4.5.1, D4.5.2, D4.5.3, D4.5.4, D4.5.5, D4.5.6, and D5.1. The course is available online in open access under Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) through Mada ICT-AID aligned OER Hub. Therefore, CCQ and any other educational institutions in Qatar and beyond, can adapt the course for use in different learning contexts and modes. It is noteworthy that this introductory course is part of the Mada ICT accessibility and

Inclusive Design specialization which is composed of three courses through which students will make a sense of Accessibility and Inclusive Design, and they will acquire the ICT accessibility skills needed to apply, and review, and evaluate the Accessibility of digital platforms in compliance with International ICT Accessibility standards and best practices. By taking the first level of the specialization, CCQ students will understand and learn foundations in ICT Accessibility and Inclusive Design. They will learn the broad scope of Disability, Accessibility and related legal landscape, and they will explore the key principles guiding Universal Design and Accessible content creation. Moreover, they will learn how PWDs use different Assistive Technologies and adaptive strategies. By completing the course, students will be able to develop, evaluate, and remediate Accessible Digital Materials, and they will be prepared for the next Mada specialization courses and further study in ICT Accessibility. The introductory course encompasses the following 7 chapters: the foundation in Disability and Accessibility; Assistive Technologies; the legal landscape of Disability and Accessibility; Universal Design and Universal Design for Learning; ICT Accessibility standards; Accessible Digital Content; and Web Accessibility fundamentals. Furthermore, an onsite visit to Mada center was conducted so that CCQ students get the opportunity to meet Mada team and get hands-on labs in the Mada innovation lab and Mada FabLab. Students were also asked to prepare capstone projects covering all learning outcomes in order to demonstrate their understanding of ICT accessibility and apply related standards and best practices while designing and creating accessible products, contents and services.

Apart from the aforementioned use cases of Mada ICT-AID competency framework by universities in Qatar, the framework was also availed in other specific training programs such as “Tamheen”. In fact, this training program aims at qualifying non-pedagogical Qatari graduates to work in the teaching profession in governmental schools in Qatar. The program is a pioneering initiative launched in November 2019 by the Ministry of Education and Higher Education in Qatar, represented by the Training and Educational Development Center (TEDC), in collaboration with national and international partners including Mada Center. A specific ICT accessibility training as part of the whole program has been designed then conducted by Mada. This year, the training of the third batch was designed using the ICT-AID competency framework, targeting accordingly a set of necessary competencies and capabilities related to disability and ICT accessibility, that teachers should acquire and integrate into their teaching practices. The tailored training program was broken down basically into the six following courses with a total number of 33 training hours: Introduction to disability and Assistive Technology; Universal Design for Learning; Accessible documents, Introduction to mobility impairments and digital accessible solutions; Introduction to sensory, visual and hearing impairments and digital accessible solutions; Usage of accessible technology solutions to serve communication difficulties; And Introduction to assistive technology, accessible solutions, and learning difficulties. A number of 6 female trainees attended the training in 2022 and graduated last June.

Conclusion and future work

It is deemed important and relevant to cover ICT accessibility and inclusive design in training programs, curricula, and courses. This is indeed prompted by the unprecedented technological developments on one hand, and the increasing number of people with disabilities and the elderly having the right to avail such technologies on the other hand, as well as the international and national legislation requiring that technology must be universally accessible to everyone, regardless of ability or age. Despite this urgent need, there is a lack of knowledge, and awareness, and expertise on accessibility, especially in the Arab region, due to, among other factors, the lack of integration of ICT-AID aligned courses in educational institutions and nonexistence, to the best of our knowledge, of a comprehensive global competency framework delimiting all required relevant competencies in the field of ICT accessibility. Within this context, Mada center has developed an open competency framework in order to guide globally training of students and workers on the foundation in ICT accessibility and inclusive design, so that they will be well prepared to excel in their accessibility professions and contribute in the creation of accessible products, contents and services. Future works include the dissemination of Mada ICT-AID competency framework upon possible different adaptations, translations, and contextualization, as well as producing guidelines and toolkits to support adopting the framework worldwide as an ICT-AID education standard.

Acknowledgment

We gratefully thank the working group of experts on Mada ICT-AID Accessibility and Inclusive Design, for their valuable inputs. To see the list of experts, please refer to the Arab ICT Accessibility Expert Group Web site by Mada “AIAEG”, an initiative from Mada Centre, established to unify the Arabic efforts and to establish the first expert hub in the region dedicated to Digital Accessibility.

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Using Brain-Computer Interface to improve learning skills for students with disabilities

a rapid review

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Brain-Computer Interface (BCI) enables direct communication between the brain and an external device. BCI systems have become a popular area of study in recent years. These technologies can be utilized in various ways to assist people with disabilities and healthy individuals. Regarding substantial BCI advancements, we can say that these systems are on the verge of commercialization. This review has considered current trends in BCI research on inclusive education to assist students with disabilities in achieving improved learning outcomes for all students in an inclusive environment.

Introduction

Over the past few decades, research on brain-computer interface (BCI) devices has become widespread. BCI enables a direct connection between the brain and an external device such as a computer, robot, neuro-prosthesis, exoskeleton, speech prosthesis, assistive technology, or wheelchair [1] [2]. Through several focus groups with persons with disabilities, we found an interest in using BCI technology to innovate new solutions and products [3]. These systems can be utilized for a variety of purposes. They are typically employed for clinical purposes but can also be used for entertainment, training, security, treatment, education, safety, communication, and control, among other applications [4][5]. Most BCI systems are separated into invasive and non-invasive approaches. The non-invasive technique is the most popular and most secure of these options. Even though numerous publications have been published and several actual applications have been developed, BCI systems still face numerous obstacles and restrictions.

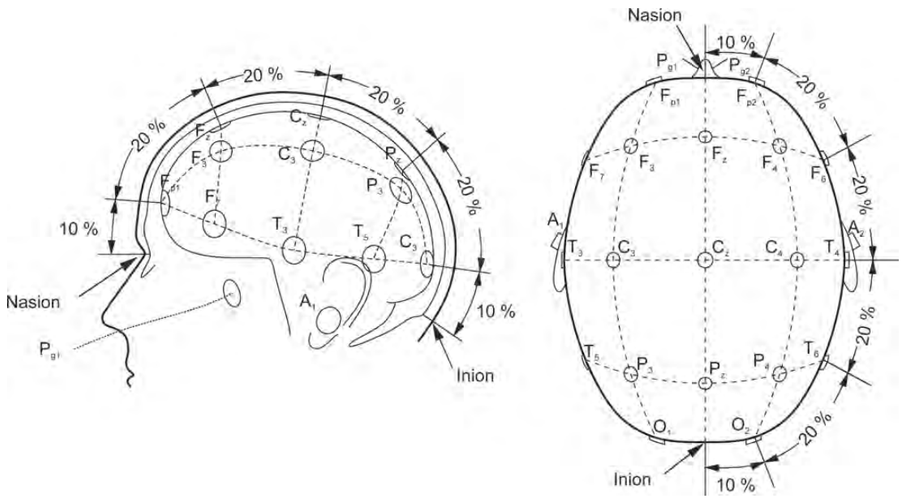

Figure 1. Possible Electrode placement over the scalp.

Understanding how the brain functions to measure and interpret brain waves is crucial. The electrical and magnetic phenomena of neural function can be monitored during brain functioning. The most popular form of electrophysiological observation is electroencephalography [6], in which biosensors measure and record electrical signals generated by brain

activity. Brain cells communicate by sending electrical impulses; the more impulses sent, the more electricity the brain generates. The pattern of this electrical activity can be measured by an electroencephalogram (EEG); these EEG data are often analyzed by a quantitative EEG (QEEG) approach, in which the frequency spectrum of the EEG signals is evaluated [7]. Figure 1 presents an overview of possible placement over the scalp to detect and monitor electrical impulses of brain activities [8].

Taking an EEG requires sophisticated, expensive, extensive, and immobile equipment; however, technological advancements have enabled mobile EEG biosensor-based embedded devices for new applications, including entertainment, control devices, and education. In these applications, a BCI establishes the relationship between the EEG-observed brain activity and the generated function [9]. Advanced BCIs include biosensors and modern signal processing units, are less expensive and more portable due to their simple design, and are as accurate as clinical EEG equipment [10]. Table 1 presents a summary of different methods.

Table 1. Summary of neuroimaging methods.

Neuroimaging method	Activity measured	Direct/Indirect Measurement	Temporal resolution	Spatial resolution	Risk	Portability
EEG	Electrical	Direct	~0.05 s	~10 mm	Non-invasive	Portable
MEG	Magnetic	Direct	~0.05 s	~5 mm	Non-invasive	Non-portable
ECoG	Electrical	Direct	~0.003 s	~1 mm	Invasive	Portable
Intracortical neuron recording	Electrical	Direct	~0.003 s	~0.5 mm (LFP) ~0.1 mm (MUA) ~0.05 mm (SUA)	Invasive	Portable
fMRI	Metabolic	Indirect	~1 s	~1 mm	Non-invasive	Non-portable
NIRS	Metabolic	Indirect	~1 s	~5 mm	Non-invasive	Portable

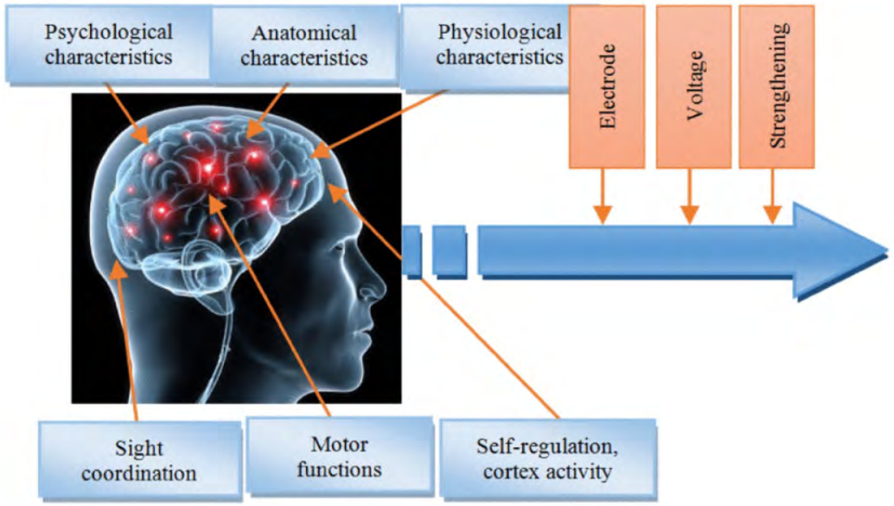

Figure 2. Sample illustration: a model of bioelectric signals.

Education research demonstrates that active student participation facilitates acquiring and retaining new information more effectively than traditional lecture-based instruction [11]. Moreover, when this active engagement is group-based as opposed to individual-based, students' problem-solving, written, and speaking skills, as well as their learning and cooperative skills [12].

Effective acquisition of practical engineering skills is possible through problem-based learning (PBL) [13], team-based learning [14], and project-based learning (PjBL) [15]. Engineering strongly emphasizes the ability to apply information in the real world.

BCI as an Assistive Technology

Significant advances have been made in the research of BCI control [16] [17]. It can be used in different use cases such as and not limited to:

- Control of external devices, such as limbs prostheses [18]
- Smart home environments [19]
- Robots and Exoskeletons [20]
- Robotic hand [21]
- Hearing prostheses [22]
- Wheelchairs [23]

- Computer programs [24]
- Virtual reality, avatars, and metaverse [25]
- Virtual environment and smart cities [26]

BCI's most important use is to give individuals intuitive control over overreaching and grasping movements using their paralyzed limbs [27]. Additional possible applications include communication [28]. One of the biggest challenges is restoring and replacing motor function or communication for people with physical disabilities.

BCI control in Educational and Serious Games

All kids rely heavily on play for their learning and growth. Both neurotypical and neurodiverse children gain more from engaging in activities that keep them interested, engaged, and offer embedded learning opportunities [29]. However, current BCI software focuses on basic, utility-driven applications, such as spelling grids and cursor movement. While valid, such applications are limited in their appeal for sustained use, particularly for young BCI users. Evidence suggests that enhancing engagement in BCI through gamified learning may result in a broader acceptance of the technology while aiding in the dissemination of BCI control schemes.[30]. A growing trend across BCI research endeavors reveals that more engaging. User-friendly activities may promote a variety of tangible boons in BCI use—both in short-term task learning and long-term BCI accuracy [31]. Therefore, there is an obvious need to support the development of more engaging, accessible BCI software that includes key play components in pediatric BCI.
BCI systems provide the new potential for both virtual plays (e.g., videogames and digital media) and physical play (e.g., manipulation of toy robots, cars, et cetera). Using the non-muscular properties of BCI, such technologies may enable previously excluded populations to explore and learn through play. BCI systems provide potential for both virtual play (e.g., videogames and digital media) and physical play (e.g., manipulation of toy robots, cars, et cetera). Using the non-muscular properties of BCI, such technologies may enable previously excluded populations to explore and learn through play. Previous research has demonstrated mediums as essential for continued learning and rehabilitation in children with disabilities. Advancements in BCI research furthering the interaction between BCI systems and play thus represent a promising untapped potential for pediatric BCI end-users.

The outcome of learning activities using BCI

BCI can play a vital role in closing the knowledge gap and improving educational skills in students with disabilities [32]. The primary learning outcomes of these courses are that students with disabilities can:

- Classify systems based on their properties and understand and exploit the implications of linearity, time invariance, and stability;
- Determine and use Fourier transforms and other signal analysis methods;
- Understand the application of control methods, proportional–integral–differential algorithms, and properties of a control;
- Understand and analyze the design implications and interconnections of physical and control systems;
- Develop mathematical models for real physical and control systems and produce block diagram implementations of the mathematical models and control methods.
- BCI can present an alternative technology to control and take online courses during crises [33].

Conclusion and future work

In general, BCI connects the brain and external devices. BCI is suitable for the improvement and facilitation of the life of everyone. BCIs can be used in many areas and inclusive education. Overall, findings show that BCI is a topic being closely studied by scientists worldwide. This study also demonstrates that BCI technology was commonly used for medical objectives. In education, BCI can be used in remote learning to control the computer for students with physical disabilities. The technology is still under development and can achieve excellent results with impact in the future.

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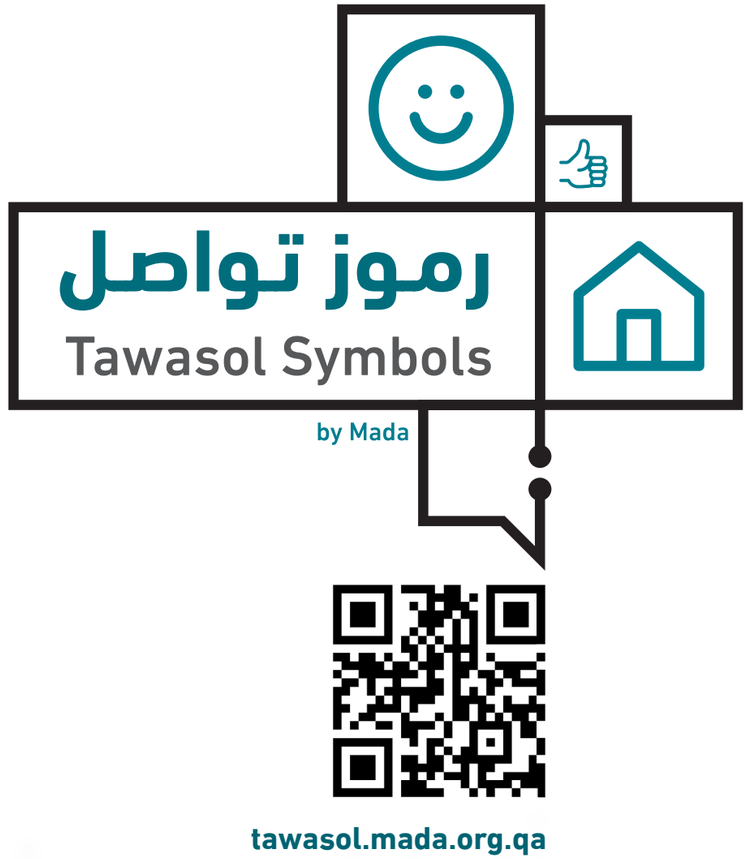

Usability Assessment of Delivery Applications for Visually Impaired People
A Case from Saudi Arabia

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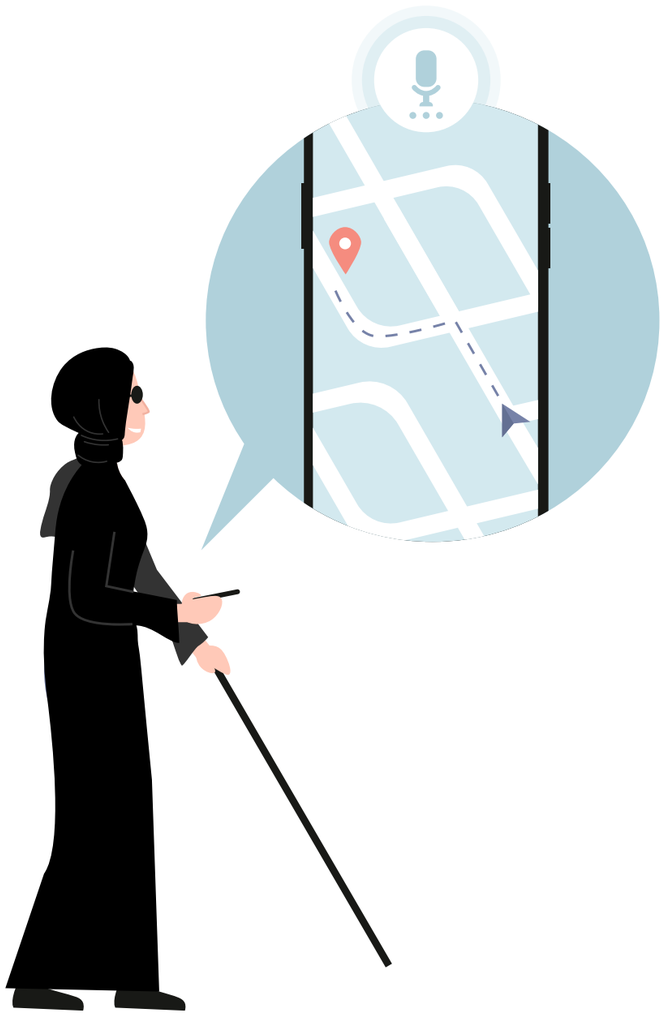

Technology has become an essential part of our lives, and many of our daily tasks have become entirely dependent on it. For example, routine chores such as shopping for household necessities, booking travel tickets, going to places using all different kinds of transportations etc., are quickly done through mobile phones. And because of how it is easy to use mobile phones, we may forget that others, such as the visually impaired, may face many difficulties when using them. In this research two of the most widely used delivery applications in Saudi Arabia, namely, Hungerstation and Mrsool were studied and evaluated in order to assess their usability for people with visual impairments. Evaluation results show that both applications have usability problems. Nonetheless, the results of the standard ISO usability metrics (Effectiveness, Efficiency and satisfaction) showed that Hungerstation is more usable than Mrsool.

Over the past years, the development of mobile devices was accompanied by many tools and applications that help visually impaired people use them. People who have blindness can use technology today to do many things such as sending emails, surfing the Internet, making purchases, and much more. Applications such as screen readers and Braille keyboards allowed them to use various electronic devices independently, which solved many of the accessibility obstacles for blind individuals.

According to [1], it is estimated that 43 million people are blind worldwide in 2020, and around 295 million people will suffer in the future from moderate to severe visual impairment. As for Saudi Arabia, nearly one million people in the Kingdom have a visual impairment [2].

Due to the high percentage of people with visual impairments in Saudi Arabia, our aim in this research is to evaluate the usability of two popular and widely used local delivery applications namely: Hungerstation (https://hungerstation.com) and Mrsool (https://mrsool.co/). These two applications are specialized in delivering food from restaurants, cafes and grocery stores, as well as other types of delivery such as delivering necessities from one place to another.

Targeting the two delivery applications was based on their popularity by both sighted persons as well as visually impaired persons, based on interviews we conducted with visually impaired people. Therefore, this research aims to measure the usability of the selected delivery applications for visually impaired people, find the issues and problems in each application and finally give some recommendations to improve the usability of the applications to be used effectively by people with visual impairments.

Methodology

Our research has gone through several stages of data collection and analysis as follows:

Preliminary stage

Consists of two steps: (1) distributing a questionnaire to visually impaired people to find out the most commonly used applications and websites. Then (2) interviewing five blind people to find the most widely used delivery applications.

Testing stage

Consists of two steps: (1) pilot testing and (2) user testing. In the pilot testing, we tested three delivery applications (Hungerstation, Mrsool and Jahez) with four visually impaired people. We tested Jahez because it was among the top chart of the Apple store for food and drinks category. But it was excluded from the study due to its very poor usability.

While in the user testing step, ten visually impaired people (5 females and 5 males) used both applications, following our test protocol while observing and recording the whole experiment.

Table 1 summarizes the participants' demographics.

	Age	Gender	Degree	Have you ever used delivery apps	what language do you prefer to use the apps with?	English language level	Technical knowledge Level	How many years have you been using the iPhone with the VoiceOver?
P1	28	M	Master	Yes	Arabic	Beginner	Advanced	5 years and above
P2	28	M	Master	Yes	Arabic	Beginner	Intermediate	5 years and above
P3	24	F	Master	Yes	Arabic	Beginner	Intermediate	5 years and above
P4	22	M	Bachelor	Yes	Arabic	Intermediate	Intermediate	5 years and above
P5	23	M	Bachelor	Yes	Arabic	Beginner	Intermediate	5 years and above
P6	20	F	Bachelor	Yes	Arabic	Intermediate	Advanced	5 years and above
P7	22	F	Bachelor	Yes	Arabic	Intermediate	Intermediate	5 years and above
P8	28	M	Bachelor	Yes	English	Intermediate	Intermediate	1-5 years
P9	20	F	Bachelor	No	Arabic	Beginner	Intermediate	5 years and above
P10	30	F	Bachelor	No	Arabic	Beginner	Intermediate	5 years and above

All the participants in the study were users of iOS devices of various models from iPhone 6 to iPhone 12 pro. An overview of the required tasks was given for each of them before the start of the testing process. A Total number of twelve tasks were tested and were divided into the following types: the search and selection process, including (choosing the restaurant, choosing the required products), the checkout process, including (choosing the payment method, adding notes, choosing the delivery location, and finally order). Tasks were arranged to correspond to the sequence of their appearance in both applications, and were done entirely depending only on the VoiceOver of the iPhone.

Quantitative methods were used in this research through the use of ISO usability metrics [3] which are: effectiveness, efficiency and satisfaction. Effectiveness is defined as the ability of a user to execute a specific task in a given setting. It can be calculated by measuring the completion rate of the task or a stage in completing a task. Efficiency is the user's ability to complete a given task quickly and accurately or time on task. Efficiency can be calculated by

how long each task takes to complete. Both Effectiveness and Efficiency can be calculated in a laboratory setting or by observation. While the level of comfort and enjoyment experienced or able to accept the expectations and requirements by a user is referred to as user satisfaction, Satisfaction is a subjective concept that can be measured through a survey, such as a Likert-scale rating [4].

Results and Discussion

The results of the usability evaluation showed that the most popular local delivery applications need to be improved, as some problems were found that hinder usability for people with visual impairments. Also, usability testing should be conducted by blind people before and after the applications are released to their potential users to avoid any future problems.

To measure the usability of the two applications, the following usability metrics were used: effectiveness, efficiency and satisfaction. The previous metrics showed that Hungerstation is more usable than Mrsool, with an overall effectiveness rate of 92.27%, average time for each task equals 1:03 minutes, and satisfaction equal to 81.95.

While Mrsool application got an overall effectiveness rate equals to 90.83%, an average time for each task of 1:13 minutes and a satisfaction score equals to 50.25.

The study of these applications allowed us to know the problems in each application and elicited some suggestions to improve the usability of delivery applications used by visually impaired people. We also hope that our research becomes the beginning of conducting similar research on other local applications of all kinds.

Design Recommendation

Here are some suggestions to improve the usability of delivery applications based on our research findings:

1. Navigation with VoiceOver and gesture: the blind person relies on the movement of his/her hand to move between the content of the page while hearing VoiceOver to understand each element's location, which must be taken into account when designing the page layout.
2. Adherence to the standard design recommendations provided by iOS and Android, such as placing the back button at the top left of the page in the English interface and its top-right in the Arabic interface.
3. Describe and label the page elements, one of the most important points that must be taken into account during the design, as the absence of a label for a button or an option makes the use of the blind impossible.
4. Reduce notifications and link them with a sound indicating their appearance if necessary; because the blind cannot know if a notification is appearing on the screen.
5. Use the correct terms for the buttons; for example, use the word "close" instead of "OK" to refer to the need to close a specific notification before returning to navigate through the page. This mistake was noticed on Mrsool select location page.

6. **Do not use layering, the appearance of parts of another page or an option as a layer above the main page is a bad and distracting factor for the blind, as the VoiceOver reads the contents for the two layers at the same time.**
7. **Do not use drop-down lists; as the blind user could not guess the type of a list and often clicks on it to be read by VoiceOver, which leads to its closure if it was a drop-down list.**
8. **Translate all buttons and page contents of the User Interface (UI), the lack of translation of the screen content may hinder the blind from accessing many options and features.**
9. **Separate the options that should allow the blind to perform operations on them, such as deleting and modifying a specific product in the cart. As product quantity reduction in Hungerstation application could not be tested in this research since the VoiceOver was reading all products together and does not separate them, and also the use of hand gestures to indicate and select only one product to delete did not work either, which indicates both a major accessibility and usability problems.**
10. **Do not separate a field from its description, such as the writing field, as the blind person is going to press on the description of the field repeatedly, thinking that the keyboard will appear like what happened while testing Mrsool application.**
11. **Add a search field to the map page is also necessary if the blind person wants to make a request for a location other than his current location.**
12. **Make sure the application update does not change the usability of the application; it was noticed when doing the experiments in this research that some of the old updates had higher usability level than the new ones.**

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Mada FabLab
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an inclusive STEM and fabrication environment for creativity and innovation and its impact on persons with disabilities

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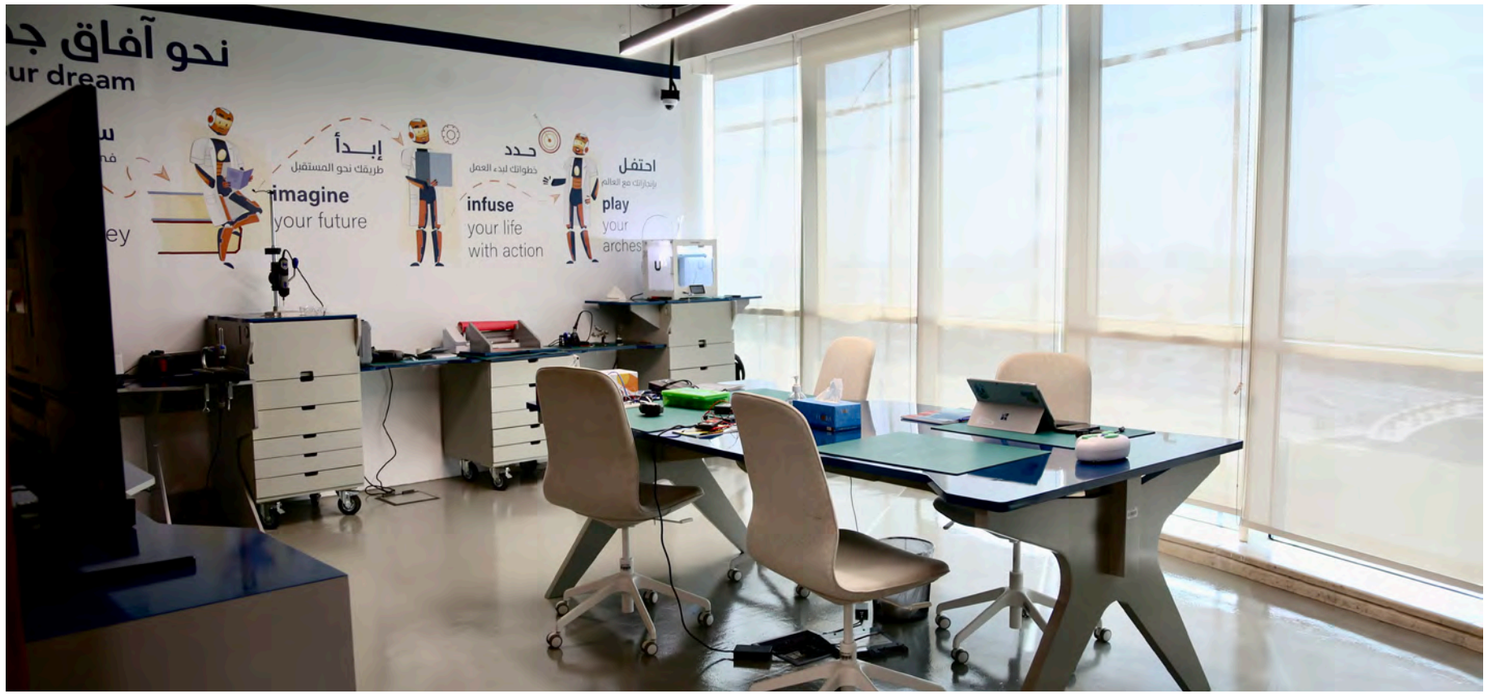
Mada Center

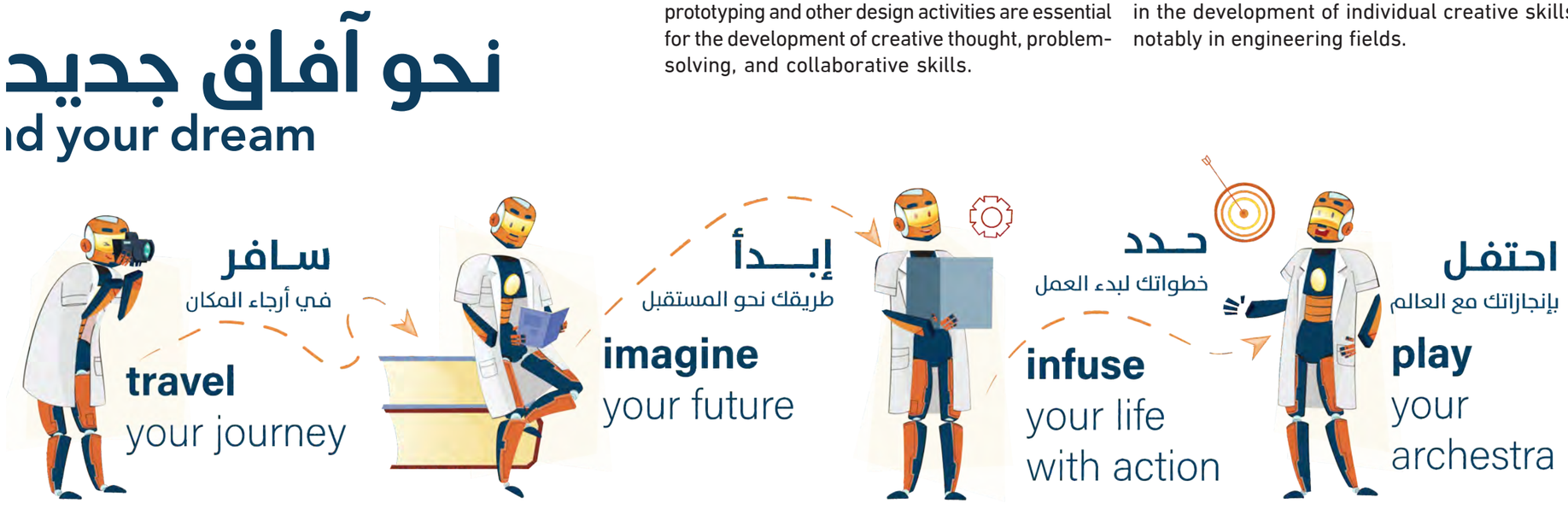


Fabrication laboratories (FabLabs) are utilized to materialize concepts. They can improve cognitive and creative abilities when used in a design-learning situation. Numerous studies have attempted to comprehend the relationship between makerspaces and creativity in a variety of disciplines, with the capacity to generate innovative consequences in makerspaces dependent on creativity. However, a comprehensive study that provides a holistic perspective on the contributions of labs as inclusive places that stimulate creativity for people with disabilities is absent. In order to address this study gap, the paper that follows provides an overview of FabLabs, makerspaces, and creativity and introduce the first of its kind MadaFabLab, as the first inclusive fablab in the world designed and tailored for innovators with disabilities "MadaFabLab". The studies revealed that fablabs contribute to the development of creative person, product, physical, and social surroundings, as well as creative process. In addition, the MadaFabLab, a novel inclusive idea, fosters problem-solving, collaborative, and communication skills, and offers appealing locations and tools for the development of creative solutions to real-world challenges and needs identified by people with disabilities. We identified and analyzed five important themes pertaining to technical skills, technological and environmental factors, STEM learning, and skill development, and focused on their significance for fostering creativity in an inclusive FabLab.

A FabLab is defined as "a creative, uniquely adaptable learning environment with tools and materials, which can be physical and/or virtual, where students have the opportunity to explore, design, play, tinker, collaborate, inquire, experiment, solve problems, and invent" [1]. In FabLabs, a greater emphasis is placed on the use of often-predefined equipment (e.g., 3D printers, laser cutters, or electronic workbenches) and the breadth of training related to this equipment. This technology enables computer support and subtractive manufacturing, design and rapid prototyping, as well as the simple materialization of highly customized products. Digital fabrication technology is regarded as an integral component of FabLabs, invention studios, and, personal fabrication setups. Schmidt [2] coined "open creative labs" as a catch-all term for all labs mentioned in the literature: entrepreneurship, public libraries, design education, higher education, science, technology, engineering, and mathematics (STEM) education, medical practices, and sustainability [3]. The majority of research conducted on FabLabs characterized them as creative, built environments that assist students, engineers, designers, architects, and healthcare professionals in developing innovative solutions to real-world problems. In this regard, the stimulating atmosphere and environment promotes the development of creative ideas and solutions. There is evidence of a growing impact of workspace environments such as makerspaces on innovation and creativity [4]. It was discovered, for instance, that the quality of the physical environment positively affects individual and team creativity. In contrast, negative characteristics of the physical environment can inhibit creativity [5].

Digital fabrication technology utilized in FabLabs influences users' thinking, ideas, creation skills, and ability to produce creative solutions in a wide range of domains, including art, science, and engineering. A study conducted by Saorin et al. [6] in makerspaces concluded that digital editing tools and 3D printers contributed to the development of engineering students' creative ability. In addition to fostering the development of creative skills, makerspaces are beneficial for fostering collaboration, problem-solving, and communication in STEM (science, technology, engineering, and mathematics) fields [7].

This article seeks to comprehend the influence of built environments, such as FabLab, on creativity according to person, process, product, (physical and social) environmental characteristics, and collaboration aspects, with a focus on people with disabilities. Four findings were outlined in the present article and a dedicated section for Mada's initiative to establish an inclusive Fablab called "MadaFabLab".



Learning and Skills Development in STEM Education

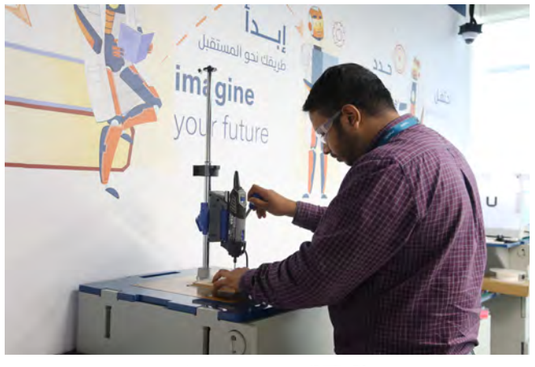
Fablab plays a significant role in helping students with disabilities develop their creative thinking, communication, and collaboration skills, particularly when the "learning by doing" approach is implemented. The type of pedagogy utilized in Fablabs was another factor that contributed to the development of the students' creative abilities. Students' motivation to learn, think, and act creatively was primarily influenced by their enjoyment of the learning process and the availability of a technologically supportive environment. Exploration, inquiry, and examination of materials were also found to foster creative outcomes from an experiential standpoint. Additionally, research on FabLabs examined the motivation for creativity in STEM education. Smith demonstrated that Fablabs in STEM can be utilized to improve creative skills and abilities such as critical thinking, problem solving, and design collaboration. In this regard, material artifacts and discarded materials found in makerspaces can have significant implications for learning how to foster creativity. Particularly, FabLabs foster conducive learning environments where prototyping and other design activities are essential for the development of creative thought, problem-solving, and collaborative skills.

Fostering Individual Creative Competence

Creativity is necessary for success in numerous fields, including design, and engineering. It is essential to develop innovative alternative solutions to a problem. According to a study in the field of engineering, makerspaces equipped with digital editing tools and 3D printers stimulate creativity [7]. Similarly, Duenyas and Perkins demonstrated that makerspaces that facilitate engagement with a variety of tools and materials help users develop creative competencies such as self-awareness, self-esteem, the ability to cope with negative emotions, and the ability to form positive relationships [8]. Similarly, Taheri et al. [9] demonstrated that FabLabs contributed to a strong sense of community, self-confidence, and entrepreneurial abilities for engineering courses, in addition to fostering creativity. In addition, they increased their problem-solving, communication, and teamwork skills. Hoople et al. [10] discovered that the presence of experienced practitioners and explicit rules of engagement were crucial for both formal and informal creative competency development inside makerspaces. In conclusion, FabLabs and makerspaces play a crucial role in the development of individual creative skills, notably in engineering fields.

Creative Product Development

Creative products must not just be creative and distinctive, but also useful, practical, and/or functional. The development of creative products is regarded as a complicated endeavor needing multidisciplinary teamwork with the necessary instruments. In this sense, interdisciplinary collaboration enabled using digital fabrication technologies in FabLabs can stimulate the inventiveness of the outcomes (i.e., prototypes and products). According to research in nursing and engineering, collaboration in a FabLab environment helps uncover real-world challenges, produce innovative ideas, and develop commercially viable prototypes. Other studies have also highlighted the favorable role makerspaces play in the conception and development of sustainable, creative, and viable goods [11]. According to the reviewed articles, FabLabs and makerspaces should be deemed ideal environments to produce creative outputs. As settings that support built environments, these places seem to have the right physical conditions and resources for developing and making real ideas into unique and long-lasting goods.



Fostering Creativity through Motivational and Inspiring Learning Environments

When supported by proper means, such as digital fabrication tools, makerspaces can be viewed as dynamic learning environments where users engage in creative endeavors [12]. As a learning setting, makerspaces enable individuals to express themselves, hence increasing the likelihood of developing creative solutions. Trahan et al. discovered that providing a learning environment in which students and teachers were permitted to fail encouraged them to experiment and explore without fear, as well as to include other participants in their creative activities [13].

Forest et al. [14] investigated the effect makerspaces have on self-perception. They discovered that 90% of users believed makerspaces as learning settings encouraged them to pursue occupations requiring creativity, design, innovation, and invention. In addition, their research revealed that design-build education fosters innovation, creativity, and entrepreneurship in engineering. Studies have demonstrated that FabLabs and makerspaces have a good impact on the self-expression, inspiration, motivation, and creative capacities of their users through the provision of encouraging and supportive physical and social environments [15].

MadaFabLab

Fablabs have the potential to alter fabrication patterns, promote science, technology, engineering, and mathematics (STEM) skills, create enterprises and jobs, and stimulate economic growth and productivity. They accomplish this by allowing virtually any member of the general public with creative ideas to participate in the design, production, and distribution of goods and services. An expanding global network of Fablabs has established an altogether new arena of opportunities at the local level to drive creativity, invention, and applied research across industries. As stated in the introduction, however, just as the internet has not been distributed consistently or inclusively to everyone, some Fablabs around the world have made the same error. Their approach disregards inclusive design in favor of cooperation, resulting in "one size fits one person" as opposed to the "universal design" dictum of "one size fits all."

Incredibly, the process that Mada Center has been creating to construct and deploy the world's first Fablab intended exclusively for persons with disabilities and become a global standard named “MadaFabLab” (https://fablab.mada.org.qa) supported through the Mada Innovation Program [16]. Since not only its space and furniture will be suggested for the integration of people with special needs, but also their content will be designed with the same strategy, combining assistive technologies and online courses with digital manufacturing. This strategy will facilitate the process of altering social norms, beliefs, and attitudes, as well as addressing unconscious prejudices and stigma, and establishing policies and procedures in training centers that are in line with these changes. In a world where change occurs at an ever-increasing rate, driven by science and innovation, inclusive education and training must utilize technology to promote universal access and increasingly individualized learning.

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