RÉPUBLIQUE LIBANAISE

CRDP
Centre de Recherche
et de Développement
Pédagogiques

MakerSpaces

IN INTERNATIONAL AND LEBANESE CONTEXTS.

RECOMMENDATIONS FOR DECISION MAKERS

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Preamble

Proceeding from its adoption of the Sustainable Development Goals of the 2030 Agenda, especially the fourth goal, which is "*to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*", and because the school is the institution capable of providing equal education opportunities for all, the Educational Center for Research and Development (CRDP) had to keep pace with the rapid development of technology. With this technological advancement, a group of economic and technological models and techniques - such as those of artificial intelligence represented by the Internet of Things - appeared. The robot has also become a part of the daily life of many institutions and companies.

Since the learner is the center of the teaching-learning process, it was necessary to find advanced educational systems that represent the modern global trends which focus on enhancing the 21st century skills among learners.

Hence, the need to create a space that allows a set of techniques, applications and modern technological methods arose in order to help learners present the best they have, not only within the school, but also outside it. Such methods enable learners to apply the knowledge and skills they have acquired in solving their life problems.

This space is known as MakerSpace, a term that was first used in 2005 to denote easy-to-reach places for the sake of exploring, learning how to use tools and materials, and developing creative projects. In this respect, this space represents a safe environment for self-learning and self-development while working on projects in teams. It is an essential place for technological experiments, for the development of models and ideas, and for problem solving. Besides, it is a means that would make it possible for schools to go back to constructive education; thus allowing students to be creative.

Because education is the best investment for the industrially and economically developed countries, global trends had to be adopted; taking into account the Lebanese reality and its needs while preserving the profile of the Lebanese Learner as well as the Lebanese identity.

Therefore, in order to achieve the general educational objectives of the Plan of Educational Development, this research was conducted to examine the Lebanese reality regarding how the MakerSpace can be invested in the teaching-learning process, whether in public and private schools and high schools or in clubs. More specifically, the study was conducted as phase one of the MakerSpace project which was designed in three phases and supervised and implemented by a committee assigned by CRDP. Based on the plan set by this committee for the MakerSpace, the study was carried out to benefit from the experiences of developed countries that had adopted this space as a part of their educational system. Thus, a team of researchers - accompanied by the committee- determined the specifications of the creative operator, the people responsible for its management, and the competencies and skills that it helps learners develop.

The study aimed at achieving those objectives concerned with technology, development, and fostering the creativity and critical thinking of the Lebanese learner who "works on developing his/her cultural and technological assets, refining his/her creative energies, and enhancing his aesthetic perceptions"; and the one who "is consciously and skillfully aware of the importance of using technology, developing it and dealing with it in terms of thought, performance, behavior and evaluation. In addition, the study came up with recommendations regarding the type of activities that can be implemented within this space and the way they can be integrated into the forthcoming curricula.

Accordingly, we present this research which includes MakerSpace frameworks, the educational impact, and models of projects that fall within this concept along with the tools that must be available. The research also specifies the profile of the educators of these creative spaces. In this respect, the study is considered comprehensive as it deals with the space in all its aspects. This in turn will help stakeholders to make the appropriate decision about adopting this new path in educational institutions.

In Education We Build Together Active and Interactive Generations

CRDP Acting President

Mr. George Nohra

Abstract

As an initial stage in a three-phase project, this study explored the literature surrounding the use of Makerspaces (MS) as educational settings both internationally and in Lebanon. A mixed methods approach was used to examine nine existing MS in Lebanon in order to investigate elements, opportunities and challenges in the development and implementation of these spaces, their impact on students' learning, the role they play in school curricula, and the profile of the Maker Educator. Interviews with Maker Educators and Center Managers, Focus Group interviews with maker users, and observations of MS in action revealed that these spaces provide a hands-on learning opportunity for students to develop 21st century skills embedded in soft skills, technical skills, cognitive skills, and scientific knowledge. Consequently, results showed that best practices in MS include meaningful projects linked to real life experiences, integration of different learning methods and strategies, expenditure in large spaces and sufficient and adequate tools, and the investment in Maker Educators that possess specific qualifications. Nevertheless, the study showed that the Lebanese MS face challenges related to funding, space, time, and technicalities. Besides, the study suggested that the existing Lebanese MS are limited in the scope of activities and do not have standardized curricula. To conclude, recommendations for the design of Lebanese MS are provided based on the best practices extracted from international literature on MS and the current study.

Keywords: **Makerspace;**
STEAM;
Making;
Learning by doing;
Flexible Learning Environment;
Design thinking;
21st century skills.

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List of Acronyms

CERD: Center for Educational Research and Development

CNC: Computer Numerical Control

DBR: Design-Based Research

DIKIW: data, information, knowledge, intelligence, wisdom, and interrelationships

FGD: Focus Group Discussions

HAMSTER: Humanities, Arts, Math, Science, Technology Engineering and Reading

LED: Light-Emitting Diodes

ME: Maker Educator

MEHE: Ministry of Education and Higher Education

MS: Makerspace(s)

MSFEA: Maroun Semaan Faculty of Engineering and Architecture - AUB

NCTQ: National Council on Teacher Quality

PBL: Problem-Based Learning

PTOR: Pre-service Teaching Observation Report

RPI: Raspberry Pi

STEAM: Science, Technology, Engineering, Art, and Math

STEM: Science, Technology, Engineering, and Math

TMH: The Makers Hub

"Today, the availability of affordable constructive technology and the ability to share online has fueled the latest evolutionary spurt in this facet of human development. We stand at a crossroads marking the end of decades of thoughtless consumption and helplessness and the beginning of a new age of personal empowerment, creation, and mastery of our world that results from using technology to solve personal problems and amplify human potential" (Martinez & Stager, 2014, p. 2).

The 21st century and the digital era have shifted the way people learn, work, and socialize with each other. Education as it is today is focused on delivering content of subjects mainly through a lecture-based approach with little connection to real-life; thus limiting students' creativity. The traditional curriculum is no longer enough to prepare students for an ever-changing high-tech world (Jerald, 2009). According to Jerald (2009), current education systems should focus on developing students' foundational knowledge and skills, practical literacies in the subject matter, and skills such as critical thinking, problem solving, communication, collaboration, creativity and information technology application.

This shift in education demands new curricula and teaching approaches. A more student-centered teaching approach is key in this shift. Hence, at the core of a 21st century education is active learning, "a method of learning in which students are actively or experientially involved in the learning process and where there are different levels of active learning, depending on student involvement" (Bonwell & Eison 1991, p.3). Using active learning strategies, the teacher serves as a mere facilitator of learning rather than the provider of information, hence shifting the students' role from consumer of information to producer of knowledge.

In this sense, Liew (2013) presents the DIKIW hierarchy that links data, information, knowledge, intelligence, wisdom, and interrelationships (Figure 1). Building on such philosophy will further improve the quality of education and subsequently enhance students' learning as they grow up to be effective citizens who are able to improve their community's way of life in the long run (Liew, 2013). These actions ripple on a global level since achieving wisdom is a long and hard journey of human development. For that reason, and to achieve the first steps towards this journey, students are in need to have **free spaces** with a lot of experience opportunities without worrying about making mistakes. They need a space where they can simply think, debug, and redo. Such experiences lead students to deeper learning. Besides, free spaces will help in developing the growth mindset of the students.

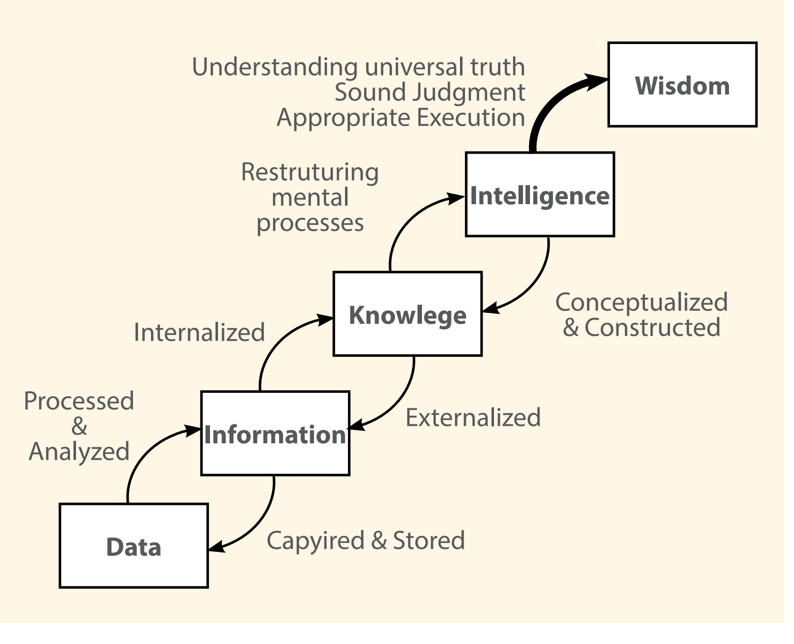

Figure 1. DIKIW Model by Liew (2013)

As a result of the above and due to the need to engage students with their community and to develop their technology skills, the "Maker Movement" was launched in 2005. According to Burke (2014), "the surge of interest in creating physical items with digital tools and internet-shared plans and techniques is known as the maker movement" (Burke, 2014). Makerspaces (MS), collaborative design, and educational activities have generated interest in diverse educational realms (Halverson & Sheridan, 2014).

MS integrate a range of subjects such as math, technology, science, and arts using an interdisciplinary approach (Hlubinka et al., 2013). When students build artifacts, they need knowledge from different disciplines to accomplish the tasks at hand. Through MS, students link schemas and knowledge banks segregated by the school system giving their learning material a deeper meaning (Simmons, 2018). MS programs are so rich that they require crossing disciplines in order to achieve their purpose. Hence, this interdisciplinary project will allow students to look at the textbook contents from a new perspective. Subjects will be interrelated rather than separate. Therefore, MS are an exemplary choice for a deeper and more authentic learning.

Introduction

The Center for Educational Research and Development (CERD) in Lebanon has been undergoing national curriculum revisions. Among these improvements has been monitoring the ICT (Information and Communication Technology) field and evaluating new tools and methods to integrate them into the new national curriculum, specifically the technology curriculum. As a result, an ICT committee was formed and a research team was allocated to conduct a literature review and a field study on MS which is an emerging topic in the field of education in general and in technology in particular. The aim of this study is to provide insights into the new national curriculum framework.

Purpose and Research Questions

This study is phase one of a three-phase study that adopts a Design-Based Research approach (DBR) (see Figure 14, p. 34). The aim of this phase is to survey the literature surrounding MS to identify best practices in the development and implementation of MS internationally. Furthermore, it aims at exploring existing MS in Lebanon to investigate elements, opportunities and challenges in the development and implementation of these spaces, their impact on students' learning, the role they play in school curricula, and the profile of the Maker Educator.

The following research questions have guided this study:

1. What are the basic elements of a Makerspace (definition, tools, physical space, safety)?
2. What are the best practices and challenges for the development and implementation of Makerspaces in Lebanon?
3. In what ways do Makerspaces impact student learning in the short term and in the long term?
4. What role do Makerspaces play in school curricula and vice versa?
5. What is the profile of a Maker educator?

Defining Makerspaces

The 21st century poses skill sets that students should possess in order to succeed in life. Creating and making are among these skills. Making is inherently human and has existed for ages but it was not until 2005 that it gained its impetus through the Maker Magazine (Burke, 2014; Dougherty, 2012; Hatch, 2014). Dale Dougherty, the founder of Maker Magazine is credited for the origin of Makerspaces with the maker movement which originated in 2005 (Halverson & Sheridan, 2014; Van Holm, 2015) where he referred to a wide spectrum of making including cooking, knitting, and gardening (Dougherty, 2012). A member of a maker is referred to as "maker, hacker, tinkerer, artist, crafter, programmer, and engineer" (Van Holm, 2015, p. 25). MS are also referred to as Hackerspaces, FabLabs (Van Holm, 2015). While these terms are used interchangeably, Van Holm (2015) clarifies that these terms have different origins, yet they share the same functions and uses. In this study, the term MS is used to refer to all these spaces. MS are spaces "where people can pursue their creativity by making things that are personally meaningful to them no matter their utility to the broader public" (Hira & Hynes, 2018, p. 2).

Makerspaces offer an experimental and innovative field where learners have the opportunity to come up with products in relation with their learning content and their curiosity. Sheridan et at. (2014) elaborate on the blend between physical and digital technologies as makers from all age groups create art, engineering, and science projects. Through these fields, students have the chance to search for solutions to problems they face regarding the educational content or to collaborate with their peers in order to find and create solutions for complex concepts (Hira, Joslyn & Hynes, 2014). Building concrete, real, and authentic artifacts links what students are learning in class to real-life situations; which clarifies the knowledge acquired in the classrooms. Martinez and Stager (2014) stated that makers construct knowledge as they build physical artifacts that have real-world value. MS are areas within or outside the classroom for students to construct knowledge rather than for teachers to directly instruct (Paganelli et al., 2017). By making, students are encouraged to think outside the box "to create, use and share" (Canino-Fluit, 2014).

Based on all the definitions presented in the literature of this study, MS are referred to as spaces that stimulate students' creativity and knowledge to create artifacts using physical and/or digital technologies that are meaningful for them or that are related to a curriculum.

Theories of Learning and Makerspaces

As Makerspaces are focused on making and creating for the purpose of learning, theories such as constructionism, experiential learning, socio-constructivism, and metacognition provide a theoretical background for these spaces.

Constructionism

The theoretical foundation of educational MS is based on constructionism which is built on Papert's philosophy of learning through hands-on activities in the teaching and learning process (Harel & Papert, 1991). Constructionism is based on knowledge construction and on learning cultures (Kafai, 2006). Knowledge construction occurs by building meaningful products and is based on the concept of using knowledge to build new learning experiences. Constructionism was also inspired by Piaget's constructivism which is founded on the theory that knowledge should be constructed by the learner. What constructionism adds is that it sees the product as a representation of the maker's understanding and knowledge (Blikstein & Krannich, 2013). Therefore, in a Makerspace, learning is achieved when the external materials are combined with an internalized idea and is presented by a physical object (Keune & Peppler, 2019). In addition, Papert (1991) believed that to further develop the knowledge, the artifact or product should be shared with others and the designer or maker should be able to explain it (Sheridan et al., 2014). Papert was an advocate for technology because he believed it is a tool that helps students transform their abstract ideas into concrete inventions and adapt to their different learning styles (Blikstein & Krannich, 2013). This theory posits that the teacher's role is to guide the students while developing their knowledge and prompting their thinking (Kurti, Kurti, & Fleming, 2014a) and it considers knowledge as intimately linked to the individual helping him/her produce his/her own perception of the world, all of which can be realized in MS.

Experiential learning

Constructionism also has common characteristics with Experiential Learning where learning happens through direct first-hand experiences (Kolb, 1984). In MS, the students engage in critical thinking, collaboration, and computational thinking. MS can also be considered as a medium for the students to engage freely in self-directed experiences to prototype, create, reflect, collaborate and therefore enhance their 21st century skills; bearing in mind that this is what experiential learning advocates for (Davidson & Price, 2018).

Socio-constructivism

Makerspaces are also built on the socio-constructivist theory which suggests that learning is enhanced through collaboration with other peers and with the environment (Perret-Clermont & Perret & Bell, 1991; Doise & Mugny, 1997). MS afford a social and collaborative environment for learners to co-think, discuss, and co-create (Sheridan et al., 2014). This socio-constructivist approach is embedded in Vygotsky's theory of cognitive development that states that learners co-construct knowledge when interacting with other partners in a guided learning environment (Vygotsky, 1986).

Metacognition

Making engages the students in the process of talking about their ideas and how they are developing a product which stimulates their metacognitive abilities. Metacognition is the knowledge of how cognition works. In other words, it helps students know how they learn. Introduced by Flavell (1976), metacognition is the knowledge about one's own learning. It includes the way students use their learning, the level of awareness they have about how they learn, and how they control the selection of strategies and modification of their plans. Therefore, metacognition makes it possible to learn how to learn. The role of the teacher would be to help the learners identify their objectives during the resolution of a problem, to control the progress of the students, and to ask a question to a learner in order to orient him/her in a specific direction

The pedagogical foundations of MS suggest that these spaces provide a learning environment that fosters learning by doing while promoting skills needed in the 21st century.

Frameworks for Makerspaces

Several frameworks about the dynamics of MS have been developed to illustrate the interaction that takes place in MS, the types of projects done, and the tools utilized.

Figure 2 represents a framework of MS developed by Kurti, Kurti, and Fleming (2014a). The arrows represent the different activities and modalities involved in an MS. The periphery of the axis represents multi-dimensions which also represents the varied elements and interactions that take place in the MS.

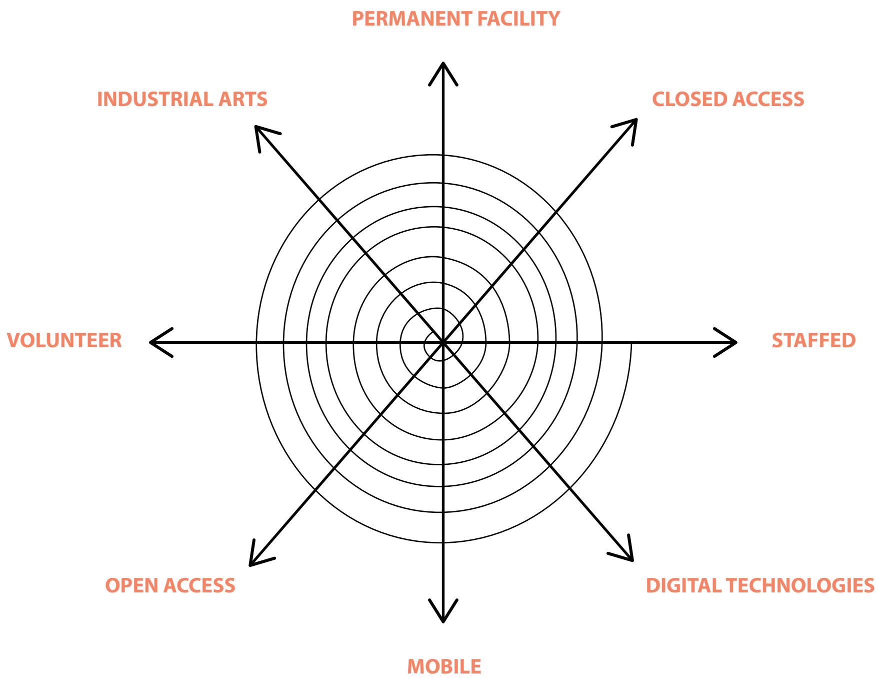

Figure 2. Makerspace Framework (Kurti, Kurti, & Fleming, 2014a)

Makerspaces are learning spaces that engage learners in all types of experiences whether successful or failing and encourage collaboration and learning from failure (Kurti et al., 2014a). All of these help students in developing their cognition and in learning to regulate their behaviors and emotions.

Hira and Hynes (2018) presented another conceptual framework of MS (Figure3). It delineates three units: people, means, and activities which are all connected through purpose. Learners are the ones who dictate how to use MS as it depends on their needs and not a given instruction. Therefore, the activities set by the learners allow them to build artifacts, through experimentation, and the teacher is a mere guide providing the appropriate space and open mindedness which give the students the opportunity to build, create and illustrate without fear of failure or judgment. Consequently, every MS serves a different target, which could be the people, the means, or the activities. It all depends on the students' purposes and needs (Hira & Hynes, 2018). All units of the framework continuously co-exist; they complete each other although they are different. Each MS may be characterized by one objective but as there are more MS to use, there will be more opportunities to find connections among them and enhance the product or artifact the learner is building. These spaces include community spaces as well, where learners build while communicating, interacting and collaborating together. This helps them improve their social skills. Therefore, all units come together to serve one purpose.

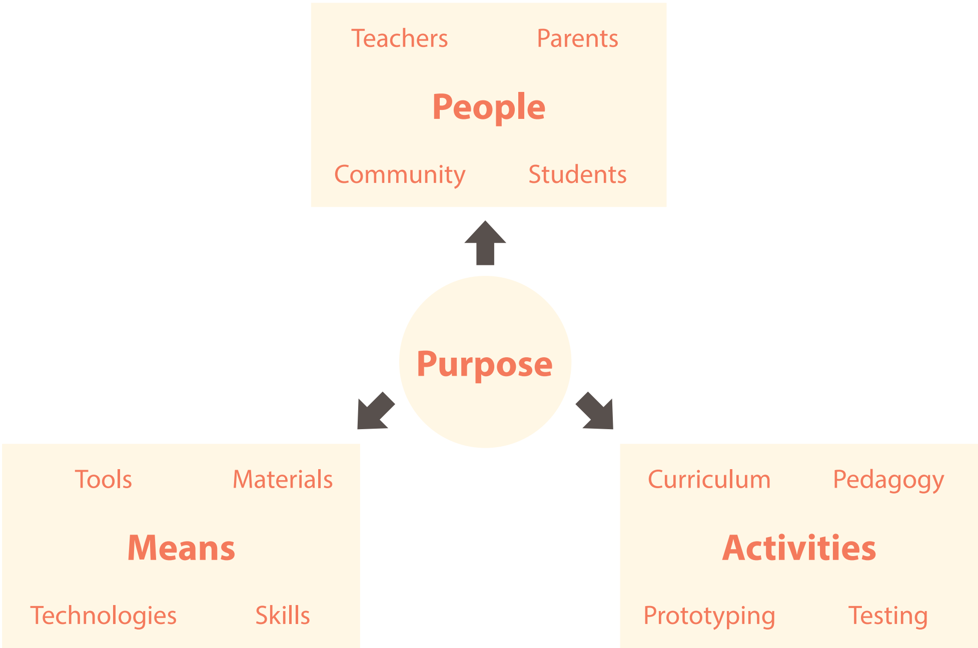

Figure 3. Representation of the Proposed People, Means, and Activities Framework for Educational Makerspaces (Hira & Hynes, 2018).

Based on several visits to MS, Van Holm (2015) developed a framework (Figure 4) concluding common patterns across MS. Projects in these MS are either a replication of an existing object or a new innovation created by the maker. Activities in MS are done either collectively or individually. Furthermore, before creating, the makers decide whether the created product should be kept for personal use or published for other users, and they also need to decide whether the product will be used commercially or not.

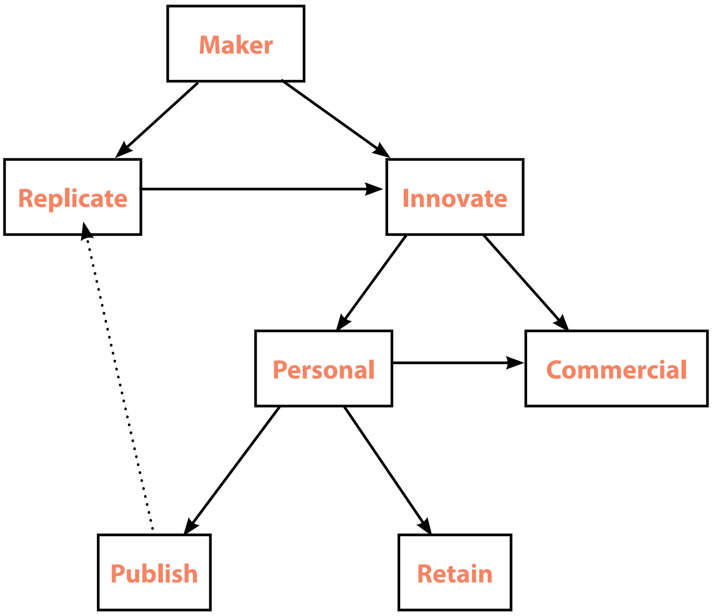

Figure 4. Framework of Makerspace Use (Van Holm, 2015)

Hence, existing frameworks shed light on the dynamics of MS as well as the interconnectedness between different activities, the stakeholders involved, and the tools employed. Furthermore, the frameworks highlight the modalities of the MS in terms of openness and flexibility in addition to the kinds of projects and their dissemination. All of these frameworks suggest that there is not a standard model that all MS follow. Instead, they are very flexible learning environments in terms of design, implementation, and projects.

Educational Benefits of Makerspaces

Educational research on the learning component of MS is still rare despite the obvious potentials that these spaces hold for students' learning (Halverson & Sheridan, 2014). Rigorous studies about the impact of MS on students' learning are not evident. Some studies have examined the impact of MS on students' learning and findings suggested that students became more interested in subjects related to the projects and performed academically better (Metni, 2019). In school settings, more research is needed to uncover how learning takes place in MS, who should be in charge of the MS, the curriculum MS follow, the impact of MS on students' learning outcomes and many other pedagogically-related aspects (Halverson & Sheridan, 2014; Hsu, Baldwin & Ching, 2017). According to the surveyed literature, activities that are held in MS cater to a student-centered education and other pedagogical aspects that are necessary in a 21st century education as represented in the synthesis below (Figure 5).

Figure 5. A Survey of the Literature Regarding Educational Benefits of Makerspaces

Preparing Students for the Workplace: A 21st Century Education

Makerspaces introduce learners to professions and prepare them for the workplace. Besides, they provide learners with a platform that enhances their own competencies in diverse areas they could be interested in, like digital skills (Shively, 2017). MS activities help students utilize appropriate skills that prepare them for the workforce (Rachel, 2018). These skills allow students to comply with the fast-growing pace of todays' market skill sets. Figure 6 lists the top 10 skills needed in 2020 based on the World Economic Forum. MS develop students' higher order thinking skills and creativity while playing, investigating, solving problems, building, and producing (Britton, 2012). In MS, students also gain life skills that will enhance their learning experiences such as effective communication and collaboration in order to find solutions for problems. Learners in MS also demonstrate strong organizational and self-management strategies (AIR, 2014; Guha et al., 2014).

Figure 6: The Top 10 Skills Needed in 2020 Based on the World Economic Forum

Making and Tinkering

Halverson and Sheridan (2014) define making in education as learning activities that are designed with the learning goals in mind. These activities are carried out in MS, classrooms, libraries, workshops, etc. MS inside schools and school libraries provide effective settings and openings for learners to memorize, create, and make use of their abilities. As the MS development "draws upon the innately human crave to create things utilizing our hands and our brains," school MS can benefit from these spaces to unleash students' creativity while maintaining their interests in the subject (Fleming, 2015, p.2). In their review of making and tinkering, Vossoughi and Bevan (2014) sorted the current published literature into three categories, "making as entrepreneurship and/or community creativity, making as STEM (Science, Technology, Engineering and Math) pipeline and workforce development, and making as inquiry-based educational practice" (p. 5).

Tinkering, on the other hand, whether digital or manual, forms a "power to act on reality" and allows the acquisition of knowledge through experimentation by responding to the theories of constructivism and constructionism explained in the former sections. Tinkering allows learners to experiment and develop their imagination and creativity and has an added value for learners who need to go through concrete experiences and explore new concepts to understand them (Zaharin, Sharif & Mariappan, 2018).

Autonomous Learning

Makerspaces are learner-centered opportunities. In a creator classroom or library, the educator acts as a coach and sometimes as a learner himself/herself as students are empowered to combine their skills and knowledge in the innovation process. MS foster autonomous learning (Mann, 2018) and investigation as "owning the learning encounter opens unexplored skylines to learners since free masterminds have the mysterious capacity to strike out into strange territory" (Kurti et al., 2014, p. 20). Cohen, Jones, Smith and Calandra (2017) elaborate on strategies that can foster autonomy in an MS. These strategies include giving the learner the freedom to choose the project, the process of completing the project and the assessment of the work, hence enhancing the sense of ownership over the project.

Authentic Learning

Makerspaces offer authentic learning experiences connected to the real world which provides learners with opportunities to engage in real life experiences distinct from what they face in their traditional classrooms. Martinez and Stager (2014) state that MS provide learners with chances to create artifacts that have real-world value and respond to current issues. Similarly, Hira, Joslyn and Hynes (2014) claim that MS provide contextualization for subject learning such as science and engineering especially when the projects are linked to the students' interests and when they involve a real-world issue.

Entrepreneurial Thinking

Research suggests that MS develop Makers' entrepreneurial thinking through exposure to different fields and social interaction with peer innovators. Sheridan et al. (2014) examined three MS and shed light on the transformation that makers go through in these spaces to become entrepreneurs. They gave examples of makers who developed certain skills in the MS and went on to establish their own business or start up based on the skills they acquired. Martinez and Stager (2013) stated that making uncovers makers' designing abilities, which gives a supportive setting for more theory-based concepts in math or science. Moreover, for more advanced students, making combines disciplines in ways that open entryways to unanticipated career paths. The idea of entrepreneurship is further emphasized by Van Holm (2015) who suggests that MS enhance entrepreneurship in three different ways. First, it attracts more people to design and this leads to having more entrepreneurs; second, the networking that is provided in MS brings about innovative design ideas, and third, MS provide a medium for makers to prototype their designs faster and therefore to acquire funding. In other words, in a world that is over saturated with the same career paths, MS provide learners with a medium to prototype their design ideas that may result in start-ups.

Differentiation and Multiple Intelligences

According to Martinez and Stager (2014), MS are designed for Makers of different genders, learning styles and capabilities. They explain how an ideal MS offers a range of activities and tools to different learners. For instance, boys may pick Arduino while girls may pick digital fabrication. However, in both cases, skills such as "engineering, circuitry, microcontroller programming, and debugging" (p. 5) will be employed in the design process. As Fleming (2015) states, MS are "uniquely versatile learning situations that our understudies require, need, and will prosper in" (p. 46).

Transferable Skills

Making is considered to promote the development of important competencies and transferable skills such as creative and critical thinking, problem solving, collaboration, leadership, and innovation (Hughes, Morrison, Kajamaa, & Kumpulainen, 2019; Metni, 2019). These skills are interrelated once students work through the process of the project in teams; they have to connect with each other and the community, and together invest time in solving problems (Metni, 2019). Sheridan et al. (2014) also emphasized the social nature of MS that brings makers together to discuss, share ideas, develop them, and solve any issues they encounter. Similarly, Blackley, Rahmawati, Fitriani, Sheffield, and Koul (2018) conducted a study on 291 elementary school students who completed a STEM (science, technology, engineering, and math) project using an MS approach. The findings of the study revealed that MS enhanced students' 21st century skills; primarily problem solving, communication, critical thinking, collaboration, and creativity. This finding is further supported by other studies such as those of Novak (2019), Bowler (2014), and Cooper (2016). Paganelli et al. (2017) mentioned that problem-solving and collaborative learning found in MS could help encourage creativity in students. Gregory and Clemen (1995) explained that students' learning experience is enhanced when learners collaborate in problem-solving as they are able to listen to different perspectives and are exposed to different solutions for the same problem.

Furthermore, MS expose students to situations where they need to make many decisions within their teams regarding selected projects, materials, tools, etc. When students go through the experience of making decisions, seeing the outcomes, and reflecting on the decisions taken, their decision-making skills improve (Santos & Benneworth, 2019). Van Holm (2015) explains that to replicate or innovate is not the only decision makers take. Many decision-making skills such as problem-solving, leadership, reasoning, intuition, teamwork, creativity and time management are part of a MS experience.

On the other hand, as learners in MS create knowledge through experimentation, exploration and creation, they control their learning while the teacher is guiding and helping them (Dousay, 2017). This is the basis of problem-based learning (PBL). MS make it easier for teachers in schools to adapt PBL by providing physical spaces and tools that allow students to search for the solution of a real-world problem that would be presented to them. The students collaborate, build, or create a product or a project in response to the problem while the teacher facilitates the problem-solving journey and might even act as the learners' partner (Dousay, 2017). Hence, transferable skills come as a natural element of an MS and students can develop these skills for life.

Development of Executive Functions

Since MS involve creation, hands-on activities, problem solving and planning steps to artifacts, they help in developing executive functions which are required skills to develop a student's performance both at the academic and the personal levels. These functions direct voluntary and rational actions as well as adaptive responses to new problems or complex situations (Hughes, 2011). Executive functions include higher order skills as inhibitory control, working memory, cognitive flexibility, problem solving, and emotional and behavioral regulation (Diamond, 2013; Roy, Le Gall, Roulin, & Fournet, 2012). They are monitored by the prefrontal cortex and they evolve based on the neuroplasticity humans have (Habib, 2014). They "make possible mentally playing with ideas; taking the time to think before acting; meeting novel, unanticipated challenges; resisting temptations; and staying focused" (Diamond, 2013). These functions can be developed and strengthened by exercise (Borst, 2018), and they evolve if they are stimulated and challenged on a daily basis (Moret & Mazeau, 2013).

In Makerspace, problem solving and planning are high-level executive functions that are based on inhibitory control, working memory and cognitive flexibility. Any problem solving and planning situation requires the activation of the three basic executive functions (Collins & Koechlin, 2012). Thus, while working in their MS, students are necessarily using all of these executive functions and challenging them. Consequently, they are helping themselves evolve in the skills previously cited and this will help them improve their performance in any other activity requiring creativity, logical thinking, and novelty.

Technical Skills

Makerspace is a rich ground for blending physical and digital material to create artifacts across different disciplines (Sheridan et al., 2014). Technical skills are sets of abilities or knowledge used to perform practical tasks in the areas of mechanics, science, mathematics, information technology and any machinery manipulation capability; the human body serves as a means to achieve a task using technical skills combined with knowledge (Damooei, Maxey & Watkins, 2008). Research on MS suggests that learners can develop technical skills related to engineering or other disciplines as suggested by Santos and Benneworth (2019). These skills make up a major element in the design and success of a project (Smith & Ann, 2017). The current and future generations of learners will sooner or later become aware of their need for manual and technical skills imposed by real life even though they might not seem to want them at the beginning.

Design Thinking

As MS are paving their ways to schools and communities, a major advantage of this movement is its process-oriented design thinking (Jarrett, 2016; Rachel, 2018; Roffey, Sverko & Therien, 2016). According to Jarrett (2016), "Design thinking is a process that helps people discover and implement solutions to problems. It is a way of problem solving that relies on individual creativity, effective teamwork, and a willingness to fail and try again, repeatedly, until the optimal solution is identified" (p. 51).

Figure 6 shows a schematic two-directional pathway of design thinking consisting of five stages: empathy, defining, ideating, prototyping, and testing (Rachel, 2018). Rachel (2018) explains that MS provide a venue for learners to understand issues in their communities, define them, come up with a solution, prototype it and implement it. Empathy is also emphasized by Jarrett (2016) who stresses the importance of developing meaningful and purposeful projects in the MS focusing on the community and the product rather than the tools. Similarly, Bowler (2014) explains that MS provide learners with an opportunity to think like designers; which gives them ownership over their projects and as a result enhances their creative confidence. Bowler further reports on students' experiences: "In actuality, the project was an exercise in design thinking, which typically involves trial and error, multiple design/test stages, figuring out workarounds, "good enough" solutions, and ongoing cost/ benefit analysis" (p. 60). Hence, the development process in MS goes way beyond accidental creation of artifacts. Makers need to be guided to think like designers and to contextualize their projects in real-life.

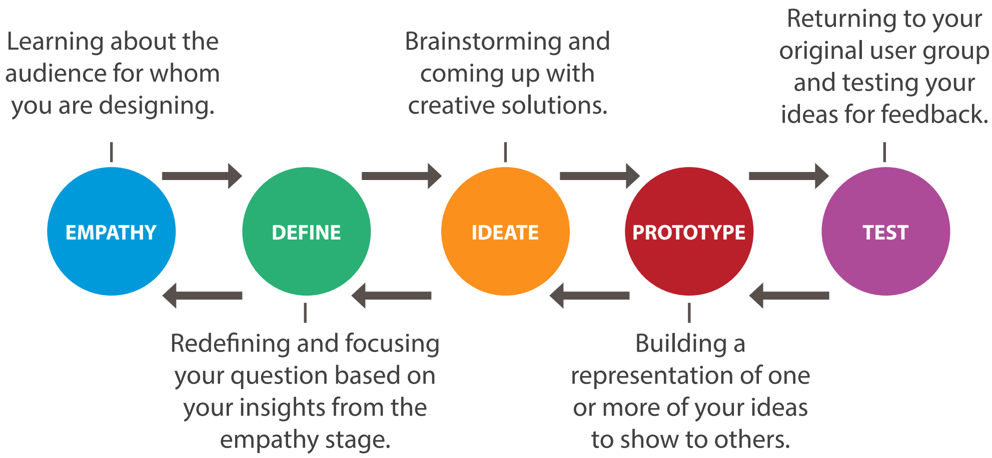

Figure 7. Design Thinking Map (Rachel, 2018)

Motivation

As MS provide students with opportunities to create and develop a sense of ownership, learners become more engaged and motivated in these spaces, especially those who are in a discouraging environment such as wars or social status, and even those who are physically impaired (Metni, 2019). In various case studies, Metni (2019) demonstrates how real positive change was observed in students' behavior, their life skills and their competencies. Through MS-based initiatives, students showed great enthusiasm as they were involved in the learning process, building their own knowledge and sharing it with their peers. Similarly, findings of a study by Vongkulluksn, Mateos, Sinatra, and Marsh (2018) suggest that students' self-efficacy in MS was enhanced when projects were linked to their interests. They also reported that design-based MS may trigger elementary students' interest in STEM when instructors offer "context-sensitive efficacy and emotion- related scaffolds" (p. 1). Hence, motivational elements of MS are linked to the types of projects and learners' interests in these topics.

Tools and Technologies Used in Makerspaces

In an MS, the tools can play a crucial role in defining the spirit of the space as they can offer disparate opportunities for the learners to discern and discover new phenomena and concepts (Schwartz, 2019). The tools could also define the purpose behind their use, and could also prompt new thoughts ideas (Schwartz, 2019).

According to Schwartz (2019), there are 9 tools that are considered to be essentially present in an MS. However, Schwartz (2019) asserts that these tools can be perilous and may necessitate the supervision of an adult. The 9 recommended tools are as follows:

1. ***Soldering iron:*** It can enable students to learn some phenomena in Physics such as the concept of electricity flow. As such, students start to learn how to solder pre-manufactured circuit boards and then move to more advanced circuit boards that entail interfacing and programming on the computer.
2. ***Vice:*** It is a wood-cutter for bigger pieces. Learners use this tool to stabilize the piece they are working on. In fact, they primarily use it for security measures.
3. ***Glue gun:*** It is a most commonly used tool. For instance, learners use it to promptly glue two objects together.
4. ***Knife cutter:*** It is a more accurate cutting tool for straight lines.
5. ***Sandpaper block:*** It is used to soften rough pieces of wood that have sharp ends.
6. ***Wire cutter:*** Students use it to explore the strip wires or to cut them.
7. ***Utility scissor:*** It is a forceful and durable scissor that could cut through fabrics, plastics and metals.
8. ***Saw:*** It is a cutting tool used for solid objects. There are 3 types of saws that could be used in an MS. For example, there is the hand saw which is mostly used by younger students and it is most often used on objects made of wood. Another one is the coping saw which has a small blade that enables students to cut curved lines on objects made of wood. Finally, there is the hacksaw that helps cutting metal objects such as pipes.
9. ***Cordless hand-drill:*** It resembles the screwdriver and can help in drilling holes in different materials and most commonly wood objects.

In addition to the traditional tools, Cohen et al. (2017) discuss that MS are most likely to include digital and technological tools such as the laser cutters, digital die cutters, 3D printers, microcontrollers and others (p.7). Moreover, some MS involve a particular software that could maneuver all the hardware (Cohen et al., 2017). The purpose of using such technologies is to build a channel between both physical and digital worlds (Cohen et al., 2017). To illustrate, microcontrollers are able to transform a physical entity such as sound waves into a digital entity through the use of a particular software (Bell et al., 2010). Other examples include the 3D printer and the queuing system (Keune & Peppler, 2019). The 3D printer operates in an opposite manner than the microcontroller; i.e, it transforms the digital designs into physical entities. Belle et al. (2010) describe it as "moving from bits into atoms". On the other hand, the queuing system spontaneously operates when the printers queue the designed prints commanded by the learners (Keune & Peppler, 2019). Hence, the queuing system functions by moving a file which contains a physical connection of the printers and their distribution (Keune & Peppler, 2019). In a study by Keune and Peppler (2019), the queue of the 3D printers consisted of 4 double-stacked tables and twelve 3D printers in order to serve the MS objectives well. They were connected by a network cable, microcomputers and custom-made software, and the function of the software was to check the uploaded files by the learners (Keune & Peppler, 2019).

The below figure is an example of an MS for English and Humanities which aimed at transforming abstract concepts into 3D representations. The objective of this experiment was to develop a deeper understanding of the mentioned subjects through understanding and engagement (Huddleston, 2019).

Figure 8. Turning Abstract Concepts Like Symbolism and Imagery into 3D Representations (Huddleston, 2019)

Safety Measures

Throughout years, some researchers have discussed the importance and necessity of safety measures in settings such as MS (Hlubinka et al., 2013; Scott, 2014; Sheridan et al., 2014). For instance, one of the safety measures is having a spacious MS in order to have working areas safely separated (Hlubinka et al., 2013). To illustrate, it is important for a user who is working on a table saw to have sufficient space in order not to obstruct another person working on a different tool. Moreover, MS should be well aerated and lit (Hlubinka et al., 2013). This is not to forget that safety equipment should be present in the room regardless of how much the user is being cautious when using the tools. As such, fire extinguishers, air filters, first aid kits, eye shields or goggles, earplugs and gloves should always be available, well-displayed, accessible and functional (Hlubinka et al., 2013; Sheridan et al., 2014). Additionally, a strict cleaning policy should be implemented and visible warning signs should be displayed in MS (Hlubinka et al., 2013).

Examples of Makerspace Projects

Different international studies describe how MS projects were implemented. However, in Lebanon, we could find few documented local examples for the implementation of MS. In the following part, we present a list of documented MS of different sizes and goals found nationally.

Open-access digital fabrication labs such as FabLab[1] are present in Lebanon. FabLabs aim to support designers and innovators to transform their ideas into working prototypes. They are considered as advanced and large MS. Furthermore, MS targeting younger ages are also found in Lebanon such as Kids Genius[2], where they adopt "Learning-by-Doing" through hands-on activities, to elaborate the youngsters' dexterity skills. Another MS, Coder-Maker[3] aims to enable students of different ages to learn to code and program a few objects. Their methodology is based on the real-life STEAM (Science, Technology, Engineering, Art and Math) concept. Other MS such as TeensWhoCode[4] are centered on coding alone. Another MS named The Little Engineer[5] aspires to bridge the gap between theory and practice, and between schools and universities. Some institutions and organizations adopted MS in their name such as The Makers Hub (TMH). They cover different technology-related fields ranging from manufacturing hardware development (woodworking and metalworking, CNC (Computer Numerical Control) machining, electronics, 3D design, 3D printing, and 3D scanning). The Doin' good MS offers hands-on vocational training to refugees in woodworking, electricity and sewing. In the International College , the Elementary School and Middle School have established in the past few years robotics and coding clubs. Students at the Faculty of Engineering and Architecture (MSFEA) of the American University of Beirut get hands-on experience in the labs, studios, and MS.

From the above listed MS, we present a word cloud to sum up the types of projects in MS in Lebanon:

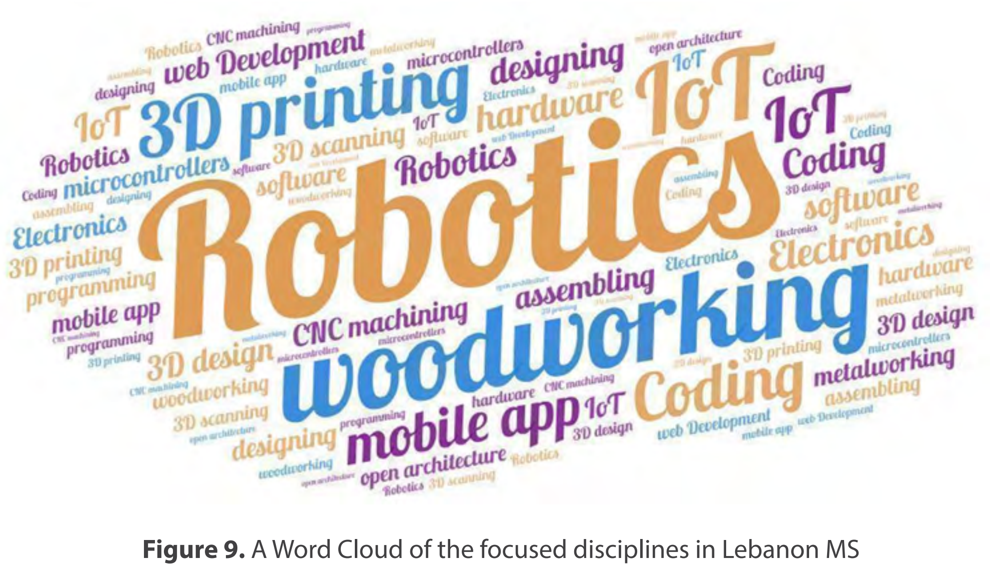

Figure 9. A Word Cloud of the focused disciplines in Lebanon MS

1. https://fablab.berytech.org/about/
2. http://www.kidsgenius.me/about-us/
3. http://www.iea.org.lb/Sections.php?ID=5
4. https://teenswhocode.com/index.html
5. http://www.thelittleengineer.com/en/About/
6. https://themakershub.co/
7. https://www.facebook.com/pg/doingoodofficial/about/?ref=page_internal)
8. http://www.thelittleengineer.com/en/About/
9. http://www.thelittleengineer.com/en/About/

On the international level, MS played a major role in the development of the local economy (Van Holm, 2017). The following MS examples were found documented online and in some articles.

Collins' article, in 2017, mentioned the following example "In Albemarle-Virginia where all 26 schools have MS and advanced tech tools, including 3D printers and laser cutters, students cut down trees and worked through several designs before creating movable, nine-foot platforms in their cafeteria". It is quite gratifying when students see that their own manufactured products are being used efficiently by them and their community. This gives a deeper and a more effective meaning to their learning.

In other exemplary cases studied across the USA and outside Chicago, "Winnetka Public Schools use the term "HAMSTER" (humanities, arts, math, science, technology engineering and reading) to describe the work done in its makerspaces" (Collins, 2017). In this example, the school highlighted a new axis that could be added to our original STEAM, showing that theories could be altered to serve the community's needs. Another case study by Collins shows that "in rural Llano ISD in Texas, students get bonus points if they use skills learned in MS in their regular classrooms. In one of their projects, students 3D-printed replicas of cells rather than making the traditional Styrofoam ball models. One student added electric circuits" (Collins, 2017). Collins explains that students should go through several steps such as information gathering, research, information analysis and brainstorming before they tackle the work; so, they can come up with a proposal describing their project.

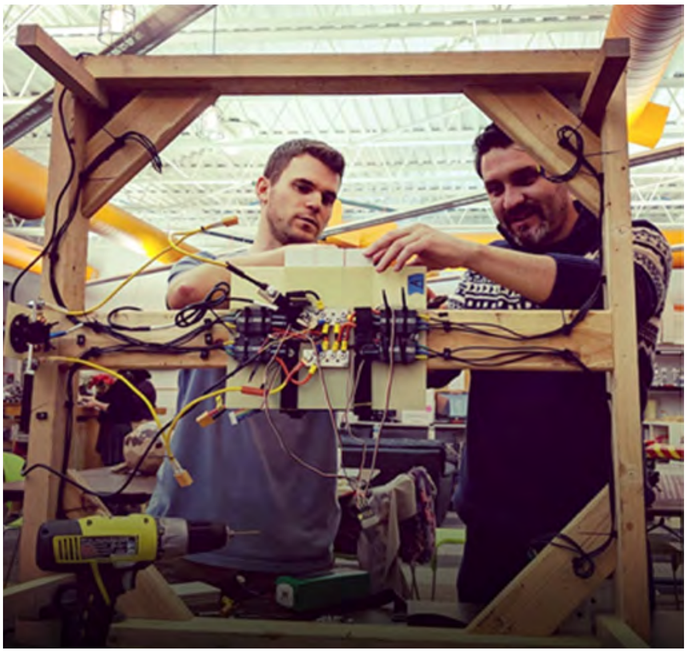

Figure 10. Nova Labs – A Community Makerspace, Virginia (https://www.nova-labs.org/)

Moreover, in the article of Keune and Peppler (2019), MS was mentioned as a good space that helps students gain additional professions. In the mentioned article, there were no counter examples mentioned.

Furthermore, Paganelli (2017) mentioned five sessions of makerspace that were used in professional development which are STEAM, Machines™ and Engineering Design, Build a Habitat, Tooling Around with Math, The Future of Music and Bookmaking.

On the opposite side of the continent, Francois Taddéi, a French educator, is breaking the wheel of the conservative model of French education system that refrains students from innovation and surpassing complex challenges. Taddéi is reinventing schools by benefiting from a range of disciplines to attract and motivate learners who will be acquiring, inventing, and applying knowledge directly through projects. Therefore, students will achieve learning "through interdisciplinary, research-based and experiential approach". Frontier of Life is a science program set by Taddéi as a testing ground. This project provides equipment and labs for disadvantaged schools to ensure that all learners have the same opportunity to innovate and create. This transformation is inspiring young learners to become more involved in sciences; as sciences and research are set to be key elements in learning. Experimental grounds give the students the opportunity to enhance their creative, systematic and critical thinking capacities in addition to social skills allowing them to work in a community. Students are given the chance not only to depict the problem and consider hypotheses; but also,

Figure 11. Event held at the Remakery (Xi, Lam, and Choi, 2019)

to experiment and engineer solutions, which will result in critical changes in our society. Our students will become "Des savanteuries", little scholars themselves, building their own knowledge. In the present time, there are more than 400 Fab labs in France[1], in addition to the implementation of MS at schools and high schools in France. Some higher education institutions are following the same path such as Montreuil University[2].

In Lilford Road-London, The Remakery is an MS that was originated to reuse waste and reclaimed materials. It enables people to make changes and impact their community and environment positively. The age range of people using the Remakery is between 20 and 40 years old (Xi, Lam, and Choi, 2019).

In Shanghai, The Xinchejian organization claims to be the first hackerspace in China (see:https://xinchejian.com/about-2/). It provides different types of making and supports a variety of projects ranging from physical computers to digital applications. In addition to the latter, the organization held various workshops; enabling people to meet, share ideas together, and learn making skills from each other (Xi, Lam, and Choi, 2019). The age of people frequenting this institution is mentioned to be between 21 and 35 years old.

On the cost level, MS in China have largely benefited from the lower costs of manufacturing facilities, tooling, components and materials compared to those in the UK and the USA (Xi, Lam, and Choi, 2019).

Given these examples, we can firmly say that MS have a strong impact on the learning process and the evolution of the community and the national economy around it.

Figure 12. Vincihub Helicopter Simulator Project (http://www.oiponline.cn/blog/xinchejian-hackerspace-shanghai)

Makerspace Curricula

Since no empirical studies focusing on the content of the curriculum in MS were found, the maker movement appeals to schools as a way to engage learners in STEM (science, technology, engineering, and math) subjects (Hsu et al., 2017). Schools have been revising their curricula and integrating MS elements in order to develop students' skills in these areas as the future jobs rely on these disciplines (Blackley, et al., 2018). Bowler (2014) states that, "the underlying goal of a MS is to encourage innovation and creativity through the use of technology, to offer a place where everything from STEM learning to critical expression to future start-ups can be nurtured" (p. 59).

In schools, these spaces represent formal initiatives linked to guided projects versus informal MS that exist outside of schools and provide a venue for a more flexible approach to making (Hsu et al., 2017). Halverson and Sheridan (2014) claim that MS aim at offering learners the flexibility of moving inside and out the space freely; hence, a more informal structure of MS is encouraged.

In that same direction, Soylu and Medeni (2018) present a vision and a proposal for an MS curriculum embedded in a university in Turkey geared towards children between 9 and 16 years old. The curriculum involves a series of courses that develop learners' competencies in Graphic design, visual arts, science and technology, music based on IT, media, IT and software, film-making, art, coding and programming. The curriculum is supposed to be implemented in a game-based environment far from a formal setting.

More particularly, for K-12 settings, Cohen, Jones, Smith and Calandra (2017) suggested a "Makification framework" that could integrate "making" into the curriculum rather than deal with it as an extracurricular activity. Their proposal "is deeply rooted in the process of making as learning and authentically connected to content with deliberate learning goals" (Cohen et al., 2017, p. 12). They synthesize and describe four core elements that are particular to making in educational contexts: Creation, Iteration, Sharing, and Autonomy. Cohen et al. (2017) suggest that the integration of these activities in school-related making activities contribute to students' learning. Hence, for all the reasons stated above, the focus of the MS curriculum is on the process rather than on a specific subject or content.

1 https://www.economiecirculaire.org/articles/h/pres-de-400-fablabs-en-france.html
2 https://www.morenoconseil.com/innovation-ici-montreuil-lance-la-1ere-universite-des-makers

The Characteristics of the Maker Educator

The characteristics of the Maker Educator (ME) in the literature are summarized by the following common criteria (Duhaney, 2019; Gerstein, 2019; Kajamaa, Kumpulainen, & Olkinuora, 2019):

- Process Facilitator
- Technology Tutor
- Research and Knowledge Provider

Gerstein (2019) explains that the ME plays 8 roles as presented in Figure 13. Unlike the traditional ways of learning, the ME needs to lead the learner on how to learn not what to learn. He also helps the learner to develop goals for the project, to organize tools, and make sure that learners are able to use the equipment in a safe way. The ME is also a resource provider, a knowledge provider, and a technology tutor responsible for teaching and helping the learners to use technology (Duhaney, 2019; Gerstein, 2019). As the MS environment involves problem solving exercises, the ME plays the role of the normalizer of ambiguous problem finding and solving while enabling and building collaboration among learners. Feedback also plays a major role in MS and the ME's role is to facilitate and elicit feedback among the users (Gerstein, 2019).

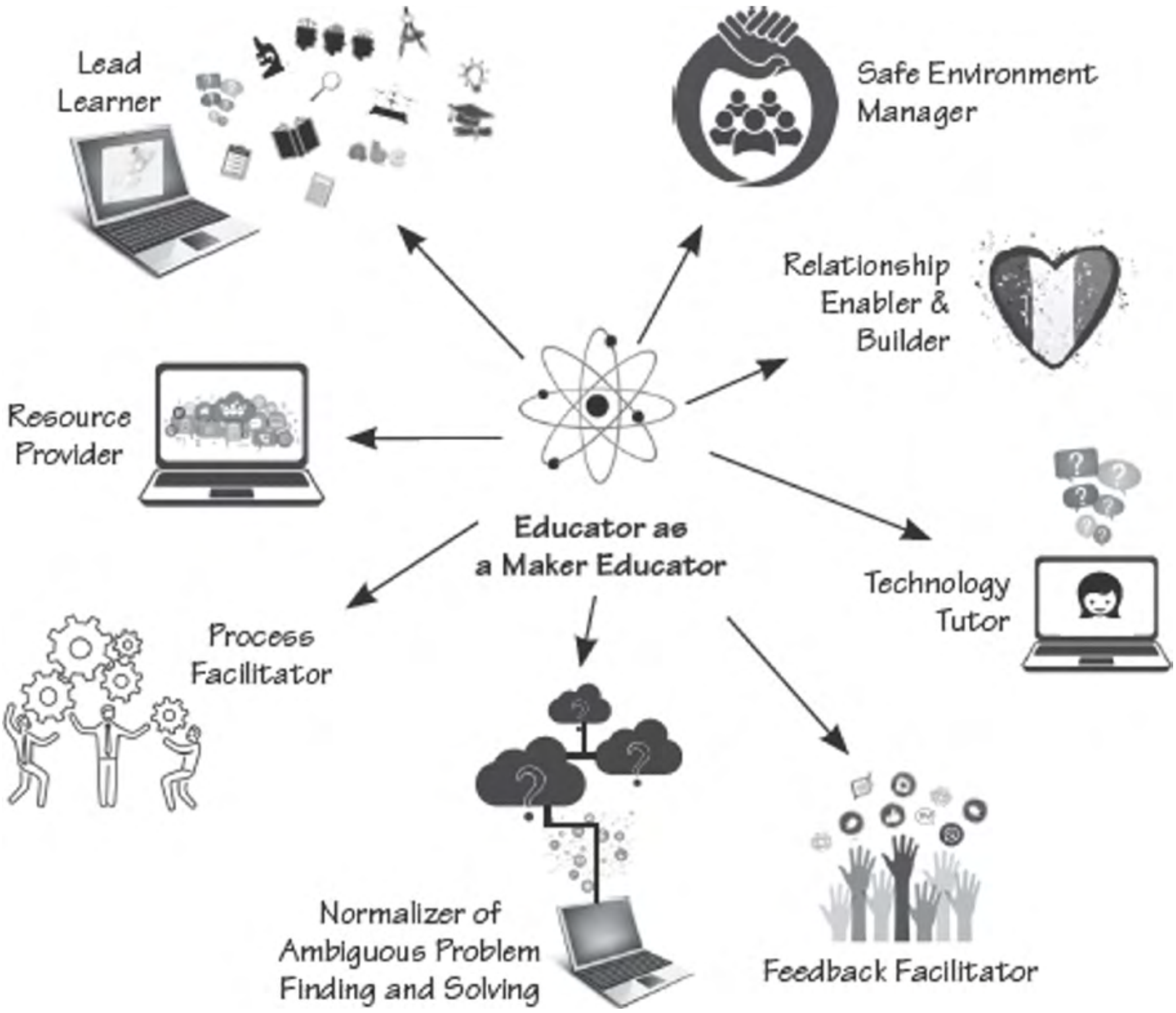

Figure 13. Educator as Maker Educator (Greenstein, 2019).

Similarly, Kajamaa, Kumpulainen, and Olkinuora (2019) state that teacher's intervention in MS environments is crucial for learners' collaboration and learning, and it falls under five categories: conceptual, procedural, technological, behavioral and motivational.

- Conceptual is related to proceeding and completing the challenge, i.e. it involves everything related to content and instructions.
- Procedural is helping to find tools and materials that suit the needs and the process.
- Technological is the help with using the technology provided.
- Behavioral is related to class rules.
- Motivational is when the teacher motivates the learners to start working on a project.

Koh and Abbas (2015) identify top competencies and skills that should be possessed by a Makerspace professional. The top competencies include the "ability to learn, adapt to new situations, collaborate, serve as an advocate, and serve diverse people" (p. 119). As for the skills, they include "management, program development, grant writing, technology, and facilitating learning" (p. 121).

Best Practices and Challenges in Makerspaces

Msick Perry et al. (2018) discuss that the research on the best practices in MS is still in an ongoing process. Ongoing research shows that the best practices in MS involve having an encouraging environment in which students are able to freely share their projects and ideas (Martin, 2015).

The process of "making" in an MS is vital as it translates learning into a more relevant and important experience as compared to the traditional model that encompasses a fixed curriculum (Gershenfeld, 2007). Consequently, making enables learners to comprehend how technology functions instead of just obtaining gratification for using it (Kafai et al., 2014).

Nevertheless, Halverson and Sheridan (2014) proposed that making should be more centered on the artifact and procedure and not solely on the tools. Moreover, making has to be contributing to a more diverse peer-to-peer learning, tutoring and mentoring roles at schools (Halverson and Sheridan, 2014; Sheridan et al., 2014).

In order to ensure an efficient working environment, MS should involve skillful, experienced and well-trained maker educators who have gone through professional trainings and developmental programs which can add to their existence knowledge and enhance their sense of self-efficacy, and their belief systems (Cohen et al., 2017).

Finally, according to Hira, Joslyn and Hynes (2014), effective classroom MS are inspired by educational theories such as the Maker Movement concept and FabLab. The authors believe that the development of adequate practices in MS should involve the following:

1. Asking and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Creating clarifications and crafting solutions
7. Taking part in argument based on proof
8. Attaining, assessing, and sharing information

On the other hand, the literature on the challenges in MS is still scarce. However, few researchers discussed the most commonly faced challenges in MS, and are usually of technical nature such as difficulties in designing, building, programming, engineering and computing (Barton, 2016) (Bowler, 2014; Kafai, Fields & Searle, 2015; Sheridan et al., 2014). Other challenges are commonly related to the lack or scarcity of funding and budgeting, unpreparedness of maker educators, and the diversity in students' learning styles and potentials (Hira et al., 2014; Keune & Peppler, 2019; Metni, 2019). In fact, one of the greatest challenges is the scarcity of the source of funding and budgeting for MS (Keune & Peppler, 2019). In return, this would affect the availability and affordability of the tools and equipment which is known as a capital challenge. Additionally, the unpreparedness of maker educators in MS represents another great challenge as maker educators must be prepared and qualified in order to help in the success of the MS project (Hira et al., 2014). Also, the different styles and potentials of learners can create considerable challenges. Maker educators should be well prepared to take into consideration the diversity of learners while planning, intervening and implementing the projects of MS as no child should be left behind while applying the MS projects (Hira et al., 2014). In a study conducted in Lebanon, Metni (2019) argues that some teachers who are supposed to promote the idea of MS are hesitant to do it as the vagueness of the topic is pushing them to feel inept and incapable. Such educators usually feel unprepared and as a result, they are likely to develop a lack of motivating themselves and their learners (Metni, 2019).

Summary of Literature Review

This literature provided a global overview of Makerspace research as it pertains to the nature of this study providing a theoretical foundation for the existence and development of educational MS. The literature suggested the potential educational benefits of these constructivist spaces as they provide a medium for learners and makers to create artifacts and solutions relevant to actual problems and real life. As a result, MS provide learners with lifelong skills necessary for survival in the workplace and in life. The literature review also provided an overview of existing frameworks for the operation and implementation of MS suggesting that these spaces are flexible by nature and give learners and makers the freedom over the process and product of the projects. Finally, the literature review shed light on MS curricula and projects and the characteristics of the Maker Educator. The next section presents the research design of a study conducted to assess the Lebanese context of Makerspace in order to inform the design of a prototype of MS that fits the local context.

Methodology

Project Design

This study is Phase One of a three-phase design-based research (DBR) study (see Figure 14 below). DBR fits the purpose of this study since it involves the design of an education-based intervention that is situated in a real educational context, focuses on the design and testing of an intervention, uses mixed methods, involves multiple iterations of design, and involves a collaboration between researchers and practitioners (Anderson & Shattuck, 2012).

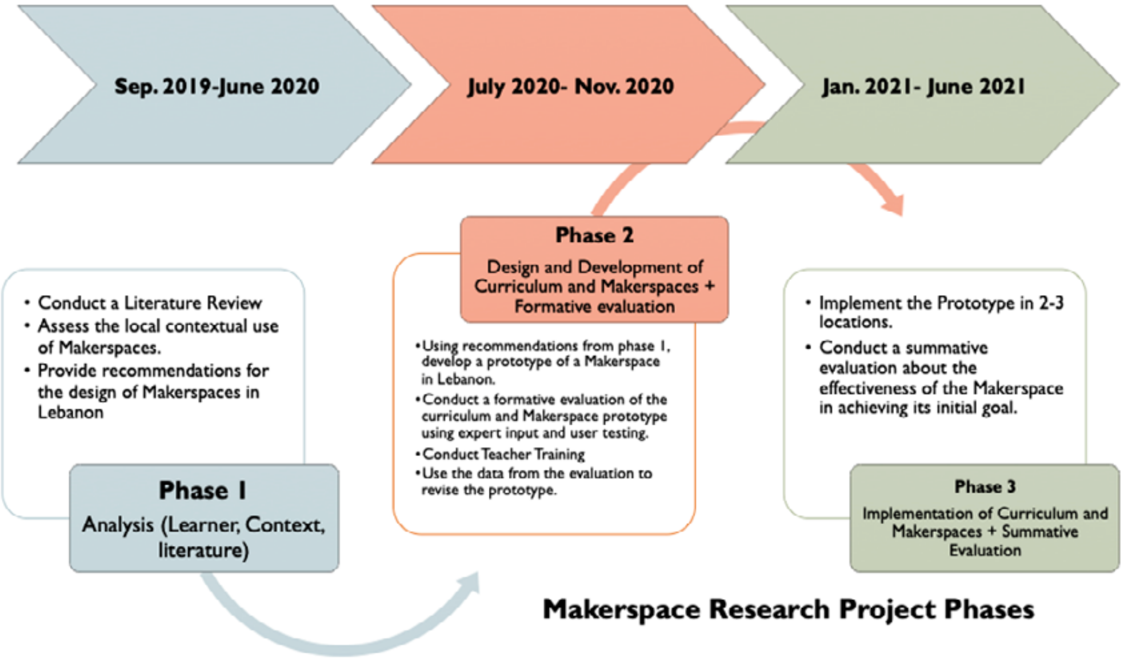

Figure 14. Makerspace Research Project Phases

Phase 1 Research Design

For this phase, an exploratory mixed methods approach was developed to investigate the state of MS in Lebanon in terms of learners and context. A hybrid methods approach refers to the integration of the two research methods -the qualitative and quantitative approaches- in the same study. In this study, a mixed methods approach was used for several aims. First of all, the integration of both research methods provides the researcher(s) a better understanding of more complex phenomena than either methods alone (Molina-Azorin, 2016). Secondly, it allows the researcher(s) to compare and contrast the two different approaches in order to search for congruent results (Molina-Azorin, 2016). Thirdly, when combining both approaches, the researcher(s) become(s) more motivated to develop a wider set of research skills which plays a role in widening the repertoire of methods (Molina-Azorin, 2016). In this study, the design is known as concurrent which means that the information from both approaches was gathered at the same time (Molina-Azorin, 2016).

The researchers conducting this study combined data from 9 interviews, 8 focus groups and 7 observations in actual MS in order to gain insights about users' perceptions of these spaces:

- Makerspace Teacher or Manager Interview: These interviews were conducted with 9 MS teachers or managers who work in 9 different locations. The interview protocol consisted of 14 semi-structured questions designed to elicit information about the main research questions.
- Focus Group Discussions/Interviews: These discussions were conducted with MS users or students in the same locations where the MS teachers and managers work. They consisted of 8 semi-structured questions with the students/users (8 FGDs; between 3 and 7 each) aged between 12 and 14.
- Observation Checklist: An observation checklist was developed to observe the actual spaces of MS and learners'/users' interactions in these spaces. Five criteria were observed on a scale of 0-3 (0 being not evident on the space and 3 being extremely evident in the space). The five observed criteria were Physical Space, Safety, Real World Connections, Active Learning, and Critical and Creative Thinking.

The data collection took place in 4 Makerspace centers and 6 schools (5 private and 1 public).

Shool/Center	Focus Group Discussions	Interviews	Observations
MS Center A	✓	✓	✓
MS Center B	✗	✓	✗
MS Center C	✓	✓	✓
MS Center D	✓	✓	✓
School A	✓	✗	✓
School B	✓	✓	✗
School C	✓	✓	✓
School D	✓	✓	✓
School E	✓	✓	✗
School F	✗	✓	✓

Table 1. Data Collection

Sampling and Inclusion Criteria

A purposive sampling method was employed in this study for several reasons. Firstly, this method provides non-probability samples based on a set of criteria and characteristics. Secondly, as explained by Creswell and Plano Clark (2011), purposive sampling is mostly used in implementation research as it comprises the selection of respondents who could be experienced about the phenomena being studied (Palinkas et al., 2013). Thirdly, this method allows individuals to rapidly and easily participate and communicate their knowledge, views, beliefs, attitudes and experiences (Palinkas et al., 2013).

The inclusion criteria comprise the age of participants, the location of MS and the profile of interviewees. During the FGDs and observation sessions, participants were mainly aged between 12 and 14 as it was found that the average age diversity of MS is between 11 and 15 (Peppler, Keune, Xia, & Chang, 2017). Moreover, the location of MS were primarily in the private sector except for one school. This is because it was found during the recruitment phase that MS are significantly more available in private schools and centers. Additionally, a crucial criterion for the profile of the interviewees was to have directly involved maker educators. The interviews included teachers and/or managers who work at school/center MS.

Recruitment

A list of schools and professionals was provided by the Center for Educational Research and Development (CERD). Accordingly, a screening process for the list was carried out by the research team to ensure that the suggested schools/centers have participants who meet the inclusion criteria for the assessment. Once the screening was complete, the research team contacted the school/center director to ensure that a day and time was scheduled for the FGDs, interviews and the observation sessions.

Instruments

Three tools were formulated for this study: the FGD guide, the interview guide and the observation checklist. All three were formulated based on the main research questions and objectives. The FGD and the interview guide included an oral introduction to the assessment and obtainment of an orally informed consent.

The FGD guide included questions regarding the definition of MS, the tools and equipment in MS, the projects and activities and the impact of MS on learners (see Appendix A).

Also, the interview guide included questions related to the definition of MS, projects and activities, subjects and curriculum, successful learning experiences and projects of students, challenges faced by maker educators, and the impact of MS on students' learning (see Appendix B). Nevertheless, FGD and interview guides were prepared in English and translated into Arabic (see Appendices C and D).

Finally, the observation checklist was inspired from Danielson Framework[1], Pre-Service Teacher/Teaching Observation Report (P-TOR[2]) and NCTQ Teacher Prep Review Key Ingredients for Strong Student Teaching[3]. The checklist included items related to the physical space of MS, safety measures, real world connections, active learning, and critical and creative thinking (see Appendix E). The checklist was prepared in English.

Procedure

Training and Pilot Phase

The field team participated in a training session regarding the tools and the data collection procedure. This training was operated by the research team at CERD. Then, a pilot phase was conducted in a private school. The three tools were tested to evaluate their viability, effectiveness and reliability. This was followed by a consultative meeting between the facilitators and the research team to validate and reinsure the adequacy and coherence of the questions in order to avoid any possibility of misleading questions.

Data Collection

Data collection spanned between December 2019 and February 2020.

FGDs and interviews were facilitated in Arabic then translated into English by the facilitators. The FGDs involved 3 to 7 participants and were conducted by a facilitator in the presence of a note-taker. The discussions lasted between an hour and an hour and a half. In parallel, the interviews were conducted in the presence of an interviewer and a teacher or director. Interviews' timings were selected per key interviewees' preferences. The interviews lasted an average of one hour. On the other hand, the observation sessions were conducted by the observers with the selected learners. Finally, as previously mentioned, venues were exclusively involving schools and centers.

Field Challenges

There was only one main challenge in the field and was related to the data collection phase. The challenge involved the multiple obstruction and postponement of field data collection due to the country's security situation as the result of recurrent manifestations.

Analysis

Thematic Analysis

In this exploratory study, the interviews and the focus group interviews were analyzed using a thematic analysis which is designated by Braun and Clarke (2006) as "a method for identifying, analyzing and reporting themes within the data" (p.79). Moreover, this approach is also defined by Parkinson et al. (2016) as "a methodical, pragmatic and supple tool that generates themes and that can be amended for use with various qualitative approaches" (p.4). Braun, Clarke and Rance (2014) elucidate that a thematic analysis can be treated in multiple fashions (p.5). However, the two principal approaches are the deductive and inductive ones.

In this study, the transcripts were analyzed using a mixed or hybrid approach; that is, comprising both deductive and inductive approaches. A deductive approach encompasses the emergence of themes based on existing theoretical frameworks while an inductive approach involves the exploration of themes from the data (Braune, Clarke, & Rance, 2014). Finally, a thematic analysis is embraced in this study for several reasons, primarily for its intrinsically flexible nature.

1 https://www.nctq.org/dmsView/2016-2017_TEG_TEXT
2 https://education.temple.edu/sites/education/files/uploads/fieldplacement/ECE2187PracticumTOR-RevisedAugust2015.pdf
3 https://www.nctq.org/dmsView/NCTQ__Standard_14_Prep_Resources__Key_Ingredients_for_Strong_Student_Teaching_compressed

Why is the Thematic Analysis Useful in this Study?

Thematic analysis is a methodological tool that is intrinsically flexible. For instance, it is dynamic in the sense that it is open to changes and amendments. Also, it allows easy access and retrieval of textual data. It is typically apposite and suitable for the analysis of interview transcripts by drawing contrasts between and within cases, thereby engendering themes (Parkinson et al., 2016). As a result, users can either analyze data during the data collection process or collect all data and then perform the analysis. However, this is not to say that thematic analysis is free of limitations. For instance, one of its main limitations is that even if it is tested empirically, it may be inadequate in terms of application in practice, and the result would be demonstrating a restricted and subjective perspective.

Observations

As for the observation checklists, they were analyzed using descriptive statistics. Stacked bar graphs were developed to show the level of availability of each of the observed criteria in the studied MS.

Results

The results of the data gathered from Interviews, Focus Group Discussions (FGDs), and Observations that were conducted in schools, MS centers, and innovation labs are presented under the headings below reflecting the constructs that were investigated in the study.

1. Elements of a Makerspace
   - Physical space
   - Tools
   - Safety
2. Makerspace Activities and Projects
3. Curriculum of Makerspaces
4. Impact on Students' Learning and Skills Development
5. Profile of a Maker Educator
6. Best Practices in Makerspaces
7. Challenges in Makerspaces

Elements of a Makerspace

The elements of an MS that were investigated in this study were mainly related to three sub-categories which are: physical space, safety, and tools available in an MS.

Physical Space

The three data sources used in this study explored Physical Spaces in MS from three different angles. While interviews asked Managers and Teachers to name their spaces, the Focus Group Discussions (FGDs) explored participants' views, perceptions and experiences with MS, and the Observations investigated the area of the space along with available tools.

In the interviews, none of the interviewees referred to these spaces as an MS. In fact, 3/9 referred to it as a "Robotics Club," 2/9 named it a "Club", 2/9 named it a "STEAM Club," while the rest named it a "Fabrication Lab," a "Physics Lab," and a "Technology Lab."

In the FGDs, the majority of the learners reported that the physical spaces at the MS they worked in were satisfactory. The FGDs expressed their views towards an MS by defining it as "a creative environment, free working space, and appealing space". In contrast, 2 FGD participants described the physical spaces they worked in as small in size and lacking essential tools by explaining that "everything we need, we can find here but the space is small and this prevents us from making a big project. We can add tools like saw and screwdrivers" (FGD, MS center); "We would like to have an AC in the hot season and a heater in the winter" (FGD, MS at school).

On the other hand, the observations that took place in schools and centers showed that the majority of observed centers and schools (86%) have desks and tables that include large surfaces for working, 86% have comfortable chairs and furniture in the workspace, 71.43% have a flexible space design, 86% have separate areas for different kinds of activities that are equipped as appropriate, and 86% display tools and materials in a user-friendly and accessible way (see Figure 15).

Tools

The three data sources investigated the tools that are available in the MS of schools and centers as presented in Figure 15 and Table 2 below and the FGD results.

The stacked bar graph 15 shows that all the observed schools and centers are equipped with classical tools and 3D printers (i and j). On the other hand, 3D scanners and sewing machines are totally absent or not evident during the observed session (k and m). A few of the institutions have laser cutting machines, woodworking tools, video, sound, and photography equipment (l, n and r). Observers noticed that a fair number of MS have arts and craft materials with an area to showcase and display students' projects and easily accessible cleaning supplies (s, t and u). More than half of the MS have internet access, soldering equipment, electronic materials and a projector/interactive board/panel (g, o, q and v). In most of the institutions, observers found that the space designated for MS is equipped with adequate power supplies, computers, tablets and utility materials (f, h and p).

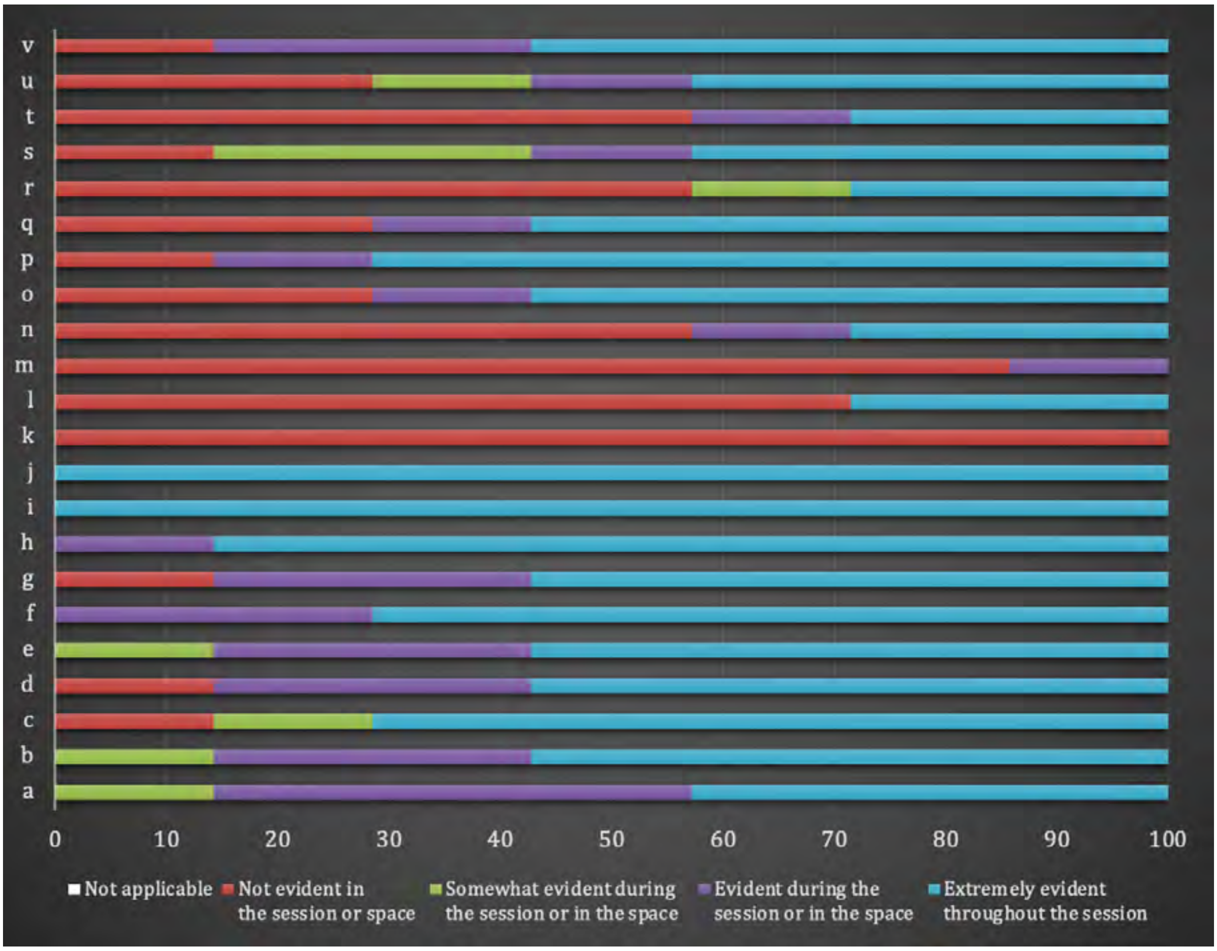

Figure 15. Stacked Bar Graph of the Physical Space Criteria Results Per the Observations

The findings from the interviews suggested that the majority of MS managers or teachers reported having 3D printers (7/9) as seen in Table 2. Other tools that managers or teachers reported in their workspaces were Arduino, Robotics Kits, Lego EV3, Laser Cutters and other basic tools such as pliers, screwdriver, hammer, wood saw, art saw, iron saw, fixed saw, glue, UHU, scissors, cutters, hot glue gun, rulers, and staplers.

Tools	Availability in the 9 schools/centers
3D Printer	7/9
Arduino	7/9
Robotics Kits	5/9
Lego EV3	5/9
Laser cutter	4/9
Basic tools: pliers, screwdriver, hammer, wood saw, art saw, iron saw, fixed saw, glue, UHU, scissors, cutters, hot glue gun, rulers, staplers	4/9
Sensors, Computers	3/9
Computer Numerical Control (CNC), Soldering iron, Power tools (battery mug, fixed mug, fixed saw, disc scissors, tin caustic, air caustic), Multimeter electrical and electronic measuring instruments (Multimeter, Oscilloscope, DC generator, Multi Wave Generator)	2/9
Raspberry Pi, Camera, 3D Scanner, Vacuum foaming machine, Little bits, Solar Panel, Tablets, Virtual Reality, Scratch, Vex Robotics	1/9

Table 2. Availability of Tools in Centers and Schools per the Interviews

On the other hand, the majority of FGDs listed the following tools as the most commonly used in the MS: Arduino, computers, programs, Lego, LCD, engines, industrial tools like saws, drilling tools, soldering irons, electronics, resistors, pliers, voltmeters, oscilloscopes, sensors, connectors, cameras. In addition, some FGDs described the kits they use at the MS, and they mainly involve the Little Engineer, VEX Robotics, and Weeemake. Also, some discussed that 3D printers and/or laser cutters are available at their schools or MS clubs. Finally, one FGD participant pointed out that there is a scarcity in the adoption of more complicated and advanced electrical tools at their school. Hence, such tools could be crucial for preparatory stages at higher-education levels. The FGD participant added: "For example, we are now using Arduino. Why don't we use more complicated electrical tools and components that will help us more to be prepared for university?" (FGD, MS at school).

Safety Measures

Safety Measures were investigated in the observations and the FGDs. The results of the observations showed that most of the schools' and centers' spaces do not outline safety procedures in the event of injuries and fires (h), and only one of the seven observed spaces had the required equipment for injuries and fires as seen in Figure 16. In a few MS, students were put to an enforced strict cleanup policy to keep the space free from clutter, (f) and they had access to protective gears during the session (g). Pathways to tools, exits and safety equipment - including first aid kits and fire extinguishers with clearly displayed safety rules - were evident in more than half of the MS (b, d and e). One of spaces' structure did not include evident pathways to tools and exits (b). Observers found that all of the observed spaces had spacious working spaces, convenient for a safe use of tools (a). Also the spaces were well-lit and ventilated (c).

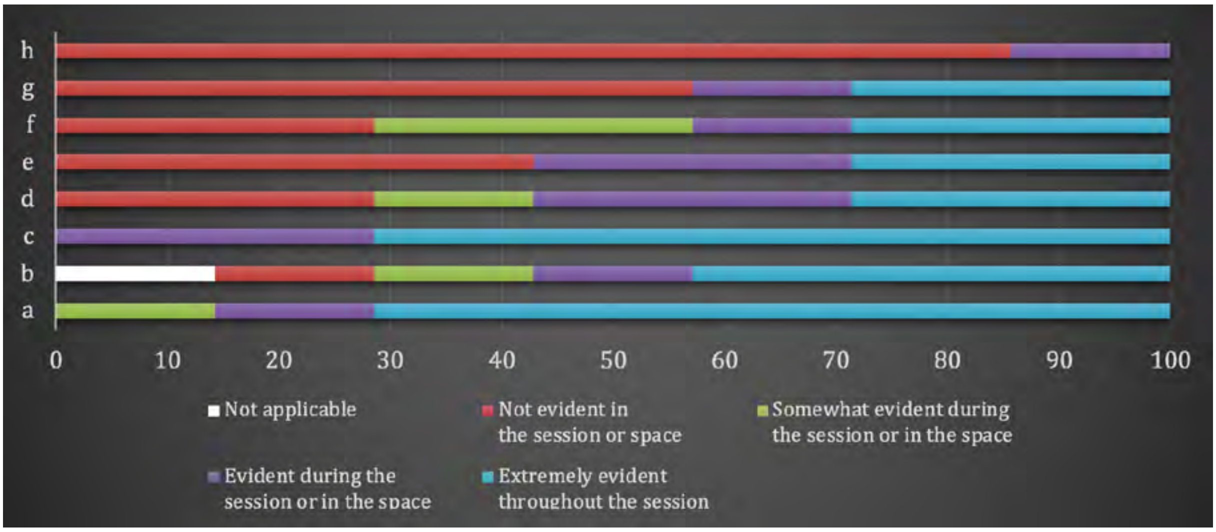

Figure 16. Stacked Bar Graph of the Safety Criteria Results Based on the Observations

Safety measures related to the use of tools like soldering irons, saws, cutters, glue guns, and screwdrivers were mentioned in some FGDs at schools. As such, these FGD participants explained that when they need to get involved in activities that require safety measures, they receive assistance from the teacher or the maker educator. For instance, one FGD participant stated: "When we need help to cut and use the tools, the facilitator or the teacher does this task for security" while another FGD participant asserted: "We cannot use the saw by ourselves for safety reasons. We need to have a mentor with us who is watching us working but there are other tools (the majority of them) that we can use by ourselves."

Makerspace Activities and Projects

The interviews and the FGDs contributed to gathering information about activities and projects that learners develop in MS, either in schools or centers. The interviews revealed the following projects as the most commonly developed in MS:

- Robotics Projects: Building robots and others
- STEAM/STEM Interdisciplinary projects
- Science projects
- Carpentry projects
- Craft projects
- Mechanical engineering
- Design
- Manufacturing
- Construction

Examples of some of these projects as described by interviewees were as follows:

The Museum in a Box Project: "In the first part, each student had to make a research about a Lebanese artifact, then write a text about 200 words describing its history, age, importance, etc. After that, the students had to make a recording of that text in a clear voice, proper tone, without any mistakes" (Interviewee, MS Center).

"The actual project that students work on for the ARC competition requires no pre-designed kit to be used. The project has to be built using Arduino sensors in order to produce a robot used for touristic purposes with no other clarifying details from the organizers" (Interviewee, MS at a School).

In the FGDs, when discussing activities and projects, the majority of learners reported working on robotics projects involving the construction, coding, and programming of robots to execute specific actions and movements. "We are working on a robot arm that segregates plastic, wood, aluminum and cardboard. The design consists of an arm that sorts the stuff using sensors which differentiate between materials through frequencies" (FGD, MS at school). "It is a Robot hand, so we do the program and we press the button, then the robot hand opens and closes" (FGD, makerspace center). Furthermore, other projects discussed by the learners were not exclusive to robotics and included:

Morse code translator: "It was about a Morse code translator. Morse code is when we have defined ticks that will represent a defined alphabet. We used an LCD screen and connected it to a button. The button is used to encode the message and the screen will show you the alphabetical letter that corresponds to the tone" (FGD, MS at school).

Automation systems: "The project is an automated balance designed to weigh a bag containing 1g of mass. Then after the amount is achieved, there is an automated hand which pushes this mass far away from a balance, and it's our own product" (FGD, MS center).

Detectors and sensors that deliver specific actions: "We want to help people, so we designed this stick with sensors whenever it detects an object, it emits a sound. We offer this object to any person in need" (FGD, MS at school).

Curriculum of Makerspaces

Both the interviews and the FGDs asked the participants about the availability of a curriculum that the centers or the schools prescribe. The answers were inconsistent across the board.

The results of the interviews revealed the following findings:

- 3/9 schools do not have a curriculum:
  - Activities are based on the users' interests and not related necessarily to the classroom.
  - The schools use lesson plans from existing MS websites.
  - The projects do not follow any specific trend; the students work on projects on their own.
- 7/9 schools and centers have a curriculum that is either adopted or developed in house:
  - 1 center has developed its own curriculum for coding and science.
  - 1 center uses Lego curriculum.
  - 1 school uses the Vex Robotics curriculum.
  - 2 schools use the French curriculum (physics).
  - 1 school developed its own curriculum consisting of 16 sessions divided among woodwork, engineering, robotics and 3D design.
  - 1 school developed its robotics curriculum as part of the technology curriculum.
  - 1 school uses the UK Raspberry Pi Digital Making Curriculum and sometimes students are given a problem from real life and asked to find a solution.

Three out of nine schools reported that they do not have a curriculum. Activities in the MS are based on the users' interests and not related necessarily to the classroom. The schools use lesson plans from existing MS websites, and the projects do not follow any specific trend. Furthermore, the students work on projects on their own as suggested by a maker educator: "The steps are discovered by students and I guide them by giving some hints." One center has developed its own curriculum for coding and science as the maker educator reported: "In advanced levels, we have our own advanced curriculum while in coding, we have developed our own curriculum because usually in coding, an online platform is used, but we have developed an offline module." Similarly, another school reported developing its own curriculum consisting of 16 sessions divided among woodwork, engineering, robotics and 3D design. Likewise, one school developed its robotics curriculum as part of the technology curriculum. On the other hand, the interviews showed that the schools and centers have adopted some existing curricula. For instance, one center reported using Lego curriculum, another school uses Vex Robotics curriculum, and a third school uses UK Raspberry Pi Digital Making Curriculum. As for schools that follow the French baccalaureate curriculum (2 schools), they have adopted the physics French curriculum.

In the FGDs, none of the learners reported a specific conventional curriculum related to the MS programs and projects. However, some learners reported that the theoretical concepts or what learners acquire in the classrooms are simultaneously applied in their experiments and projects at the MS. Hence, there exists an actual link between subjects and concepts studied in the classrooms and the MS projects. "This project relates the potentiometer studied in the classroom to real life and creates something useful" (FGD, MS at school). To elaborate, these learners specifically pointed out that such theoretical concepts practiced at the MS are mainly related to technology and physics classes.

"In the physics class, we were studying the interference between waves. The next session, we came here to see how this interference occurs and some students had the opportunity to tweak some parameters and make the experiment more interactive" (FGD, MS at school).

Impact on Students' Learning and Skills Development

The three data sources, Interviews, FGDs, and Observations yielded information about the cognitive aspect of MS in terms of impacting students' learning. A triangulation of data gathered from the different sources confirms that MS activities promote a variety of skills such as critical thinking, problem solving, creativity, decision making, collaboration, communication, active learning, technical skills, autonomy, real world connections, applying theory to practice, gaining scientific knowledge, and enhancing students' self-confidence.

In particular, the data gathered from interviews resulted in the following word cloud suggesting the overarching skills that students acquire in MS based on the maker educators' or managers' perspectives.

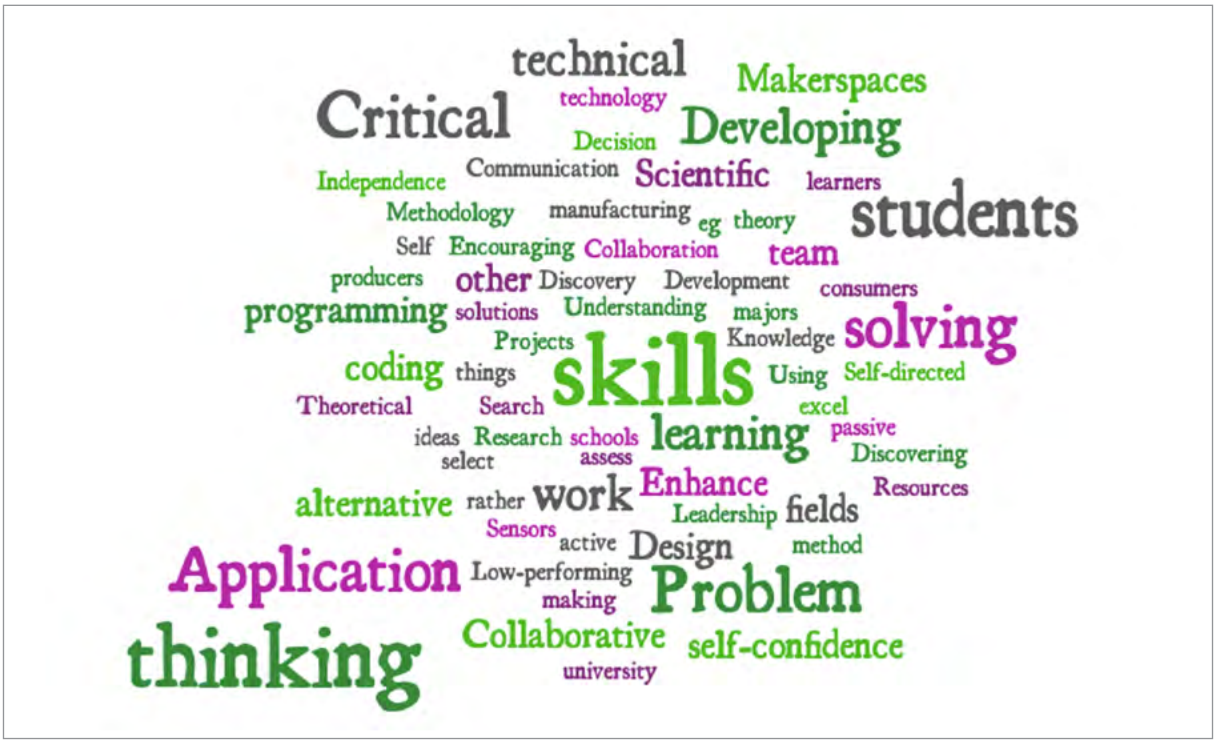

Figure 17. A Word Cloud of the Skills that Learners Develop as a Result of MS as Reported by Maker Educators or Maker Managers

Below are some quotes from the interviews that demonstrate the skills developed in MS:

"So you found that the students are aware of thinking about multiple solutions and orientations. At first, I faced a problem that many students lack the ability to orient their thoughts in alternative ways. But now, and after many seasons, these students became different."

"They also became able to teach themselves and discover sources of information with the aim of carrying out scientific experiments outside the curriculum; which opens the horizon for them to learn anything they want in the future."

"The skills might basically start by writing a simple program to light a LED, learning how to wire the jumper wires, how to use the screwdriver, or how to design and build a simple model. The skill sets they acquire range from coding skills like learning about sequencing, repetition, selection, variables and writing algorithms to building a project. Along the way, students develop logical and critical thinking by finding solutions to certain problems, coming up with ideas, designing physical constructs, making the first model, testing it, debugging to see what went wrong, criticizing the 1st model and enhancing it. They develop resiliency in solving problems. Students also learn how to work together in many STREAM projects; hence acquiring collaboration skills."

As for the FGDs, the majority of the learners reported that MS are less formal and more flexible settings. They engage learners in hands-on and real-life activities as well as in creating and developing scientific knowledge, motor skills, creative skills, critical thinking, problem solving, decision making, and interpersonal skills.

The majority of the students asserted that MS are more open, relaxing working spaces and environments as compared to traditional classrooms. Moreover, the majority of learners reported that MS offer a real-life space for them to translate their theories into practice. Besides, such spaces provide more freedom and less pressuring environments. As such, two FGDs respectively marked out that MS are "more open and relaxed, and all the tools are in the space as if I am in a specialized lab for the work that I am doing" and that "here in the robotics lab, we work hands-on and not only listen to the teacher, and we enjoy more than only studying… If we work and enjoy, then we will be more encouraged to learn and we will understand better" (2 FGDs, MS at schools).

Students in FGDs also reported that MS allow them to create and engage in hands-on tangible activities. One FGD participant expressed the following:

"Creating something new is the most important and appealing thing here. When we have a special idea, we execute it by transforming it into a project" (FGD, MS at school).

Another FGD explained:

"In class, we only sit and listen to the teacher, but actually here in the robotics lab, we use our hands rather than just listen to the teacher, and we enjoy more than just studying" (FGD, MS center).

A third FGD affirmed:

"In class, everything is theoretical as we are receiving information without seeing the application while here, we learn something and we apply it and also learn about the problems that we could face in practice" (FGD, MS at school).

Furthermore, it was reported by the majority of FGDs that they gained scientific knowledge regarding the robotic systems, coding, programming and designing, a finding that is confirmed by the interviews. One FGD clearly explained:

"The information I have learned from this project is about the robotic system; whenever the camera or sensor detects something moving, the robot moves and when we press on the stop button the robot stops" (FGD, MS center).

Other students reported the following:

"We learn how to design, we use physics in design and math in programming". "This project made us learn more programming since it is needed in the university. For example, if you want to do mechanical engineering, this work we are doing here will help in the university courses since we did it ahead of time" (2 FGDs, MS at schools).

Another FGD participant explained that his experience in the MS can have an advantageous impact on his higher education by stating: "We come here because we do what we like to do in this space and we practice and try things that may help us in the university in the near future" (FGD, MS at school).

As for the observations, three sections in the observation checklist were designed to identify cognitive and pedagogical implications of MS, and these were active learning, real world connections, and critical and creative thinking.

With respect to the evidence of active learning in MS, the overall outcome of the observation showed that the observed activities met these criteria as evident in Figure 18. All observed sessions showed that the teacher/facilitator employed effective questioning and discussion strategies, facilitated the learning-by-doing process, and demonstrated flexibility and responsiveness in meeting the learning needs of all learners during the session (a, b and d). As observed, most of the learners proved to be responsible for their own self-directed learning and developed their own problem-solving skills by engaging in constructing knowledge and communicating to others (f, h and j). Although the majority of the observed MS in Lebanon showed promising results, in a few rare cases, the teacher did not encourage learners to think for themselves and to make choices, ask questions and take ownership of the learning process. This somehow discouraged learners to take initiatives to test a hypothesis and try-and-fail, then to retry in order to become innovators (c, e, g and i).

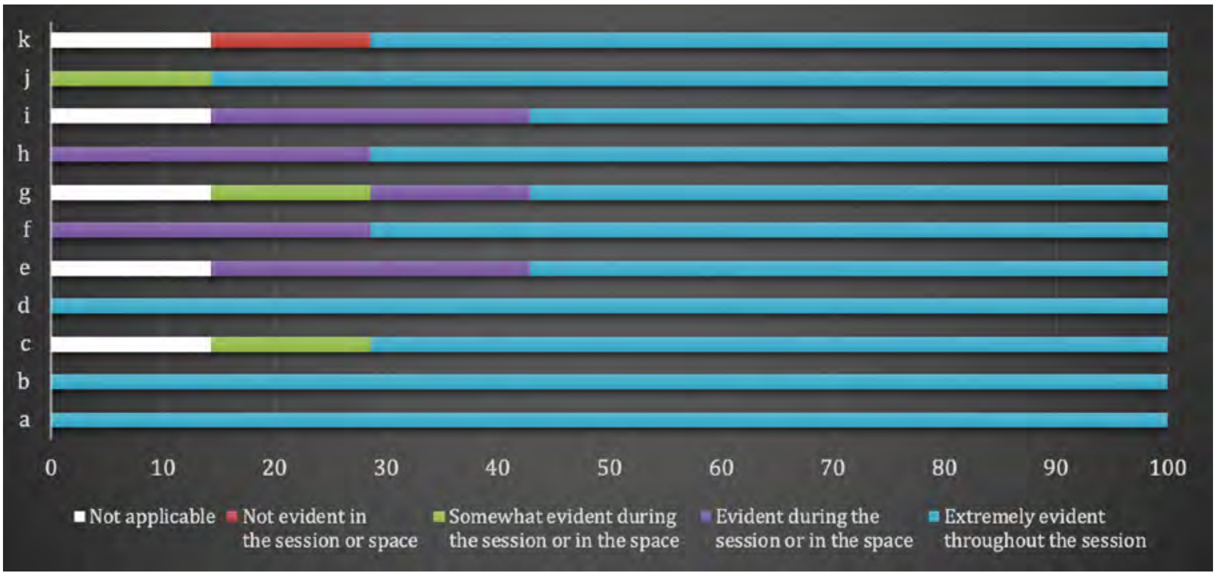

Figure 18. Stacked Bar Graph of the Active Learning Criteria Results Per the Observations

As stated by the FGDs, one of the main objectives behind using MS is the connection it brings with the real world through experimentation. Based on the observations, in all the observed sessions, all of the teachers situated learning in real-world contexts, connecting MS instructions to learners' lives and to the world while using materials based on their curriculum (a and b). Furthermore, most of the students (in 86% of the observed MS) demonstrated evidence of engagement in authentic learning and/or evaluative tasks and articulated how the session is connected to their lived experiences and/or the world beyond the classroom (c) as evident in Figure 19.

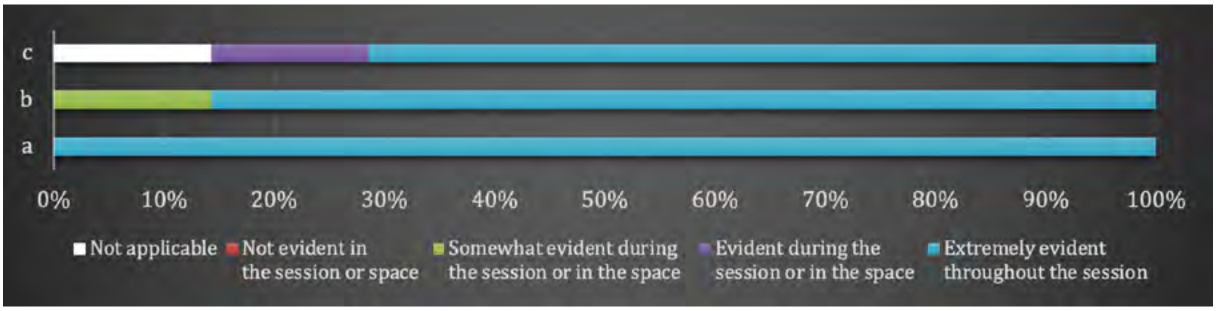

Figure 19. Stacked Bar Graph of the Real World Connections Criteria Results Per the Observations

The observations also examined evidence of creativity and critical thinking skills from the teachers'/facilitators' instructional approaches and the students' behavior. As evident in Figure 20, despite the fact that the overall outcome reflected positive evidence of teachers modeling critical and creative thinking, inquiry and reflection for learners (a), observers noticed, in a few cases, that teachers did not promote a risk-taking environment and did not inspire learners to develop original and unique ideas (b). In most of the observed MS, the teacher/facilitator asked open-ended questions that have no pre-established answers, which enabled learners to respond creatively. As for the learners, during the observed sessions, all of them raised questions, asked for clarification and suggested alternatives regarding the content of the session/project, to their teacher or classmates (d). In the majority of the MS, students' participation and work demonstrated a tendency towards higher order innovative thinking (e).

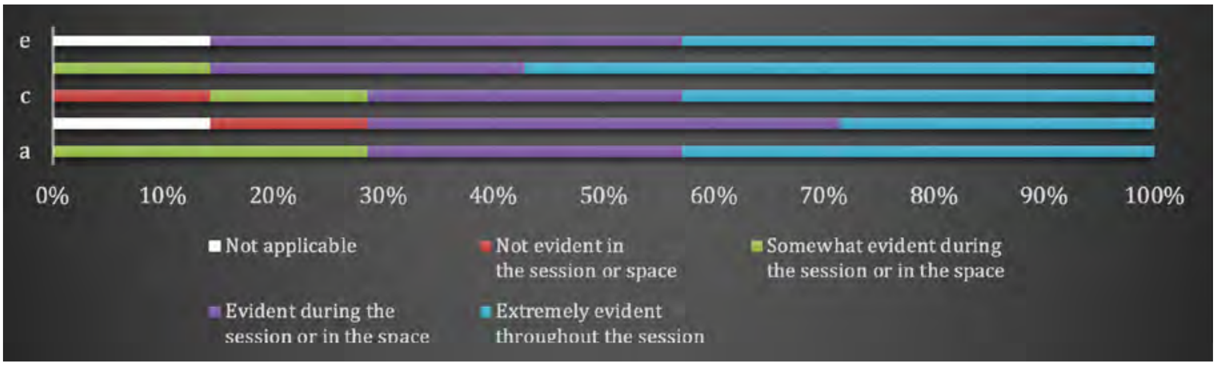

Figure 20. Stacked Bar Graph of Critical and Creative Thinking Criteria Results Per the Observations

Profile of a Maker Educator (ME)

Both interviews and FGDs helped us to examine the characteristics of an ideal ME who is able to handle activities in an MS. Both data sources suggested that an ME should be knowledgeable in technology and physics and should be a guide and a facilitator.

Based on the interviews, it was revealed that the characteristics of an ME - conveyed by interviewed MEs or maker managers- are creativity, possessing technical skills, being knowledgeable in physics, technology, and engineering, possessing knowledge in multiple disciplines, showing openness to collaborate with other experts and teachers, and acting as a guide. As explained by one interviewee, an ME should possess a variety of skills:

"He/she has to be curious, polyvalent, owning technical skills like using a saw, and having knowledge in many domains. He/she has to know about electronic circuits, programming, and safety rules. This is because the facilitator is capable of producing any needed item."

Other interviewees suggested that engineers would make ideal MEs, and when this role is absent from an MS, the ME should resort to getting input from engineers:

“He/she has to be knowledgeable in engineering, or an engineer. But in Lebanon we don’t have engineers in schools. Personally, I’m a physics teacher, so at least the ME has to be a physics teacher who can apply science and math and someone who has some programming skills; which is somehow difficult to find.”

In addition to these skills, some interviewees focused on the role of an ME as a facilitator and a guide rather than a provider of information and solutions besides being creative and possessing technology skills. Several interviewees reported that an effective ME should combine technology and scientific knowledge. As such, an ME should not only be knowledgeable in multiple disciplines, but also willing to collaborate with experts and teachers from other disciplines when a need arises.

“The knowledge and the technical skills are essential for the facilitator but this is not enough. He/she needs to be creative and this is not far from someone who teaches scientific subject matters. He/she also needs to have good communication skills the way he/she leads in order to lead students, ... I am a facilitator. If students need something in physics, math or any subject matter; I facilitate their contact with the concerned person.”

“Specialized in teaching primary and secondary students physical computing. Raspberry Certified Educator, Arduino Certified, CAS Master Computer Science Teacher, BSc in Applied Physics with Electronics, Apple Certified Educator, Microsoft Certified Instructor, IOS developer. Yes, I sometimes coordinate with teachers from other disciplines while working on certain related projects.”

As for the learners, they were asked by the FGDs to express their opinions about the role of the ME. The results were in line with the findings of the interviews. The majority described the roles of ME primarily as guiding, assisting, informing, giving hints, facilitating and encouraging learners to keep on trying until they solve problems during the making of their projects. For instance, one FGD reported:

“The maker educator tells us to focus on a certain area of the problem or guide us to where the problem could be in programming. He does not tell us directly what the problem is. Instead, we discover it ourselves so as not to make the same mistake in the future. For example, he/she explains how stuff works so that we know where our mistake is” (FGD, MS at school).

Another FGD added:

“Usually he/she explains concepts and then distributes tools for us to apply the concepts. We are given a fixed time for that and the teacher goes through the groups and checks the work of students and helps the groups who are facing challenges in application by explaining the reason for the problem, how to solve it and how to avoid it in the future” (FGD, MS at school).

A different FGD explained:

“First of all, he/she tells us for example: Do the project that you want, then we work according to hints and instructions on what to do when we face any obstacles. He/she interferes and helps in a way. He/she is a facilitator” (FGD, MS at school).

Finally, it was reported by some FGDs that teachers of physics and technology are the main ones who partake in the learners’ MS journeys while only one FGD explained having a permanent lab facilitator in addition to their classroom teacher. “The teacher brings us to this space. The facilitator is always in the space and prepares the materials and tools for our session” (FGD, MS at school).

Best Practices in Makerspaces

Both the interviewers and FGDs asked participants (ME, Maker Managers, and Learners) to share best practices associated with the development and implementation of MS based on their experiences. Data from both data sources showed that meaningful projects related to real life experiences are key to the success of an MS.

In the interviews, the MEs and Maker Managers reported several best practices in MS, but there were three overarching findings.

To begin with, several interviewees reported that projects in MS should be linked to real life and provide actual solutions to problems so that learning becomes meaningful. In one of the MS, the interviewee gave the example of a home automation system project that learners had to create and emphasized the importance of meaningful projects. The same interviewee stressed the idea of encouraging local production by the users of an MS. Similarly, another interviewee explained the design process and the hands-on learning that takes place:

"Making a Button: This activity concentrated on the creativity of the students, how they were going to make this button, the design, what material they used, and how effective and functional their buttons were. I usually work in a way similar to what engineers apply because I consider them little engineers. They first think of the idea, design it, make a sketch, create a first model, do the coding part, and assemble the electronic parts to Raspberry PI and the breadboard. Then, they test the first model to see if it works as expected. If not, they criticize and think: What went wrong? Where is the error? Let's spot it, is it in the code, wiring, or design? How can we enhance the first model to be more efficient? This is an iterative process in engineering, we repeat and repeat until we get a satisfying result."

In another school, the interviewee reported designing the following projects: "We invented the follow me travel bag which has a GPS and works on Bluetooth to send notifications…We invented the smart pillow that tracks the sleeping pattern."

Another overarching finding regarding best practices was related to the space of an MS. Several interviewees stated the importance of having a large space to initiate an MS:

"First, there should be a dedicated room - at least 5mx5m in area since the field itself is 3x3, and sometimes less - of course with cabinets for storage. It should also have some space for the equipment, all workshop tools for cutting metals."

"A good starting point would be to have: g) a large room with enough space, h) at least 10 Raspberry Pi computers with their starting kits and some sensors, i) a mouse, keyboard and an HDMI screen for each RPI, j) speakers for the RPIs, k) some screwdrivers, simple tools, l) a 3D printer, m) hot glue guns, with glue, UHU, tapes, staplers, n) basic chassis with motors and wheels to build robots, o) some coding / robotics posters, p) a safety rules sheet, q) a nearby fire extinguisher in case of an emergency."

Furthermore, the interviewees explained that a common best practice in an MS is to have a qualified and well-trained teacher or maker educator. As such they recommended having "qualified teachers with technical degrees"; "I prefer if the facilitator is trained on leadership and other skills before he/she starts working with students."

Other best practices were reported sporadically by different interviewees:

- Projects should not be linked to a curriculum.
- Projects should unleash the students' creativity.
- Teachers should support learners to become independent and autonomous.
- An MS should include a UPS.
- The presentation of idea/project is what matters.
- The project should be integrated in a curriculum.
- For younger ages, teachers should start with a Lego robotics kit.
- Teachers should give students the basics and support them to create their own projects.
- Teachers should integrate Arduino.
- Teachers should integrate woodwork in the Makerspace.
- Teachers should integrate technology subjects with computers and arts.
- Teachers should engage learners in Design thinking: iterative process of engineering.
- Teachers can start with computers and micro controllers with a curriculum and activity book.

In the FGDs, all learners expressed their views, perceptions and experiences related to the best practices adopted at their MS. These best practices essentially involved different learning methods and strategies that enhanced students' understanding and learning of theoretical concepts, and namely complex concepts. "Many students in physics for example do not know and cannot imagine how some issues work. So, this space teaches them how to work and how to do different kinds of issues" (FGD, MS at school). Moreover, learning methods reported by the majority of learners included learning through experimentation and learning through trial and error. For example, 3 FGD participants asserted:

"What is unique is that the student is the one who is doing the work. When you are doing the work, you know what you are doing and what is happening";

"We have to keep working till we succeed in the project. We learn to work and verify the errors by keeping trying, we learn how to make the connections among different components of the project";

"Learning here is experimental, we make our product, we feel its value, when we make a mistake and then solve it, we learn better" (3 FGDs, MS at schools).

Challenges in Makerspaces

Challenges related to the MS were deduced from both the Interviews and FGDs. Technical and financial issues were both identified in data gathered from the data sources.

In the interviews in particular, the participants reported challenges related to the space, funding, time, and technical issues. With respect to space, some interviewees reported that the small space of the MS makes it difficult to navigate and to involve students. "On the other hand, the lack of space made it impossible to involve all students." Other interviewees reported the issue of time in getting projects completed, "Time!! As the standard educational session lasts only for 50 minutes, the actual time to implement the experiment is 30 minutes maximum."

As for funding and technical challenges, these findings were shared across interviews and FGDs.

Technical Challenges: According to the students, these involved difficulties in programming, coding sensors, fixing parts of robots such as the engines, and designing specifically in hiding parts of a device. For example, 3 FGD participants listed:

"The problems are always in programming because the interface or language might change"; "The problem is with programming and uploading the code, the teacher helped us in reviewing the code and uploading it"; "The challenge was the coding of the sensors and how to control each sensor separately" (3 FGDs, MS at schools).

This finding is in line with the responses of the interviewees who reported challenges associated with the level of difficulty of technical skills. One interviewee suggested: "I was explaining once how the ultrasonic sensor works and students had to wire it to the breadboard with all the other sensors and then check its accuracy. The wiring part required more skills from the students; it was a bit hard for them."

Financial Challenges: The majority of learners remarkably reported that there is scarcity in the resources due to financial obstacles. These learners explained: "We miss items for robots like sensors, connections, tires," and "we need a laptop with high specifications, for programming: some programs are big and heavy and this requires a fast computer" (2 FGDs, MS at schools). Lack of resources and tools was a major finding in the interviews and was reported by several interviewees as shown below:

"In some cases, after students plan the steps of their project, they encounter challenges that they cannot handle. Sometimes, they cannot find the tools they need, or they don't have enough money to buy what they need, so after crossing half the way, they make the appropriate modifications to their project or they change the idea of their project completely and start again."

"Sometimes, during our preparation for competitions, we face some technical difficulties, and not all technical equipment are available as spare parts. Sometimes, the delivery orders take longer than expected, or some parts of our robot fail prior to the completion day. Providing needed equipment is another important issue. Because this is a science lab not for robotics, the school bought more tools like screwdrivers and drills…, so the space needs to be well equipped."

On the other hand, one FGD participant reported a lack of human resources which is specifically the lack of professional mentoring. "We stayed for 2 years without a coach. The teachers in our school are not professional trainers. They cannot give us any additional value in programming" (FGD, MS at school). Finally, 1 FGD elaborated that another resource-related issue is the inaccessibility of school MS during day-offs. However, the FGD added that this challenge was overcome after an intermediary contact between the school director and MEHE. This eventually was solved by allowing the learners to visit the school MS based on the director's request and approval of MEHE. The FGD declared: "We plan for a meeting, normally on Friday which is a vacation, we contact the school director to inform him/her because he/she has to inform MEHE and get approval for opening the school on a day-off" (FGD, MS at school).

Discussion

Research Question 1: What are the basic elements of a Makerspace (definition, physical space, tools, safety)?

This study examined the basic elements of Lebanese MS as they pertain to physical spaces, tools and safety measures. Data from interviews, observations, and FGDs revealed that physical spaces were not construed and defined as MS. The findings unveiled the disparate associations to these spaces. For instance, each space had a different name and served a different purpose. Main findings showed that these physical spaces were substantially referred to as Labs and clubs of robotics, physics, and technology. In fact, the study demonstrated that the use of "Makerspace" as a definition to such spaces was not prominent since the majority of schools still exclusively use these spaces as milieus where teachers practice technology and physics subjects and where students subsequently apply their projects. Similarly, Davee, Regalla, and Chang (2015) discussed that there are other terms that can be associated with MS such as creativity Lab, Science Lab, Robotic Learning Lab, FabLab, Innovation Lab and others. Nevertheless, in this study, albeit the majority of students did not directly define their spaces as MS, they described their activities as involving "making". For instance, Davee et al. (2015) explained that an MS is not defined by a compilation of tools, but rather by enabling users the action of "making".

Nonetheless, main findings showed that the spaces were considered satisfactory and flexible although some spaces lacked particular tools and equipment. In fact, major tools in such spaces involved the Arduino, 3D printers, Lego, and robotics programs. Previous studies found that the most prominent tools used in MS were Lego bricks, 3D printers, welding machines, kilns, oscilloscopes, iron pour, laser cutter, and software (Cohen, 2017; Collins, 2017; Keune & Peppler, 2019; Sheridan et al., 2014).

Finally, many studies highlighted the importance of safety measures in MS (Hlubinka et al., 2013; Schwartz, 2019; Scott, 2014; Sheridan et al., 2019). However, in this study, safety tools were available for students but there was a lack of an outline of safety procedures or a plan in cases of injury and fire. Hence, there was an accessibility to safety tools but a lack of preparation and practicality on how to act in emergency cases. There was also an absence of strict clean-up policies. Safety measures involved well-lit and ventilated spaces, spacious settings, and the clear access to first aid kits, fire extinguishers, goggles and gloves.

Research Question 2: What are the best practices and challenges for the development and implementation of Makerspaces in Lebanon?

In this study, data from interviews and FGDs revealed that students expressed their views and perceptions both towards the best practices for a successful MS environment and the challenges in such spaces. Main findings revealed that the most salient best practices are related to having (1) meaningful projects that can be related or applicable to real life experiences, (2) a large space for the MS and (3) qualified and trained teachers. Furthermore, data from FGDs showed that it is crucial to have learning methods and strategies that could enhance students' learning and understanding of complex concepts as well as learning through experimentation and trial and error. On the other hand, challenges were of technical and financial nature. Another less redundant challenge was spatial and time-related.

Best practices

The main findings related to the best practices for a better MS environment are illustrated in Figure 21 below.

Figure 21. Best Practices in MS as Expressed by the Interviewed Maker Educators and Makerspace Managers and the Learners

Data from interviews and FGDs further revealed that students believe that obtaining projects that are relatable to their real-life experiences can provide a successful environment for MS. For instance, in a study by Gershenfeld (2007), findings showed that when MS provide a learning by-demand model rather than just a traditional space, learning becomes more meaningful as well as more useful to be applied later on in life (as cited in Hsu, Baldwin & Ching, 2017). Besides, since MS are built on constructionism and experiential learning, this study showed that Lebanese MS strive to keep the experience in MS as real as possible.

Moreover, data uncovered that it is crucial to have a spacious setting with sufficient and adequate tools and equipment. In fact, two studies by Anderson (2012) and Gershenfeld (2005) showed that the availability of tools render the physical world in MS more flexible and malleable to learners and more resembling to the digital one (as cited in Van Holm, 2015).

Additionally, having MS educators was not sufficient. Data revealed that it was highly important to have prepared, qualified and well-trained maker educators. Koh and Abbas (2015) asserted that for MS programs to be more durable, there should be well-qualified and professional educators, and a support team. Also, Cohen (2017) highlighted the importance of having skilled and well-trained maker educators by going through professional development programs that could boost and enhance teachers' relevant technological knowledge, self-efficacy, and belief systems.

Finally, in this study, it was found that having learning methods and strategies that could enhance students' learning and understanding of complex concepts in specific was regarded as a crucial better practice for a fruitful MS environment. Data showed that learning methods and strategies for understanding simple concepts is as equally important as learning those required for understanding complex concepts. Blikstein and Krannich (2013) revealed that in engineering and science, students can come across different concepts in a meaningful and contextualized manner, but abstract concepts such as friction and momentum can become more concrete and consequential when they are used in activities and tasks within a project.

Nevertheless, learning through experimentation and trial-and-error was abundantly reiterated in the data. It was found that this creates a sense of self-reliance and resilience. A study by Vassoughi and Bevan (2014) showed that making programs that involve and encourage risk-taking, experimentation, and iteration substantially enhance students' learning and development.

Challenges

Data from interviews and FGDs revealed financial and technical challenges as depicted in Figure 22. In this study, main findings showed that technical challenges were related to difficulties in programming, designing, coding sensors, and fixing parts of robots. Correspondingly, some previous studies reported that technical challenges were also related to designing, building, programming and computing (Bowler, 2014; Kafai, Fields & Searle, 2015; Sheridan et al., 2014).

On the other hand, financial challenges mainly involved the lack of capital resources as the result of the lack of funding of materials and equipment. Similarly, a study by Keune and Peppler (2019) emphasized that there are financial challenges in MS and are initially budgeting and funding. Another financial challenge found in this study was the lack of human resources, i.e, the absence of professional mentoring. Metni (2019) discussed that teachers may sometimes feel incompetent and dubious when the topic is ambiguous and when they find themselves unable to motivate students. Hence, a human resource challenge is not solely related to the physical absence of professional mentors but also their unpreparedness.

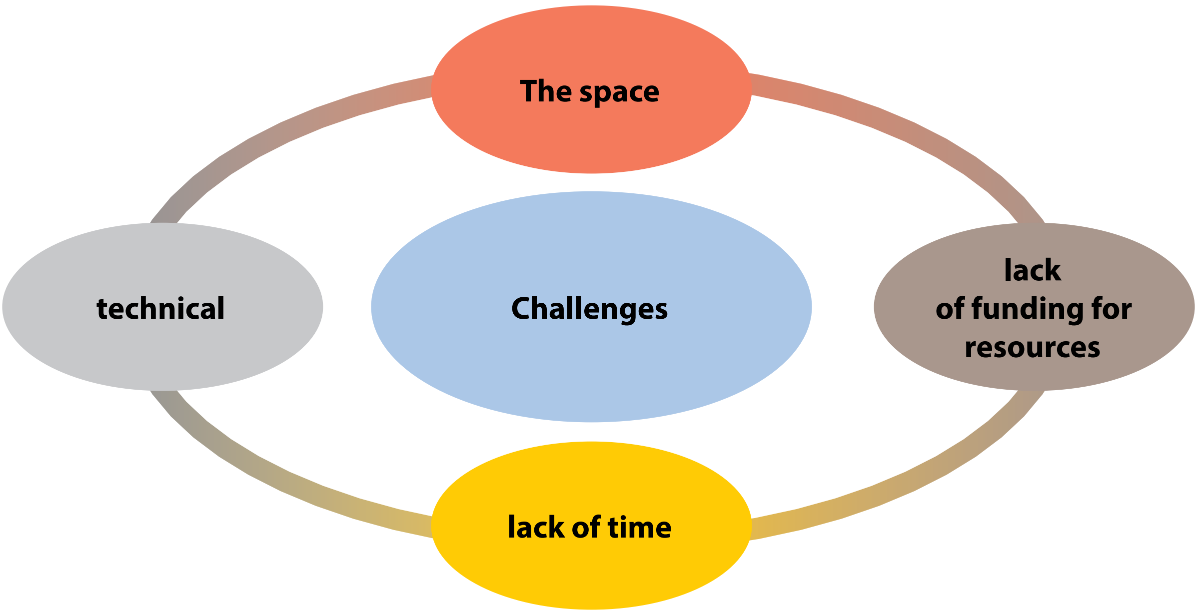

Figure 22. Challenges Associated With MS as Outlined by the Interviewed Maker Educators and Makerspace Managers and the Learners

Nonetheless, in this study, challenges also involved spatial and time-related challenges that mainly involved concise spaces where teachers were not able to navigate and engage students. Time-related challenges were exclusively related to the inability of students to complete their projects within a restricted period of time. This challenge was found to be very crucial as students had personal interests and differences. Hira, Joslyn and Hynes (2014) asserted that the different styles and potentials of students must be acknowledged while planning, intervening and implementing the projects of MS as no learner should be abandoned during the application of MS activities and projects.

Research Question 3: In what ways do Makerspaces impact student learning?

This study explored the impact of MS on students' learning from a qualitative perspective without referring to learners' scores and examining their learning outcomes. Research in this area is scarce (Halverson & Sheridan, 2014), yet the literature to date suggests that MS provide student-centered environments that cater to the development of a skill set necessary for learners in the 21st century. Data from interviews, observations, and FGDs focused on the cognitive and learning aspect of MS and revealed a set of themes that are highlighted in Figure 23. Findings showed that MS have the potential to promote learners' skills that are not as easy to develop in the traditional classroom. In other terms, MS provide students with opportunities to engage in a set of interrelated skills that provide a holistic approach to the learners' education through authentic hands-on projects while developing their technical, soft, and cognitive skills that enhance their self-confidence. Therefore, the skills in Figure 23 are interconnected as one promotes and enhances the other(s) in well-designed MS.

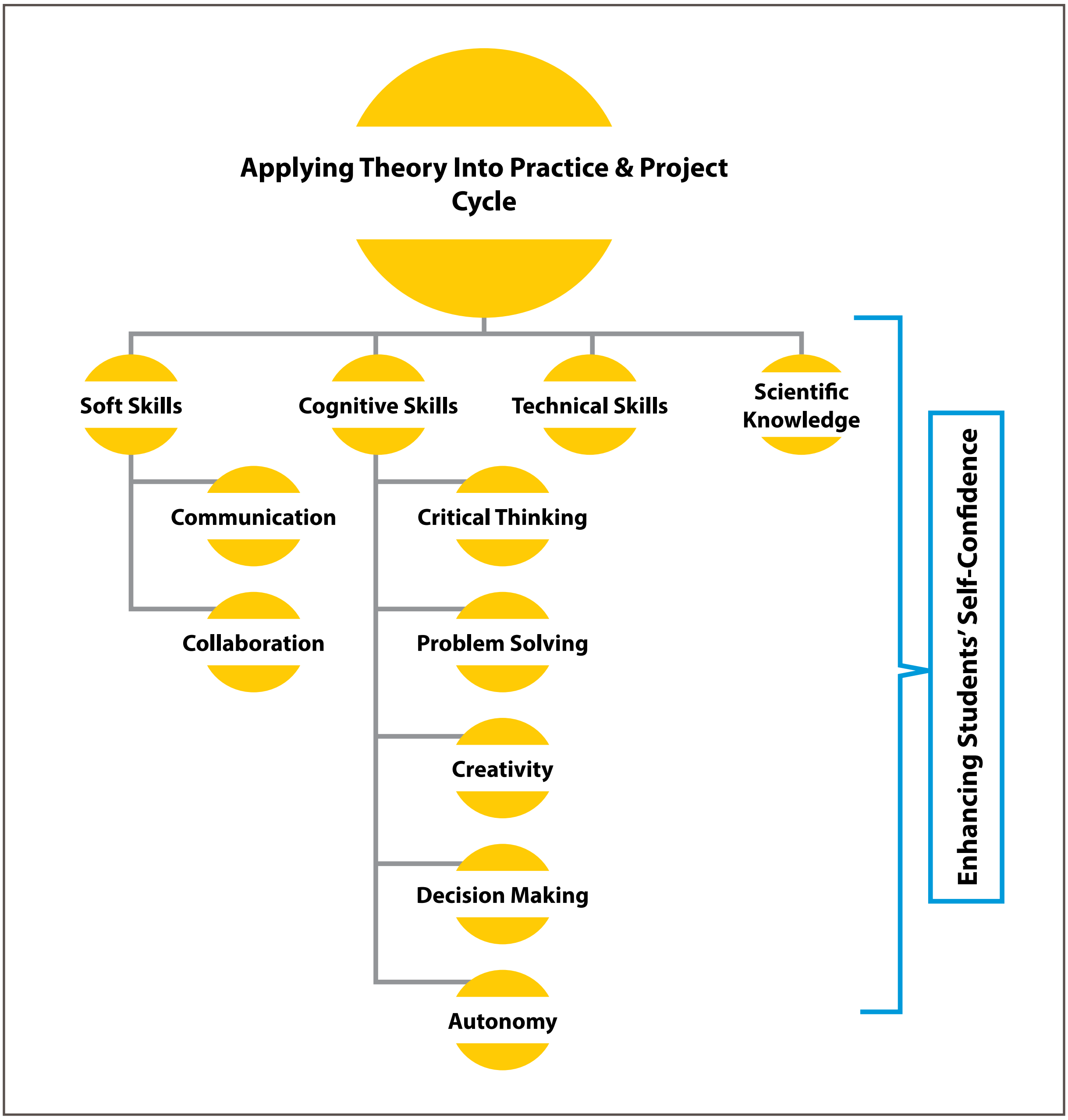

Figure 23. Themes of Skills Developed as a Result of MS in Lebanon

Applying Theory to Practice and Project Cycle

This study confirmed that students who are actually enjoying their learning journeys are more likely to be motivated through "learning by doing". The interviewees also recurrently reported that these spaces allowed students to apply theory to practice. This is attributed to the project-based approach of MS and engaging learners in "Making." Hence, engaging learners in making and tinkering serves the purpose of these spaces, and implementing real life and tangible projects or products makes learning more relatable to the learners (Halverson & Sheridan, 2014; Martinez & Stager, 2014). This is why it would be significantly crucial to integrate them in the Lebanese context.

The project cycle in an MS goes through several steps: ideation, prototyping, testing and revising (Rachel, 2018). This study showed that MS activities follow a design thinking approach that involves learners in multiple stages to design a project while developing soft skills, cognitive skills, scientific knowledge, and technical skills at the same time. Design thinking is a major component in MS as it involves learners in discovering and developing solutions to problems using creative and innovative approaches (Jarrett, 2016).

Technical Skills

Findings from this study suggested that learners in MS develop several motor skills that are technical by nature. Construction and building (gross motor skills), cutting, assembling, soldering and wiring (fine motor skills) are among the skills that learners develop as a result of participating in MS. Furthermore, the availability of tools in MS contribute so much to the development of these skills and to the "Making" capabilities in the MS (Hsu et al., 2017).

Soft Skills: Collaboration and Communication

As MS are highly based on a project-based learning approach (Santos & Benneworth, 2019), collaboration is a main component of these spaces. This study emphasized the role of collaboration in developing the projects; specifically, as reported by the learners in FGDs and the interviewees in the MS. Sheridan et al. (2014) describe MS as social environments where people meet and greet and collaborate on projects. For them, spaces should be designed in a way to afford this collaboration. Similarly, as collaboration takes place, learners' communication skills are enhanced as suggested by FGDs. Interviewees also confirmed that communication is enhanced when learners are asked to present their ideas and projects to others. This element of articulation enhances learners' communications skills as suggested by interviewees. Communication as an acquired skill in MS was also found to be a key developed skill in other studies (Blackley, Rahmawati, Fitriani, Sheffield, & Koul, 2018).

Cognitive Skills: Critical Thinking, Decision Making, Problem Solving, Creativity, and Autonomy

The three data sources yielded to complementary information regarding the element of creativity in MS. While interviewees and the learners in the FGDs suggested that creativity is enhanced in MS, the observations showed that this element was not fostered in some spaces. This may be attributed to the nature of the projects that were observed in specific centers or during specific sessions. Creativity is a core acquired skill in MS (Hsu et al., 2017) and is highly linked to entrepreneurship. Research shows that learners who participate in MS have the tendency to develop their creativity and entrepreneurial thinking (Sheridan et al., 2014).

This study drew a link between critical thinking and problem solving as inseparable skills in an MS. Per the interviewees and the FGDs, when learners in an MS face a problem, they need to think critically to find alternative solutions and to overcome obstacles. This is due to the iterative nature of projects in MS which go through different cycles until the final outcome is achieved as portrayed by an interviewee in an MS center. These skills were further noticed in the observations where learners raised questions, asked for clarification, or posed alternative possibilities about the content of the session/project. Critical thinking and problem solving are major findings in other studies that investigated cognitive skills in MS (Blackley et al., 2018).

Projects that learners create in MS do not only require collaboration, critical thinking and problem solving, but also decision making when it comes to choosing the best solution (Kafia et al., 2014). This skill was brought up by both learners and MS teachers of managers. This comes as a natural outcome of the project cycles that are an essential process in MS.

Similarly, the results of this study align with the findings of previous studies regarding the role of the maker educator as a guide rather than a provider of solutions and ideas. As suggested in this research, the interviewed maker educators or managers explained that with time, learners are able to teach themselves and search for answers to their questions. Several interviewees stated that as learners engage in discovery learning, they develop this independent and autonomous self-teaching skill. This finding comes in line with the notion of Kurti and Fleming (2014) who emphasized ownership of learning as an outcome of MS.

Scientific Knowledge

The interviewed MS instructors and owners brought up the relationship between students' involvement in MS and their interest in scientific majors and knowledge. One of the interviewees in a school explained that learners develop a lifelong interest in scientific programs whether at universities or later when they establish their own robotics clubs. This indicates that the scientific knowledge gained in MS impacts learners' career options and goals. This finding coincides with the results of Metni (2019) and Blackley et al. (2018) who state that students who are engaged in MS projects that are related to science develop understanding of the subject as well as interest in it. As a result, their performance improves.

Enhancing Students' Self-Confidence

The maker educators who were interviewed in the MS emphasized the role of accomplished projects in developing learners' self-esteem and self-confidence. This sense of accomplishment was observed in low achieving learners who were able to excel in MS per one of the interviewees. In line with previous research, Metni (2019) explains that MS contribute to under-privileged populations and motivate them to transform. Similarly, Blackley et al. (2018) confirm that learners' self-confidence is enhanced as a result of the success and failure cycle. Hence, in their nature to develop learners' technical and cognitive skills, MS provide a venue for students with different abilities and backgrounds to create and achieve a sense of accomplishment, which in turn leads to transformative learning experiences.

Research Question 4: What role do Makerspaces play in school curricula and vice versa?

In general, the maker movement appeals to schools as a way to engage learners in STEM (science, technology, engineering, and math) subjects (Hsu et al., 2017). This is the case in schools that have guided projects. In more informal settings, Wardrip and Brahms (2015) claim that making is focused on exploration, play and discovery (as cited in Hsu et al., 2017) The general findings from this study suggest that only two of the examined schools link MS activities to their curricula. These schools mainly follow the French curriculum and more specifically use the Physics curriculum in the MS. The remaining centers or schools have either developed their own curricula or adopted curricula that exist online. In schools, this indicates that MS are not embedded in the curriculum; not even vice versa except in a few cases. This allows instructors to freely come up with projects that might not have clear learning outcomes. Hence, the focus is on the projects and the technical skills in these schools although interviewees and learners mentioned other cognitive skills achieved in MS. Similarly, as MS are a trend, the absence of a curriculum suggests that there is deficiency in planning for meaningful learning as well. As for MS centers, the findings indicate that the curricula are mainly adopted or developed in-house; which results in a more structured approach for implementing MS.

As for projects, the results show that most of them are robotics related with fewer projects which focus on other skills such as carpentry and construction. This suggests that the scope and activities of MS that exist in Lebanon are mainly related to technology dismissing other fields that could engage learners in creating real-life solutions to problems without the use of technology. Sheridan et al. (2014) shed light on other activities and projects carried in three MS such as sewing projects, bike repair, visual art, woodwork, design and fabrication, music and video creation, creating phone cases, and circuitry related projects. The spaces described by Sheridan et al. (2014) involve a multitude of activities that do not orient the learners to one type of projects. Similarly, the availability of multidisciplinarity in an MS provides multiple options for learners to mix and match disciplines; which enhances innovation (Brahms & Crowley, 2014).

Research Question 5: What is the profile of a Maker Educator?

According to this study, the profile of an ME in a Lebanese context is presented in Figure 24. Results from previous research regarding the characteristics of ME confirm some of these findings in terms of possessing technology skills, being a knowledge provider, and acting as a facilitator as suggested by Duhaney (2019), Gerstein (2019) and Kajamaa et al. (2019). Another major finding is the ability of an ME to learn and collaborate; a fact which was brought up by the interviewees who emphasized the importance of resorting to other experts when an ME faces an issue. This finding aligns with the conclusions of Koh and Abbas (2015) who stress the importance of collaboration and continuous learning as main characteristics of an ME. Another characteristic brought up by the learners in the FGDs was the "encouragement" of the Maker Educator for learners to keep on trying until they solve a problem. This finding confirms with the views of Kajamaa, et al. (2019) who state that "Motivation" is one of five categories that teachers' collaboration with the learners in MS should fall under.

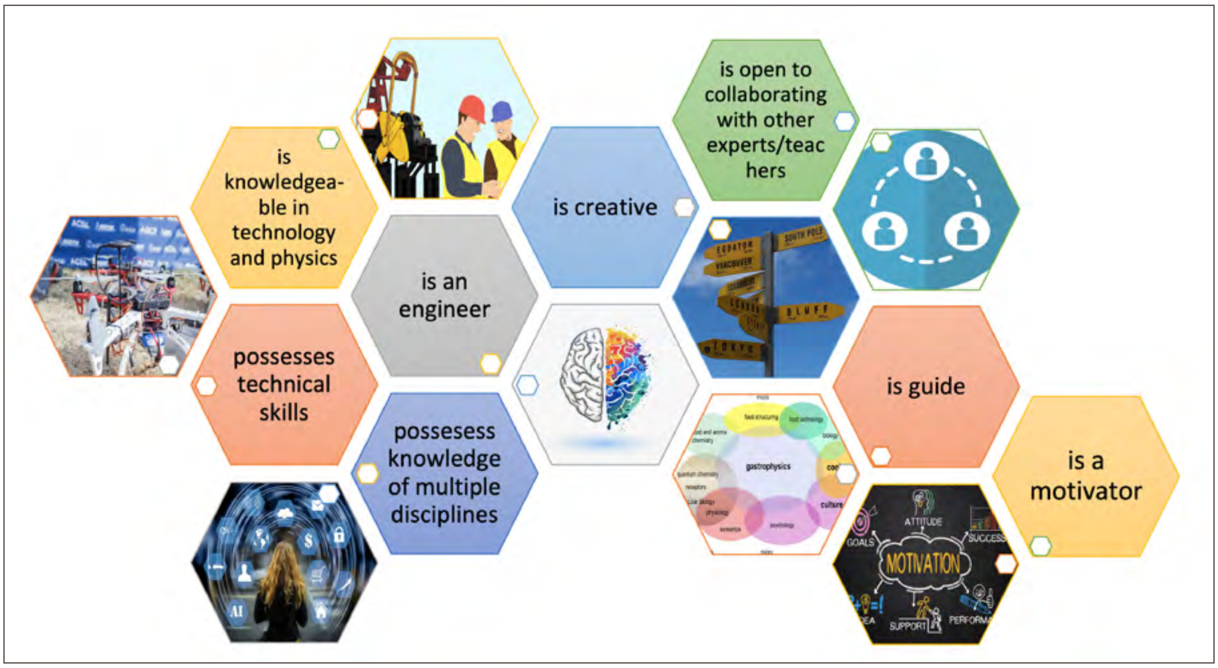

Figure 24. Profile of a Maker Educator as Described by the Interviewed Maker Educators and Makerspace Managers and the Learners

In this study, further characteristics were added to those mentioned in previous research as implied from interviews conducted with ME and managers. In a Lebanese context, these characteristics involve knowledge of multiple disciplines (Math, Physics, technology, engineering, etc.). The ME should also be creative. These findings were brought up by several interviewees to complement the profile of an ME. Hence, when considering an ME to teach in and manage an MS, several considerations should be taken including the educational background of this individual who should be knowledgeable in technology, engineering or Physics and a variety of skills such as manual ones. In addition, he/she should be flexible and open to learning new skills.

Recommendations

This research yielded to the following recommendations regarding practices and implementation of MS:

Makerspaces Model in the Lebanese Context

- It is highly recommended to name the Lebanese MS as Makerspaces instead of technology labs and robotics labs in order to align with the international movement of "Making" and to avoid limiting the space to science projects and robotics. Hence, MS should allow different types of projects and not be limited to technology.
- Lebanese MS should take into consideration other activities such as sewing projects, bike repair, car repair, visual art, woodwork, design and fabrication, music and video creation, creating phone cases, and circuitry related projects. These projects are worth exploring in phase 2; the prototype phase.
- While the projects and the tools in MS in Lebanon are limited to electronics and robotics (and this is not recommended), it is recommended to include at least the following tools in the MS: computers, software, laser cutters, 3D printers, and Lego kits. Besides, MS should include other making tools related to arts, carpentry, sewing, etc

  Based on extensive research of existing MS, the research team created a manual of recommended tools for MS that will be published as Volume 2: "Guideline and Tools Matrix". In the manual, the importance of each tool is designated with a scale ranging from 1 to 10, where number 10 corresponds to an important basic tool that every maker space should include. Lower numbers on this scale are linked to more specialized MS. The guideline of this manual describes in detail the technical specifications of the tools and other related information which are organized and presented in tables (Volume 2, Guideline and Tools Matrix).
- In Lebanese MS, safety rules should accompany safety tools and clear procedures in case of emergency and/or injuries. Hence, a safety handbook should be developed to guide Lebanese MS.
- A large space for an MS should be provided to allow mobility and flexibility as well as an adequate number of tools. This means that the Lebanese MS should be large enough for students to collaborate on projects and move freely. This space could include multiple rooms with labs and tools for different purposes (Woodwork, Circuitry, audio visual studio, robotics, iron work, etc.).
- Qualified and well-trained maker educators must be provided. They should have the knowledge and the "know-how" in technology and multiple disciplines and should serve as a guide to the learners. Hence, capacity building for ME or instructor should be taken into consideration.
- Budget for MS should be allocated; taking into consideration the tools and resources required to allow students to create projects that meet learning outcomes (See Volume 2, Guideline and Tools Matrix).

Makerspaces Integration in the Lebanese Curriculum

- The Lebanese curriculum should consider integrating "Making" in all subject areas individually or interdisciplinarily, hence providing students with hands-on learning experiences and activities. Therefore, a STEAM approach to the Lebanese curriculum is highly recommended.
- MS projects should be relatable to real-life in order to create a meaningful learning experience for learners. In other words, it is recommended to guide makers to identify actual problems in the Lebanese community and to use MS to create solutions for these problems. The set of activities should be integrated in a multidisciplinary approach and within different subject areas not limited to robotics and sciences.
- Schools are recommended to allocate time within the curriculum for MS activities whether during the school schedule or after school.
- A very important outcome of MS is the skills that students gain while "Making." Hence Lebanese MS are advised to guide students to create projects and activities that emphasize cognitive, soft, and technical skills necessary for the 21st century education (see Figure 24).

Conclusion

As the world has shifted into a digital age at a fast pace, the future is yet to bring along more innovations that impact all aspects of life. Hence, schools and universities have to prepare students to be part of the change as contributors or as main change makers. There is a need to implement curricula that foster the development of learners' literacies, skills, and knowledge in general, and to present a context for learning in particular. Therefore, learning should be meaningful to students by contextualizing it in real-life. This study, similarly to previous ones, has shown that the impact of MS on learners is mostly positive. MS provide students with a medium to connect subjects learned in class with each other and with current issues. This study and previous studies also show that learners in MS develop a skill set such as critical thinking, problem solving, communication, creativity, decision making, and collaboration that is transferable to their daily lives. This study also confirms that MS enhance learners' self-directed learning and autonomy along with technology skills and scientific knowledge. These skills and the design thinking process, that engages learners in an iterative cycle of ideation, design, implementation and revisions, influence the learner's self-confidence positively.

Furthermore, this study sheds light on MS in the Lebanese context. Along with the impact of MS on students' learning, the study investigates tools, safety procedures, physical space, characteristics of a Maker Educator, sample projects, and best practices and challenges in the implementation of MS. The results suggest that the design of MS in Lebanon should take into consideration careful planning in terms of space; an issue that allows flexibility and collaboration. Furthermore, funding for the MS should be taken into account and tools and projects should not be limited to electronics. Instead, MS should focus on the process and the product and on creating solutions in response to real-life issues. Only in these cases an MS would be purposeful and meaningful. The study also suggests that the maker educator who runs the center should possess certain skill sets and should be well-trained to guide learners in this environment. To sum up, MS, need to be implemented formally as part of school curricula or informally in after school activities; knowing that there are common considerations across the models.

This phase of the three-phase design-based research approach provides a corner-stone for the development of Phase 2 of the project which involves the design and development of integrated interdisciplinary MS activities in the curriculum and a prototype of an MS. As schools shift to developing MS, a whole paradigm shift concerning how and what students learn should accompany this transition. Existing frameworks, such as those set by Van Holm (2015), Kurti et al. (2014a) and Hira and Hynes (2018), provide guidance into the structure and dynamics of MS. Most importantly, the authors focus on the socio-constructivist aspect of MS and the flexibility in designing these spaces. As part of the revised Lebanese curriculum, MS should be the new learning space where learners are allowed to think outside the box and use the information they acquire in an applied setting. Unlike traditional schooling, MS empower learners with the ability to create their own learning and make sense of information while engaging in fun, meaningful and interest-specific activities. Therefore, schools should unleash this creativity in students by giving them the right tools and guidance to innovate.

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Appendix A

Focus Group Discussions

(Interviewer asks the Makerspace teacher/owner to bring a project they have already worked on or are currently working on)

Interviewer: We are here today because we want to hear and learn from you about your experience in this Center/Class. So, thank you for your honest feedback.

It is best to conduct this interview in the Center/Class and probe the learners to elaborate their responses.

1. First, we would like to know what you like most about this space.
2. What do you think is missing in this space? What would you like to add to it?
3. Can you please describe how the teacher helps you in this space?
4. Show me/ Tell me about a project that you are currently working on or that you have completed. What is special about this project?
5. Please describe the step-by-step process for designing this project.
   a. How did you come up with the idea?
   b. How did you design it?
   c. What tools did you use?
   d. Did you work alone or with a team?
   e. How did you keep track of the tasks?
   f. How did you interact with the team?
   g. What challenges did you face?
   h. How did you overcome these challenges?
6. What new information did you learn from this project?
7. What new skills have you learned from this project and other projects?
8. How does your learning in this space differ from learning in a regular classroom? Where do you learn more? And why?

Appendix B

Teacher/Makerspace Owner Interview

Interviewer: Thank you for taking the time to meet with me/us. This interview aims at gathering information about your experience with Makerspaces or innovation labs and your perceptions about them. Therefore, I/we would appreciate your objective feedback to better serve our purpose in achieving research reliability

It's best to conduct the interview in the Makerspace if possible.

1. We are conducting this interview with you because we are aware that your school/center engages learners in innovative projects. What do you name this space/center?
2. Could you please describe the following about this space:
    - Type of projects that learners complete.
    - Tools that learners use to complete these projects.
    - The age group or grade level of the learners.
3. Which disciplines (subjects) use this space/lab? Do you think it should be strictly limited to computer/technology classes? Please explain. (Probe the interviewee to elaborate on this idea.)
4. Is the space/lab linked to a specific curriculum? If yes, please explain. If not, where do the ideas and projects in this space/lab come from?
5. Is the space used for formal, structured learning activities led by a teacher? Is it used for informal, student-directed learning and exploration? Or is it blended? Please explain.
6. Describe 2 or 3 learning experiences or projects that were successful. What made them successful?
7. Describe 2 or 3 experiences that were not successful in this space/lab. Why were they unsuccessful?
8. What are some of the challenges that you face in this space/lab on a daily basis.
9. Describe an ideal innovation space or lab that would be successful in a Lebanese context or school.
10. If you were to recommend the development of an innovation lab or space in a school or a center, what would be a good starting point? What steps would you recommend?
11. Describe the learning journey of a student in this space/lab. What skill sets does he/she usually start with? And what skills does he/she develop over the sessions? (Probe the interviewee to talk as much as possible about the skills.)
12. How do you think this space has impacted your students' learning? How do you assess their learning?
13. How long have you been teaching? And have you identified any differences between the way your students learn in this space and the way they learn in traditional classes? Please explain.
14. What skills and degrees does the facilitator in your Makerspace possess? Does he/she coordinate with teachers from other disciplines?

Interviewer: Again, thank you for your time. This has been a very informative interview.

Appendix C

الدليل للمُيّسرين لإجراء مقابلات مع أطفال
مناقشات مجموعة التركيز (Makerspace)

يُعتبر المستند التّالي دليلًا توجيهيًّا للمُيّسرين خلال إجراء مقابلات مع مجموعة التّركيز المؤلّفة من أطفال. تدوم المناقشة من ساعةٍ إلى ساعة و15 دقيقة.

معلومات عن إجراء جلسة المناقشة مع مجموعة التركيز(على أن يملأها مدوّن المداولات)

التّاريخ	
الموقع	
عدد المشاركين	
مدّة المناقشة	
استخدام أداة التّسجيل	
اسم الميُّسر	
اسم مُدوّن المداولات	
رمز جلسة المناقشة	

يطلب الشخص الذي يقوم بإجراء المقابلة من مدرس / مالك مساحة الصانع إحضار مشروع قد تم العمل عليه أو يتم العمل عليه)

الشخص الذي يقوم بإجراء المقابلة: نحن هنا اليوم لأننا نريد أن نسمع منك وأن نتعلم منك عن تجربتك في هذا المركز / الفصل الدراسي . لذلك نشكرك لتغذيتك الراجعة الصادقة.

من الأفضل إجراء هذه المقابلة في المركز / الفصل الدراسي وحث المتعلمين لتوضيح إجاباتهم.

1. **أولاً: نود أن نعرف ما هو أكثر ما يعجبكم في هذه المساحة.**

2. **ثانيًا: برأيكم، ما المفقود في هذه المساحة؟ ماذا تريدون أن تضيفوا إليها؟**

3. ثالثًا: من فضلكم، هل يمكن أن تصفوا لنا كيف يساعدكم المعلم في هذه المساحة؟

4. رابعًا: أروني / أخبروني عن مشروعٍ تعملون عليه حاليًا أو أكملتموه؛ وما هو المميز في هذا المشروع؟

5. خامسًا: من فضلكم، وصِّفوا عملية إنشاء هذا المشروع خطوة بخطوة.

أ. كيف توصلتم لهذه الفكرة؟

ب. كيف قمتم بتصميمها؟

ت. ما الأدوات التي استخدمتموها؟

ث. هل عملتم بمفردكم أم مع فريق؟

ج. كيف تتبّعتم المهام؟

ح. كيف تفاعلتم مع الفريق؟

خ. ما هي التحديات التي واجهتكم؟

د. كيف تغلبتم على هذه التحديات؟

6. سادسًا: ما هي المعلومات الجديدة التي اكتسبتموها من هذا المشروع؟

7. سابعًا: ما هي المهارات الجديدة التي اكتسبتموها من هذا المشروع والمشاريع الأخرى؟

8. ثامنًا: كيف يختلف تعلمكم في هذه المساحة عن تعلمكم في الفصل الدراسي التقليدي؟ أين تتعلمون أكثر؟ و لماذا؟

Appendix D

الدليل للمُيّسرين لإجراء مقابلات مع المخبرين الرئيسيين
مقابلة المعلم/ مالك مساحة الصانع (Makerspace)

يُعتبر المستند التّالي دليلًا توجيهيًا للمُيّسرين خلال إجراء مقابلات مع المخبرين الرئيسيين. تدوم المناقشة من ساعةٍ إلى ساعة و15 دقيقة.

التّاريخ	
الموقع	
دور المخبر الرئيسي	
مدّة المقابلة	
استخدام أداة للتّسجيل	
اسم الميُّسر	
رمز المقابلة مع المخبر الرئيسيّ	

الشخص الذي يقوم بإجراء المقابلة: شكرا لك لتخصيصك الوقت للقائي/ للقائنا.

تهدف هذه المقابلة إلى جمع معلومات حول تجربتك مع مساحات الصانع أو مختبرات الابتكار وتصوراتك عنها. لذلك ، أنا أقدر/ نحن نقدر تغذيتك الراجعة الموضوعية لخدمة موثوقية بحثنا بشكل أفضل.

من الأفضل إجراء المقابلة في Makerspace إن أمكن.

نحن نجري هذه المقابلة معك لأننا ندرك أن مدرستك/مركزك يُشرك المتعلمين في مشاريع مبتكرة.

1. **أولًا: ما اسم هذه المساحة/المركز؟**

2. **ثانيًا: من فضلك، هل يمكن أن توصّف ما يلي حول هذه المساحة:**
   - أ. **نوع المشاريع التي يقوم المتعلمون بإكمالها.**
   - ب. **الأدوات التي يستخدمها المتعلمون لإكمال هذه المشاريع.**
   - ت. **الفئة العمرية للمتعلمين أو مستوى الصف.**

3. ثالثًا: ما هي التخصصات (الموضوعات) التي تستخدم هذه المساحة / المختبر؟ هل تعتقد أنه ينبغي أن تقتصر حصرا على فصول الكمبيوتر / التكنولوجيا؟ يرجى التوضيح). حثّ الشخص الذي تمت مقابلته لتوضيح هذه الفكرة).

4. رابعًا: هل المساحة / المختبر مرتبطة بمنهج محدد؟ إذا كانت الإجابة ب «نعم»، يرجى التوضيح. وإذا كانت الإجابة ب «لا»، فمن أين تأتي الأفكار والمشاريع في هذا المساحة / المختبر؟

5. خامسًا: هل يتم استخدام المساحة في أنشطة التعلم الرسمية والمنظمة بواسطة معلم؟ أم أنها غير رسمية، أكثر تعلمًا واستكشافًا وتوجيهًا للطلاب؟ أو متمازجة؟ يُرجى التوضيح.

6. سادسًا: صف تجربتين/ أو ثلاث تجارب ناجحة لمشاريع تعليمية . و ما الذي جعلها ناجحة؟

7. سابعًا: صف تجربتين أو ثلاث تجارب لم تكن ناجحة في هذه المساحة / المختبر. ولماذا لم تكن ناجحة ؟

8. ثامنًا: ما هي بعض التحديات التي تواجهها في هذه المساحة / المختبر يوميًا؟

9. تاسعًا: صف مساحة أو مختبرًا ابتكاريًا ناجحًا في مدرسة لبنانية أو في سياق لبناني.

10. عاشرًا: إذا كنت تنصح بتطوير مساحة أو مختبر للابتكار في مدرسة أو مركز ما، فما هي نقطة الانطلاق الجيدة؟ ما هي الخطوات التي تنصح بها؟

11. حادي عشر: صف رحلة تعلم لطالب في هذه المساحة / المختبر. ما هي مجموعات المهارات التي يبدأ المتعلمون بها؟ وما هي المهارات التي يطورونها خلال الجلسات؟ (حث الشخص الذي تتم المقابلة معه للتحدث قدر الإمكان عن المهارات).

12. ثاني عشر: أتعتقد أن هذه المساحة أثّرت على تعلم طلابك؟ كيف تقيّم تعلمهم؟

13. **ثالث عشر: منذ متى بدأت التدريس؟ وهل لاحظت أي اختلافات في كيفية تعلم طلابك في هذه المساحة مقابل الدروس التقليدية؟ كيف؟**

14. **رابع عشر: ما هي المهارات والدرجات التي يمتلكها الميسّر في المساحة الخاصة بك؟ هل ينسق مع المعلمين ذوي التخصصات الأخرى؟**

الشخص الذي يقوم بإجراء المقابلة: مرة أخرى ، شكرا لك على وقتك. لقد كانت هذه المقابلة غنية جدًا بالمعلومات.

Appendix E

Observation Checklist

1. ***Teacher/ Facilitator***

2. ***Subject(s):***

3. ***Observer:***

4. ***Session Title:***

5. ***School/Center/Club:***

6. ***Date of the Session:***

7. ***Time of the Session:***

8. ***Grade Level:***

9. ***No. of Students:***

Please rank the statements below based on your observation:

Not evident in the session or space	Somewhat evident during the session or in the space	Evident during the session or in the space	Extremely evident throughout the session
0	1	2	3

1. Physical Space	Scale 0	1	2	3
a. Desks and tables include large surfaces for working.				
b. Chair / Furniture is comfortable.				
c. Design of space is flexible.				
d. Separate areas for different kinds of activities are equipped as appropriate.				
e. Materials are easy to find (containers and tools are easy to find and clearly labeled).				
f. The space has adequate power supplies.				
g. The space has adequate internet access.				
h. The space has adequate and enough computers/tablets.				
i. The space has a printer.				
j. The space has a 3D printer.				
k. The space has a 3D scanner.				
l. The space has a laser cutting machine.				
m. The space has a sewing machine.				
n. The space has woodworking tools.				
o. The space has soldering equipment.				
p. The space has utility materials (utility scissors, glue gun, wire cutters, saw, vice, knife cutter, sandpaper block, cordless hand drill, etc.).				
q. The space has electronic materials.				
r. The space has video, sound & photography equipment (Cameras & Accessories, and Multimedia workstations with a variety of software).				
s. Space has arts & craft materials (Button Maker, Circuit, and miscellaneous craft materials and supplies).				
t. Space has cleaning supplies easily accessible for cleaning up.				
u. Space has an area to showcase and display student projects.				
v. Space has a projector/Interactive board/panel.				

Comments on Physical Space:

2. Safety	Scale 0	1	2	3
a. Enough space is provided for tools to be used safely.				
b. Pathways to tools, exits, and safety equipment are clear opportunities for student practice, as well as for new resources and technologies when appropriate and useful.				
c. The space is well lit and ventilated.				
d. The space is equipped with a first aid kit and a fire extinguisher.				
e. Safety rules are clearly displayed.				
f. Strict cleanup policy is enforced to keep the space free from clutter.				
g. Students have access to protective gears while working (Earmuffs, goggles, etc.).				
h. Space outlines safety procedures in the cases of injuries, fires, etc.				

Comments on Safety:

3. Real World Connections	Scale 0	1	2	3
a. Teacher/Facilitator situates learning in real-world contexts and connects Makerspace instruction to learners' lives and to the world beyond the classroom.				
b. Teacher/Facilitator uses materials based on the curriculum.				
c. Learners engage in authentic learning and/or evaluative tasks and articulate how the session is connected to their lived experiences and/or the world beyond the classroom.				

Comments Real World Connections:

4. Active Learning	Scale			
	0	1	2	3
a. Teacher/Facilitator ensures that all learners meaningfully participate in the session by employing effective questioning and discussion strategies.				
b. Teacher/Facilitator facilitates student learning by doing (with manipulatives, guided inquiry, technological tools and experiments).				
c. Teacher/Facilitator encourages learners to think for themselves, to make choices, to ask questions, and to take ownership of the learning process.				
d. Teacher/Facilitator demonstrates flexibility and responsiveness in meeting the learning needs of all learners in the 'real time' progression of the session.				
e. Teacher/Facilitator encourages learners to take initiatives and become innovators.				
f. Learners are responsible for their own self-directed learning.				
g. Learners are able to test a hypothesis and have the freedom to question why and try again (Learning how to fail and try again).				
h. Learners are focusing on ideas or problems and developing their problem-solving skills.				
i. Learners are encouraged to take initiatives and become innovators.				
j. Learners engage in constructing knowledge and communicating it to others (e.g., small group discussions, drawings, blog entries, think/pair/share, cooperative groups).				
k. Learners demonstrate their understanding through projects, reports, debates, presentations, and student exhibitions.				

Comments on Active Learning:

5. Critical and Creative Thinking	Scale 0	1	2	3
a. Teacher/Facilitator models critical and creative thinking, inquiry, and reflection for learners as important and explicit components of the learning process.				
b. Teacher/Facilitator creates a Makerspace environment that promotes risk-taking and inspires learners to develop original and unique ideas.				
c. Teacher/Facilitator asks open-ended questions that have no pr-eestablished answers, which enables learners to respond creatively.				
d. Learners raise questions, ask for clarification, or pose alternative possibilities about session/project content (to teacher or classmates).				
e. Learner participation and work demonstrate movement towards higher order or innovative thinking (e.g. taking positions, seeing point of view, recognizing patterns, comparing/contrasting and identifying biases).				

Comments on Critical and Creative Thinking:

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Preamble

Proceeding from its adoption of the Sustainable Development Goals of the 2030 Agenda, especially the fourth goal, which is "*to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*", and because the school is the institution capable of providing equal education opportunities for all, the Educational Center for Research and Development (CRDP) had to keep pace with the rapid development of technology. With this technological advancement, a group of economic and technological models and techniques - such as those of artificial intelligence represented by the Internet of Things - appeared. The robot has also become a part of the daily life of many institutions and companies.

Since the learner is the center of the teaching-learning process, it was necessary to find advanced educational systems that represent the modern global trends which focus on enhancing the 21st century skills among learners.

Hence, the need to create a space that allows a set of techniques, applications and modern technological methods arose in order to help learners present the best they have, not only within the school, but also outside it. Such methods enable learners to apply the knowledge and skills they have acquired in solving their life problems.

This space is known as MakerSpace, a term that was first used in 2005 to denote easy-to-reach places for the sake of exploring, learning how to use tools and materials, and developing creative projects. In this respect, this space represents a safe environment for self-learning and self-development while working on projects in teams. It is an essential place for technological experiments, for the development of models and ideas, and for problem solving. Besides, it is a means that would make it possible for schools to go back to constructive education; thus allowing students to be creative.

Because education is the best investment for the industrially and economically developed countries, global trends had to be adopted; taking into account the Lebanese reality and its needs while preserving the profile of the Lebanese Learner as well as the Lebanese identity.

Therefore, in order to achieve the general educational objectives of the Plan of Educational Development, this research was conducted to examine the Lebanese reality regarding how the MakerSpace can be invested in the teaching-learning process, whether in public and private schools and high schools or in clubs. More specifically, the study was conducted as phase one of the MakerSpace project which was designed in three phases and supervised and implemented by a committee assigned by CRDP. Based on the plan set by this committee for the MakerSpace, the study was carried out to benefit from the experiences of developed countries that had adopted this space as a part of their educational system. Thus, a team of researchers - accompanied by the committee- determined the specifications of the creative operator, the people responsible for its management, and the competencies and skills that it helps learners develop.

The study aimed at achieving those objectives concerned with technology, development, and fostering the creativity and critical thinking of the Lebanese learner who "works on developing his/her cultural and technological assets, refining his/her creative energies, and enhancing his aesthetic perceptions"; and the one who "is consciously and skillfully aware of the importance of using technology, developing it and dealing with it in terms of thought, performance, behavior and evaluation. In addition, the study came up with recommendations regarding the type of activities that can be implemented within this space and the way they can be integrated into the forthcoming curricula.

Accordingly, we present this research which includes MakerSpace frameworks, the educational impact, and models of projects that fall within this concept along with the tools that must be available. The research also specifies the profile of the educators of these creative spaces. In this respect, the study is considered comprehensive as it deals with the space in all its aspects. This in turn will help stakeholders to make the appropriate decision about adopting this new path in educational institutions.

In Education We Build Together Active and Interactive Generations

CRDP Acting President

Mr. George Nohra

“Makerspace” is a small word for a large universe where one can build his/her own creations

makerspace is giving learners a real chance to build and create their own knowledge and finding innovative ways to do it. As Piaget said “*learners are little scientists*” and if we don’t let them “do” they will never have the chance to achieve proper mind growth; a mindset that they need to acquire vital long-term skills that are strongly needed to improve and evolve intellectually and socially. Through this “learning-by-doing” process, learners will build the wisdom they need to thrive.

From small projects as simple as controlling a light, to very complex ones such as building a drone, Makerspace is the appropriate destination providing learners with enough space and suitable tools to design and execute their project. Small simple Makerspaces can be built with relatively low-cost materials while specialized evolved ones can become limited to big-budgets.

Creating a “Makerspace” is not an easy job and a diverse one that requires a set of tasks and skills. One would start from an idea to create a personalized or customized set of projects, calculate the cost (setup cost, operational cost, safety installations and kits, staff cost…), and choose the location according to the required space, up to determining the necessary required tools. One of the main purposes of the current volume is to help someone to determine the quality and quantity of tools needed for any customized Makerspace, based on the number of students or groups of students. Through the technical specifications of each tool, our team organized in this same table the required working area, the storage volume and extra installations requirements needed for some of the tools. While browsing through the pages of the tools’ table, one will notice the training/risk level suggested by our team, based on the probable injury that might yield from any misuse of each tool. Moreover, safety-related tools were also added to the table.

It is crucial to mention that all of tools cannot be limited to our team’s table, since every new day the world is witnessing newly created/manufactured ones on the markets. In our table we have elaborated the most important tools that are need for the creation of most of the present Makerspaces.

The following Guidelines is a map for the tools’ table/matrix that follows. It is quite important to read the guidelines carefully in order to use the data recommendations wisely, according to your customized needs, the Makerspace’s available budget and the desired projects that someone would like to create.

The Makerspace team created a matrix sheet that includes required tools allowing one to set up customized makerspaces. In the matrix, the tools were named, detailed with their specifications and categorized. Some tools are key elements to most of the makerspaces and thus tools' importance is designated with a scale ranging from 1 to 10 in the matrix. A few sets of tools, required for makerspaces are in both metric and imperial measurement scales. The recommended quantity of each tool is displayed in the matrix based on the maximal number of students in a classroom in public high schools in Lebanon *(30 students, 6 groups made out of 5 students each)*. This quantity also takes into consideration the frequency of use, the use duration and the price factor of each tool. The approximate average prices of the tools in international and local markets are also indicated in the matrix and they were found at different sellers and websites. It is important to mention that prices may vary from one seller to the other and they are also subject to time, quantity, specifications and quality of the tools. In addition to the latter, it is recommended to buy tools that need periodic and systematic maintenance with a maintenance contract. Electrical protection of instruments/tools and personnel safety are taken into consideration. First aid kits and fire protection elements are a must in makerspaces.

On the space management level, the total required storage volume, specified in the matrix, is a very important factor that allows one to provide makerspaces with appropriate storage utilities such as closets, cabinets, drawers and shelves.

On the safety level, makerspaces have a variety of low-tech and high-tech tools and equipment. Designated corresponding risk levels/training level ranging from 1 to 3 indicates the seriousness of the injuries that may result from a misuse of some tools. Thus, to use tools with training/risk level 3, the students must first complete the code of conduct and safety quiz and score 100% to pass. While tools of training/risk level 2 require the signature of a Makerspace User Agreement and to completion of a mandatory equipment usage/training and safety orientation. Tools of training/risk level 1 do not require any training or orientation.

This document represents a guideline for the tools' matrix sheet:

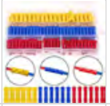
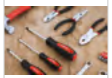
In the "color code" column, one can see the tools' category in which a tool has been classified using a color code:

- The first category (in green): these are reusable tools or the instruments which can be used multiple times.
- The second category (in blue): these are the consumable items that are intended to be used and need to be replaced.
- The third category (in purple): Important tools for the makerspace, the building should be equipped with.

A fourth category has been added (in brown) and that suggests a subdivision of the working place in sections according to multiple parameters. The presented area/volume numbers in this category have been increased by 25% in order to take into consideration pathways and storage.

1. **In the "#" column**, items/tools number.
2. **In the "Tools & Materials" column**, items/tools names.
3. **In the "Description" column**, instrument/tools' definition and function.
4. **In the "Figure" column**, figure of the instrument/tool.
5. **In the "Size/Specification" column**, technical specifications and type of each tool.
6. **In the "Importance" column**, importance of tools shown with a scale of 1 – 10. The number 10 of this scale is attributed to basic instruments and tools that every makerspace should include, while the number 1 is attributed for tools needed in full spectrum makerspaces or specialized ones.
7. **In the "Min Qty" columns**, recommended number of pieces or sets. For the highly recommended tools, of importance 10, one extra piece or set is added.
8. **In the "Estimated U. Price" column**, unit's price.
9. **In the "Estimated T. Price" column**, total cost based on the recommended quantity.
10. **In the "Required Working Area" column**, required installation and working area for some tools. This criterion is not applicable for most of the tools that must be stored on shelves, in cabinets and drawers.
11. **In the "Required Storage Volume" column**, required per-unit storage volume for most of the tools and consumables.
12. **In the "Required Storage Volume. Total" column**, required total storage volume for the entire quantity of each tool and consumable.
13. **In the "Extra Installations requirement column**, extra installation requirements needed for some tools.
14. **In the "Acquired Skills" column**, skills that a student is expected to acquire.
15. **In the "Required Training/Risk Level"**, risk level/training level associated with each tool.

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
ReusableToolsList															
	JOINING														
	1	**Staple Gun**	A staple gun or powered stapler is a hand-held machine used to drive heavy metal stapling into wood, plastic, or masonry. Staple guns are used for many different applications and to affix a variety of materials, including insulation, house wrap, roofing, wiring, carpeting, upholstery, and hobby and craft materials.		- Manual - 3/8" (10 mm)	10	7 pcs	18	126	N.A.	0.00050	0.0035	- Storage Cabinets, Drawers or Shelves	Stapling	3
	2	**Hot Glue Gun**	An electric gun-shaped device that heats up cylindrical canisters of glue, and ejects the hot glue when the trigger is squeezed.		- 220 VAC - 40W - dia: 11 mm	10	7 pcs	5	35	N.A.	0.00085	0.0059	- Storage Cabinets, Drawers or Shelves	Soldering / welding	3
	3	**Pop Hand Riveter**	Pop riveting is a technique that is used to join thin pieces of metal and it can also be used to join plastic sheet. The rivet has two parts; the pin and the rivet. The pop rivet pliers are used to pull the pin through the rivet and as this happens the rivet is deformed slightly so that it joins the metal or plastic pieces.		- Manual - 3 nosepieces: 1/8” 5/32” 3/16”	5	2 pcs	6	12	N.A.	0.00181	0.0036	- Storage Cabinets, Drawers or Shelves	Riveting	3
	4	**Big Sewing Needles**	A sewing needle, used for hand-sewing, is a long slender tool with a pointed tip at one end and a hole (or eye) at the other. Hand sewing needles come in a variety of types/ classes designed according to their intended use and in a variety of sizes within each type.		- Set include blunt needles: 3 x 5.2 cm Large-eye 3 x 6 cm Large-eye 3 x 7 cm Large-eye And 1 x Clear bottle	5	3 set	1	3	N.A.	0.00002	0.0001	- Storage Cabinets, Drawers or Shelves	Sewing by hand	2
	5	**Paint Brushes**	A paintbrush is a brush used to apply paint or sometimes ink. They are available in various sizes, shapes, and materials. Thicker ones are used for filling in, and thinner ones are used for details. They may be subdivided into decorators' brushes used for painting and decorating and artists' brushes use for visual art.		- 1”	8	6 pcs	3	18	N.A.	0.00011	0.0007	- Storage Cabinets, Drawers or Shelves	painting	1
	6				- 3”	5	6 pcs	5	30	N.A.	0.00045	0.0005	- Storage Cabinets, Drawers or Shelves	painting	1
	7	**Straight Pins**	Straight pin - pin consisting of a short straight stiff piece of wire with a pointed end; used to fasten pieces of cloth or paper together.		- 40 mm length - 50 pcs/Packet	8	2 Pkts	0.5	1	N.A.	0.00001	0.0000	- Storage Cabinets, Drawers or Shelves		2

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	8	**Splice Set**	Used when wires are joined inside an electrical outlet box, or inside a junction box where wires come together in an electrical appliance. It is the quickest and easiest of all splices to make, but it is never used where there may be stress or strain put on the connection later on.		- Set of 1200 pieces - Connectors: A.W.G22-16 A.W.G16-14 A.W.G12-10	6	1 set	15	15	N.A.	0.00252	0.0025	- Storage Cabinets, Drawers or Shelves		1
	9	**Tap And Die Metric**	Taps and dies are tools used to create screw threads, which is called threading. Many are cutting tools; others are forming tools. A tap is used to cut or form the female portion of the mating pair (e.g. a nut). A die is used to cut or form the male portion of the mating pair (e.g. a bolt).		- Metric - M3 to M12 - 40 pcs/set	5	2 set	25	50	N.A.	0.00217	0.0043	- Storage Cabinets, Drawers or Shelves		2
	10	**Tap And Die Sae**			- SAE - 1/8" to 1/2" - 40 pcs/set	5	1 set	30	30	N.A.	0.00217	0.0022	- Storage Cabinets, Drawers or Shelves		2
	MECHANICAL														
	11	**Screwdriver Set (Precision)**	A screwdriver is a tool, manual or powered, used for screwing (installing) and unscrewing (removing) screws. A typical simple screwdriver has a handle and a shaft, ending in a tip the user puts into the screw head before turning the handle. The shaft is usually made of tough steel to resist bending or twisting. Precision screwdriver is a screwdriver in which the top of the handle can rotate, so as to support the palm of the hand while two fingers control the rotation of the screw.		- 1.4 to 3 mm	10	6 set	2	12	N.A.	0.00029	0.0017	- Storage Cabinets, Drawers or Shelves		1
	12	**Screwdriver Set (Big)**			- 1/8" to 1/2" - Magnetic tip	10	6 set	5	30	N.A.	0.00150	0.0090	- Storage Cabinets, Drawers or Shelves		1
	13	**Hex Allen key Metric**	A hex key, Allen wrench or Allen key, is a simple tool used to drive bolts and screws with hexagonal sockets in their heads. The tool is usually formed of a single piece of hexagonal rod of hard steel, with blunt ends that are meant to fit snugly into the screw's socket, bent in an "L" shape with unequal arms. The tool is usually held and twisted by the long arm, creating a large torque at the tip of the short arm. Reversing the tool lets the long arm reach screws in hard-to-reach places.		- Ball Head - 1.5 to 10 mm	9	6 set	4	24	N.A.	0.00111	0.0067	- Storage Cabinets, Drawers or Shelves		1
	14	**Hex Allen key Sae**			- Ball Head - SAE 5/32" to 1/2"	9	1 set	4	4	N.A.	0.00111	0.0011	- Storage Cabinets, Drawers or Shelves		1

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty		Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	15	**Torx Allen Key**	Torx, developed in 1967 by Camcar Textron, is a trademarked type of screw drive characterized by a 6-point star-shaped pattern. A popular generic name for the drive is star, as in star screwdriver or star bits.		- 9 pcs/Set - T5 to T20	6	1	set	4	4	N.A.	0.00111	0.0011	- Storage Cabinets, Drawers or Shelves		1
	16	**Claw Hammer**	A claw hammer is a tool primarily used for driving nails into, or pulling nails from, some other object. Generally, a claw hammer is associated with woodworking but is not limited to use with wood products.		- 500 grs	10	7	pcs	5	35	N.A.	0.00177	0.0124	- Storage Cabinets, Drawers or Shelves		2
	17	**Rubber / Plastic Mallet (Hammer)**	A mallet is a kind of hammer, often made of rubber or sometimes wood, that is smaller than a maul or beetle, and usually has a relatively large head. Mallets are used in various industries, such as upholstery work, and a variety of other general purposes. It is a tool of preference for wood workers using chisels with plastic, metal, or wooden handles, as they give a softened strike with a positive drive.		- 340 grs	10	7	pcs	5	35	N.A.	0.00104	0.0073	- Storage Cabinets, Drawers or Shelves		2
	18	**Combination Wrench Metric**	A combination wrench is a double-ended tool with one end being like an open-end wrench or open-ended spanner, and the other end being like a box-end wrench or ring spanner. Both ends generally fit the same size of bolt.		- Metric 8 to 24 mm - 14 pcs/Set	10	3	set	30	90	N.A.	0.00441	0.0132	- Storage Cabinets, Drawers or Shelves		1
	19	**Combination Wrench SAE**	A combination wrench is a double-ended tool with one end being like an open-end wrench or open-ended spanner, and the other end being like a box-end wrench or ring spanner. Both ends generally fit the same size of bolt.		- SAE 1/4" to 7/16" - 11 pcs/Set	10	1	set	30	30	N.A.	0.00441	0.0044	- Storage Cabinets, Drawers or Shelves		1

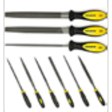
Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	20	**Ratchet Socket Set Metric**	A ratchet is a type of wrench (spanner in British English) that inserts into a socket to turn a fastener, typically in the form of a nut or bolt. A ratchet incorporates a reversible ratcheting mechanism which allows the user to pivot the tool back and forth to turn its socket instead of removing and repositioning a wrench to do so.		- 4 to 14 mm - 46 pcs/Set	8	2 set	20	40	N.A.	0.00051	0.0010	- Storage Cabinets, Drawers or Shelves		1
	21	**Ratchet Socket Set Metric**			- 10 to 24 mm - 12 pcs/Set	8	1 set	35	35	N.A.	0.00051	0.0005			1
	22	**Ratchet Socket Set SAE**			- 3/16" to 1 1/4"	8	1 set	30	30	N.A.	0.00051	0.0005			1
	23	**Joint Pliers (Channel Locks)**	Tongue-and-groove pliers are a type of slip-joint pliers. They are also known as water pump pliers, adjustable pliers, slippy pliers, groove-joint pliers, arc-joint pliers, Multi-Grips, tap or pipe spanners, gland pliers and Channellocks. They have serrated jaws generally set 45 to 60 degrees from the handles. The lower jaw can be moved to a number of positions by sliding along a tracking section under the upper jaw. An advantage of this design is that the pliers can adjust to a number of sizes without the distance in the handle growing wider.		- 8"	5	3 set	6	18	N.A.	0.00044	0.0013	- Storage Cabinets, Drawers or Shelves		2
	24				- 12"	5	1 set	8	8	N.A.	0.00079	0.0008	- Storage Cabinets, Drawers or Shelves		2
	25	**Miter Box**	A mitre box (US spelling, "miter box") is a wood working tool used to guide a hand saw to make precise mitre cuts in a board. The most common form of a mitre box is a 3-sided box which is open at the top and the ends. The box is made wide enough to accommodate the width of the boards to be cut. Slots are cut in the walls of the box at the precise angle at which the cut is to be made. These slots provide the guide for the saw to follow. Most commonly, the slots in the mitre box are cut at 45 degrees and 90 degrees.		- Fix angle with 22.5. 45 and 90 degrees. - Cutting Width 100 mm	5	6 pcs	15	90	N.A.	0.00228	0.0137	- Storage Cabinets, Drawers or Shelves - Air Handling Unit (HVAC) to prevent dust.	Wood-working	1
	26	**Pvc Pipe Cutter**	A pipecutter is a type of tool used by plumbers to cut pipe. Besides producing a clean cut, the tool is often a faster, cleaner, and more convenient way of cutting pipe than using a hacksaw, although this depends on the metal of the pipe.		- Max pipe diameter 1 5/8" (42 mm)	5	2 pcs	3	6	N.A.	0.00677	0.0135	- Storage Cabinets, Drawers or Shelves		3
	27	**Socket Set Metric**	Socket set is a set of one ratchet and metal tools of different sizes that fix onto the ratchet and are		- Metric - 41 Pcs/Set - 3/8" Ratchet size	8	2 set	10	20	N.A.	0.00152	0.0030	- Storage Cabinets,		1

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	28	**Socket Set SAE**	used to fasten and unfasten nuts on pieces of equipment		- SAE - 41 Pcs/Set - 3/8" Ratchet size	8	1 set	10	10	N.A.	0.00152	0.0015	Drawers or Shelves		1
	29	**Driver Bits**	Driver bits apply torque to screws. They are the interface that transfers torque from a tool, such as a screwdriver, t-handle, or drill, to the mating recess on top of a helically-threaded fastener.		- Features: Double Head - Material: Alloy Steel - Screw Head Size: 6.35mm - Screw Head Type: Slotted, HEX, Phillips - Package: 10Pcs - Magnetic: Yes	3	2 set	5	10	N.A.	0.00003	0.0001	- Storage Cabinets, Drawers or Shelves		1
	30	**Hollow-Shaft Nut Drivers Metric**	This Nut Driver is great for long bolts or threaded rod applications. The anti-slip rubber handle provides comfortable operation.		Rod Material: Chrome-vanadium Steel Handle Material: PP + TPR Screw Head Type: Hexagon Size: 3 to 14mm (Metric)	5	2 set	20	40	N.A.	0.00119	0.0024	- Storage Cabinets, Drawers or Shelves		1
	31	**Hollow-Shaft Nut Drivers SAE**			Rod Material: Chrome-vanadium Steel Handle Material: PP + TPR Screw Head Type: Hexagon Size: 3/16" to 1/2" (SAE)	5	1 set	20	20	N.A.	0.00119	0.0012			1
		Utilities													
	32	**Air Compressor**	An air compressor is a device that converts power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. The energy contained in the compressed air can be used for a variety of applications, such as pneumatic pistons in machines, pneumatic tools, spray guns,..		- Single Phase. - 220VAC. - Ultra Quite - 110 L/min. - 550W.	5	1 pcs	200	200	N.A.	N.A.	N.A.	- Electrical Power Sockets		3
	33	**Shop Vac**	A vacuum cleaner, also known simply as a vacuum, is a device that causes suction in order to remove debris from floors, upholstery, draperies and other surfaces. It is generally electrically driven.		- Wet and Dry - 20 Ltrs - Stainless Steel - Hepa Filter	10	1 pcs	250	250	0.23	N.A.	N.A.	- Cleaning Area		1

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty		Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	ELECTRONICS															
	34	**Microcontrollers: Arduino, Raspbery Pi, Adafruit, ESP8266 ....**	A microcontroller (MCU for microcontroller unit) is a small computer on a single metal-oxide-semiconductor (MOS) integrated circuit (IC) chip. In modern terminology, it is similar to, but less sophisticated than, a system on a chip (SoC); a SoC may include a microcontroller as one of its components. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. - Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. - ESP8266 is a wifi SOC (system on a chip) produced by Espressif Systems. It is an highly integrated chip designed to provide full internet connectivity in a small package.		- Package Included: (Scroll Down) 1 X Arduino UNO Board or ESP8266 1 X USB Cable 1 X Jump Cable 1 X Breadboard 5 X LED Light 1 Pack Resistor 1 X Female to male dupond line 1 X Potentiometer 1 X Buzzer 1 X 74HC595 1 X Infrared receiver 1 X LM35 1 X Flame Sensor 1 X Ball Switch 1 X Photoresistor 1 X Key button 1 X Remote control 1 X 4-digit display tube 1 X 8*8 Dot matrix module 1 X 1-digit display tube 1 X Stepper motor driver board 1 X Stepper motor 1 X 9g Servo 1 X IIC 1602 LCD 1 X XY joystick module 1 X Temperature module 1 X Water test module 1 X RFID Module 1 X RFID keychain 1 X RFID White card 1 X Sound Module 1 X Relay Module 1 X Clock Module 1 X 4*4 Key board 1 X RGB 3 color module 1 X 9V battery Snap	10	7	set	35	245	N.A.	0.00235	0.0164	- Storage Cabinets, Drawers or Shelves		2

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	35	**Soldering Iron (Automatic Stand)**	A soldering iron is a hand tool used in soldering. It supplies heat to melt solder so that it can flow into the joint between two workpieces. A soldering iron is composed of a heated metal tip and an insulated handle.		- Automatic stand - 220 VAC - 60 W	10	7 set	45	315	N.A.	0.00342	0.0240	- Air Handling Unit (HVAC) to prevent toxic smoke inhalation or Extractor Fan - Storage Cabinets, Drawers or Shelves		3
	36	**PCB Fuse Holder**	PCB mounts, or fuse holders, provide the installation hardware for a fuse. They are used in circuits to contain, protect and mount fuses.		- 5*20 mm - Set of 50 - 4A - 250V	10	1 set	10	10	N.A.	0.00004	0.0000	Storage Cabinets, Drawers or Shelves		
	37	**Soldering Tips**	Soldering iron tips are made of a copper core plated with iron. The copper is used for heat transfer and the iron plating is used for durability.		- Different shapes - Different Sizes - copper - 5 pcs/Set	5	3 set	2	6	N.A.	0.00000	0.0000	- Storage Cabinets, Drawers or Shelves		2
	38	**Crimper Tool**	A crimping tool is a device used to conjoin two pieces of metal by deforming one or both of them in a way that causes them to hold each other		Material: Carbon Steel crimping pliers wire 0.5-1.5 mm2 alicate AWG 20-15	6	3 pcs	8	24	N.A.	0.00179	0.0054	- Storage Cabinets, Drawers or Shelves		2
	39	**Wire Cutter**	Wire cutter is an edge tool used in cutting wire		Dimensions: 5.9 x 3.6 x 0.8 inches ; 0.64 ounces 2.5mm Hardened Carbon Steel	10	7 pcs	3	21	N.A.	0.00026	0.0018	- Storage Cabinets, Drawers or Shelves		2
	40	**Wire Stripper**	Wire Stripper,Wire Crimper And Multi-Function Hand Tool		Total Size (Locked): 7 x 2.1 x 0.5in 10-22 AWG	5	6 pcs	4	24	N.A.	0.00093	0.0056	- Storage Cabinets, Drawers or Shelves		2
	41	**Combination Plier**	Lineman's pliers, Kleins and combination pliers, or simply pliers are a type of pliers used by linemen, electrical contractors and other tradesmen primarily for gripping, twisting, bending and cutting wire, cable and small metalwork components. They owe their effectiveness to their plier design, which multiplies force through leverage. Lineman's pliers are distinguished by a flat gripping surface at their snub nose. Combination pliers have a shorter flat surface plus a concave / curved gripping surface which is useful in light engineering to work with metal bar, etc.		- 220 mm	10	7 pcs	8	56	N.A.	0.00036	0.0025	- Storage Cabinets, Drawers or Shelves		2

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty		Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	42	**Diagonal Cutter**	Edge are full cut and recommended for cutting, stripping copper and soft lead wires. Most-ideally work in precise circuit board. Smooth grip insulation with spring for long confortable work.		Material:Stainless Steel&PVC Type:Cutter Plier tool Length 140mm Cutting capacity Plastic, Copper wire,ect.	5	6	pcs	4	24	N.A.	0.00019	0.0012	- Storage Cabinets, Drawers or Shelves		2
	43	**Solder Sucker**	A desoldering pump, colloquially known as a solder sucker, is a manually-operated device which is used to remove solder from a printed circuit board. Most of it are plunger type which has a cylinder with a spring-loaded piston which is pushed down and locks into place. When triggered by pressing a button, the piston springs up, creating suction that sucks the solder off the soldered connection.		Item Weight 2.4 ounces Product Dimensions 7.5 x 0.8 x 0.8 inches Material metal, plastic	10	7	pcs	2	14	N.A.	0.00008	0.0006	- Storage Cabinets, Drawers or Shelves	Soldering / welding	2
	44	**Digital Multimeter AC/DC**	A multimeter is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance. A multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy.		- Digital Display - AC/DC Voltage - AC/DC Amperes - Continuity / Diodes / Resistors - Capacitors - Frequency	10	7	pcs	15	105	N.A.	0.00217	0.0152	- Storage Cabinets, Drawers or Shelves	Measuring / uisng instruments	2
	45	**Digital Thermo-hygrometer (Industrial)**	Digital thermo-hygrometer is temperature/humidity sensing instrument that is easily portable, have permanent probes, and a convenient digital display. It has an internal sensor for air temperature and humidity. PCE-444 is a combination digital hygrometer and digital thermometer used to measure air temperature, relative humidity, dew point temperature and wet bulb temperature.		- Digital Display - Temperature - Humidity	6	1	pcs	65	65	N.A.	0.00045	0.0005	- Storage Cabinets, Drawers or Shelves	Measuring / uisng instruments	2
	46	**Digital Air Flow Meter**	An air flow meter (also known as a mass air flow sensor) is a device that allows you to measure the rate of airflow. This means that an air meter measures the velocity of air. In addition to velocity, airflow meters have the ability to measure air pressure as well. Some airflow meters are even capable of detecting the direction of the wind.		- 0 to 40 m/s	6	1	pcs	20	20	N.A.	0.00046	0.0005	- Storage Cabinets, Drawers or Shelves	Measuring / uisng instruments	2

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	47	**Breadboard**	A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate		- 830 points	10	7 pcs	2.5	17.5	N.A.	0.00091	0.0064	- Storage Cabinets, Drawers or Shelves		1
	48	**Third Hand**	practical tool for soldering work, electronics and model making.		Magnification: 5X Material: Metal Color: Sliver Holders: 2 Alligator Clips mounted on a Cross-Arm Bar Rotation: 360 Degree Swivels Glass Lens Diameter: 2.36" /60mm Size: 154x100x125mm/6. 006x3.9x4.875in Weight: 298g/10.43oz	6	6 pcs	2	12	N.A.	0.00193	0.0116	- Storage Cabinets, Drawers or Shelves	Soldering / welding	1
	49	**Tweezers**	Tweezers are small tools used for picking up objects too small to be easily handled with the human fingers. The word is most likely derived from tongs, pincers, or scissors-like pliers used to grab or hold hot objects since the dawn of recorded history		stainless steel ,100mmx8mm	10	7 pcs	0.5	3.5	N.A.	0.00000	0.0000	- Storage Cabinets, Drawers or Shelves		2
	50	**Heat Gun**	A heat gun is a device used to emit a stream of hot air, usually at temperatures between 100 °C and 550 °C (200-1000 °F), with some hotter models running around 760 °C (1400 °F), which can be held by hand.		Dimensions 9.1 x 3.4 x 9.4 inches Material Reinforced PP Power Source AC 220V Maximum Power 1500 watts	10	2 pcs	20	40	N.A.	0.00461	0.0092	- Storage Cabinets, Drawers or Shelves		3
	CUTTING														
	51	**Hole Saw**	is a saw blade of annular shape, whose annular kerf creates a hole in the workpiece without having to cut up the core material. It is used in a drill.		Carbon steel Includes: 1-1/4-inch 1-1/2-inch 1-3/4-inch 2-inch	10	2 set	10	20	N.A.	0.00414	0.0083	- Storage Cabinets, Drawers or Shelves		3
	52	**Metal File**	tool of hardened steel in the form of a bar or rod with many small cutting edges raised on its longitudinal surfaces; it is used for smoothing or forming objects, especially of metal.		Material: metal Size: 3*140 Package Included: 6 pcs Needle Files	8	2 set	4	8	N.A.	0.00006	0.0001	- Storage Cabinets, Drawers or Shelves		3
	53	**Wood File**				8	2 set	4	8	N.A.	0.00006	0.0001			3
	54	**File Card**	A file card brush is used to clean a file to ensure longer life and efficiency.		any	5	2 pcs	6	12	N.A.	0.00264	0.0053	- Storage Cabinets, Drawers or Shelves		3

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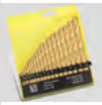
	55	**Chisel/Rasp Set**	A tool with a characteristically shaped cutting edge of blade on its end, for carving or cutting a hard material such as wood, stone, or metal by hand, struck with a mallet, or mechanical power.		1/2", 3/4", 1",	8	2	set	6	12	N.A.	0.00327	0.0065	- Storage Cabinets, Drawers or Shelves		3
	56	**Tin Snips**	It is a hand tool used to cut sheet metal and other tough webs. There are two broad categories: tinner's snips, which are similar to common scissors, and compound-action snips, which use a compound leverage handle system to increase the mechanical advantage.		Weight13.3 ounces MaterialMetal	8	2	pcs	8	16	N.A.	0.00110	0.0022	- Storage Cabinets, Drawers or Shelves	Cutting	3
	57	**Box Knives**	It is a small cutting tool that is designed for opening cardboard boxes and typically consists of a retractable razor blade in a thin metal or plastic sheath.		Stainless Steel Size18mm Heavy Duty Blade	10	7	pcs	2	14	N.A.	0.00049	0.0034	- Storage Cabinets, Drawers or Shelves	cutting	3
	58	**X-Acto Knife**	X-Acto is a brand name for a variety of cutting tools and office products owned by Elmer's Products, Inc. Cutting tools include hobby and utility knives, saws, carving tools and many small-scale precision knives used for crafts and other applications.		Matetial: Stainless steel Handle Length:12 cm Blade Size:37x8x0.4mm	10	7	pcs	2	14	N.A.	0.00002	0.0001	- Storage Cabinets, Drawers or Shelves	cutting	3
	59	**Scissors**	Scissors are hand-operated shearing tools. A pair of scissors consists of a pair of metal blades pivoted so that the sharpened edges slide against each other when the handles (bows) opposite to the pivot are closed. Scissors are used for cutting various thin materials, such as paper, cardboard, metal foil, cloth, rope, and wire.		Material: Stainless Steel Size: 9.5 Inch (242mm)	10	7	pcs	5	35	N.A.	0.00051	0.0035	- Storage Cabinets, Drawers or Shelves		3
	60	**Metal Drill Bits HSS**	Drill bits are cutting tools used to remove material to create holes, almost always of circular cross-section. Drill bits come in many sizes and shapes and can create different kinds of holes in many different materials. In order to create holes drill bits are usually attached to a drill, which powers them to cut through the workpiece, typically by rotation. The drill will grasp the upper end of a bit called the shank in the chuck.		- High speed steel drill bits for sheet iron, aluminum, copper, wood, plastic etc. - 1 to 10 mm - 19 pieces/set - Titanium coated	10	3	sets	15	45	N.A.	0.00036	0.0011	- Storage Cabinets, Drawers or Shelves		3

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	61	**Sanding Block**	A sanding block is a block used to hold sandpaper. In its simplest form, it is a block of wood or cork with one smooth flat side. The user wraps the sandpaper around the block, and holds it in place (by inserting a fitted piece of cardboard under the sandpaper, one can soften the impact on the wood and protect against tears or uneven wear on the sandpaper). Sanding blocks are helpful because they prevent the "waves" created by plain sandpaper.		- Material : Sponge - 4 pcs/set - Size for each: 98*68*25 mm + coarse (grade 60 to 80 Grit) + medium (grade 120 to 180 Grit) + fine (grade 240 to 320 Grit) + superfine (grade 400 to 600 Grit)	8	3	set	8	24	N.A.	0.00067	0.0020	- Storage Cabinets, Drawers or Shelves		2
	62	**Hacksaw**	A hacksaw is a fine-toothed saw, originally and mainly made for cutting metal. The equivalent saw for cutting wood is usually called bow saw. Most hacksaws are hand saws with a C-shaped walking frame that holds a blade under tension. Such hacksaws have a handle, usually a pistol grip, with pins for attaching a narrow disposable blade. The frames may also be adjustable to accommodate blades of different sizes. A screw or other mechanism is used to put the thin blade under tension.		Saw Blade Material:High-carbon steel Frame Material: Alloy Hacksaw Length: 255mm (10.03Inch) Hacksaw Height: 95mm(3.74 Inch)	10	6	pcs	15	90	N.A.	0.00168	0.0101	- Storage Cabinets, Drawers or Shelves		3
	63	**Wood-Saw**	A saw is a tool that's used to cut wood. It can be a hand tool or a power tool, and it usually has either a blade or a disk with a jagged cutting edge. The verb saw means to cut through wood or another material using a saw or other tool. In woodworking and carpentry, hand saws, also known as "panel saws", are used to cut pieces of wood into different shapes. This is usually done in order to join the pieces together and carve a wooden object.		15"(380mm) blade length and has 9 points per inch	10	6	pcs	10	60	N.A.	0.00136	0.0081	- Storage Cabinets, Drawers or Shelves	woodworking	3
	64	**U-shape Saw**	Saw blades can be cut: Mahogany, bamboo sticks, miscellaneous wood and other soft and hard wood, wood, horn, amber, seal stone, acrylic sheet (plexiglass), PPR tube, plastic, carbon steel, thin copper tube, aluminum and other metals		Material: Wood + Stainless Steel - Height: Approx. 110mm - Length: Approx. 250mm	10	6	pcs	10	60	N.A.	0.00138	0.0083	- Storage Cabinets, Drawers or Shelves		3

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	65	**Block Plane**	A block plane is a small metal-bodied woodworking hand plane which typically has the blade bedded at a lower angle than other planes, with the bevel up. It is designed to cut end grain and do touchup or finish work. It is typically small enough to be used with one hand.		Weight 250 gram Dimensions 16 x 7.5 x 4 cm Size 3-1/2" Material Die Cast Handle Material Die Cast Measurement System Metric	8	3	pcs	10	30	N.A.	0.00048	0.0014	- Storage Cabinets, Drawers or Shelves	woodworking	3
	66	**Deburring Tool**	A burr is a raised edge or small piece of material that remains attached to a workpiece after a modification process. It is usually an unwanted piece of material and is removed with a deburring tool in a process called 'deburring'. Burrs are most commonly created by machining operations, such as grinding, drilling, milling, engraving or turning.		- S10 Steel Blade - 148 mm	5	2	pcs	5	10	N.A.	0.00059	0.0012	- Storage Cabinets, Drawers or Shelves		3
	67	**Countersink**	A countersink is a conical hole cut into a manufactured object, or the cutter used to cut such a hole. A common use is to allow the head of a countersunk bolt, screw or rivet, when placed in the hole, to sit flush with or below the surface of the surrounding material.		High Quality M2 Steel Construction 7 single Flute and 90 Degree Point Angle 1/4" Shank Fits Most Common Power Drills Sizes Include: 3 to 10 mm	5	1	set	10	10	N.A.	0.00041	0.0004	- Storage Cabinets, Drawers or Shelves		3
	68	**Awl**	A handy tool for piercing holes for rivets, snaps, eyelets etc.		Material:Wooden handle,Steel awl Total length: 11cm Cone tip Dia. : appr. 0.1cm/0.04"	7	2	pcs	2	4	N.A.	0.00015	0.0003	- Storage Cabinets, Drawers or Shelves		3
	69	**Cutting Mat A2**	A cutting mat is a measurement tool used for sewing and crafts projects. Generally, cutting mats are a rectangular piece of durable material, such as vinyl or rubber. They are marked on one side with a grid guide of specific measurements, usually of one quarter to one inch (6.35 mm to 2.54 cm). A cutting mat is used both to protect the surface you are cutting on, and to provide measurement guidelines and references to ensure a clean and straight cut. It is useful in a variety of projects and is considered an essential for accuracy in many crafts.		Material: PVC Color: Green Item Size: 60 * 45 * 0.3cm Item Weight: 1175g	10	6	pcs	15	90	N.A.	0.00135	0.0081	- Storage Cabinets, Drawers or Shelves		1
	70	Cutting Mat A3			Material: PVC Color: Green Item Size: 45 * 30 * 0.3cm Item Weight: 550g	3	2	pcs	8	16	N.A.	0.00068	0.0014			1

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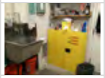
	BATTERIES / POWER														
	71	**9V Battery Clip**	This connector makes it so that anyone can easily connect their project to a battery with a standard +9v connector on it. If you enjoy breadboarding your circuits, these connectors are also very useful for connecting your battery pack power supplies to your prototyped circuits.		Material: Copper and Plastic Color: As picture shown Wire Length: Approx. 15cm Connector Length:2cm	5	6 pcs	0.2	1.2	N.A.	0.00000	0.0000	- Storage Cabinets, Drawers or Shelves		1
	72	**4 AA Battery Holder**	A battery holder is one or more compartments or chambers for holding a battery. For dry cells, the holder must also make electrical contact with the battery		Material : Plastic, Electric Part Dimension : 6.7 x 6.3 x 1.9cm (L*W*H); Cable Length : 14cm Battery Type : 4 x 1.5 V AA Plastic On/Off Switch Designed with a cap, and a on/off slide switch.	5	12 pcs	1.2	14.4	N.A.	0.00009	0.0011	- Storage Cabinets, Drawers or Shelves		1
	73	**3 Aa Battery Holder**	A battery holder is one or more compartments or chambers for holding a battery. For dry cells, the holder must also make electrical contact with the battery		Material: Hard plastic Battery type: 3 pcs AA Battery Case Holder AA Battery Holder Case with wire leads for soldering / connecting With ON/OFF switch Size: app.6.6 cmx4.7cmx1.8cm	8	12 pcs	1	12	N.A.	0.00002	0.0003	- Storage Cabinets, Drawers or Shelves		1
	74	**2 Aa Battery Holder**	A battery holder is one or more compartments or chambers for holding a battery. For dry cells, the holder must also make electrical contact with the battery		Material: plastic Color: black, as picture shows Wire Length: approx 14cm	10	12 pcs	0.85	10.2	N.A.	0.00001	0.0002	- Storage Cabinets, Drawers or Shelves		1
	75	**Alligator Clips**	A crocodile clip (also alligator clip) is a sprung metal clip with long, serrated jaws which is used for creating a temporary electrical connection. This simple mechanical device gets its name from the resemblance of its jaws to those of an alligator or crocodile. It is used to connect an electrical cable to a battery or some other component.		Alligator Wire SM Color 10pcs/set 50 cm	10	6 sets	3	18	N.A.	0.00171	0.0103	- Storage Cabinets, Drawers or Shelves		1
	STORAGE TOOLS														
	76	**Safety Cabinets**	Fire resistant safety cabinets to keep oil, flammable liquids, corrosives, pesticides and hazardous materials.		- Fire Resistant - 60x50x120 cm	10	1 pcs	250	250	0.69	N.A.	N.A.	- Store Room		1
	77	**Locker Cabinet**	A Locker Cabinet contains small, usually narrow storage compartments called Lockers. These lockers are commonly found in dedicated cabinets, very often in large numbers, in various public places such as locker rooms, workplaces, middle and high schools, transport hubs and the like.		- 66x185x52 cm - 4 cells each	10	8 set	250	2000	14.85	N.A.	N.A.	- Locker Room		1

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	POWER TOOLS														
	78	**Jigsaw (Electric)**	A jigsaw – which is also sometimes called a saber saw – is a versatile tool that allows you to cut curves and complex shapes out of a variety of materials including wood, ceramic tile, plastic laminate or metal.		Power: 800W Voltge: 220-240v, 50hz Max Cutting Angle: 45° Max.Cutting Thickness: Wood: 80mm Aluminum: 20mm Steel: 10mm	8	2 pcs	50	100	N.A.	0.00761	0.0152	- Storage Cabinets, Drawers or Shelves	using power machine	3
	79	**Sewing Machine**	A sewing machine is a machine used to stitch fabric and other materials together with thread.		12 stitches 1 four-step buttonhole 5-piece feed dog Maximum stitch length 4mm Maximum stitch width 5mm Push-pull bobbin winder Snap on presser feet Vertical oscillating hook bobbin	5	2 pcs	150	300	8.00	N.A.	N.A.	Area B	sewing	3
	80	**Cordless Power Drill**	A drill is a tool primarily used for making round holes or driving fasteners. It is fitted with a bit, either a drill or driver, depending on application, secured by a chuck. Some powered drills also include a hammer function.		Battery Powered Lithium ion Voltage 20 volts Wattage 1500 watts Torque 115 in-lb Speed 650 RPM	10	6 pcs	60	360	N.A.	0.00832	0.0499	- Storage Cabinets, Drawers or Shelves	using power machine	3
	81	**Extension Cord**	An extension cord, power extender, drop cord, or extension lead is a length of flexible electrical power cable (flex) with a plug on one end and one or more sockets on the other end (usually of the same type as the plug).		- Universal Socket - 10A - 4 Gang - 3 m	10	7 pcs	7	49	N.A.	0.00202	0.0141	- Storage Cabinets, Drawers or Shelves		1
	82	**Dremel**	The concept of the original Dremel Moto-Tool was to rotate a bit at high speed, the bit being held in a collet. Variable-speed versions may cover a range of 3,000–37,000 RPM. The Dremel concept relies on high speed as opposed to the high torque of a conventional power drill. By inserting an appropriate bit (or burr) the tool can perform drilling, grinding, sharpening, cutting, cleaning, polishing, sanding, routing, carving, and engraving.		Metal, Stone, Plastic, Sand Paper, HSS Multi purpose, Universal fitment, Multi function Scrolling, Circular, Cylindrical, Cone, Cup, Pen, Wheel, Needle 220 volts AC 1.3 A 130 watts Installation Method Strut-Mounted Handle Material Nail, Bone, Plastic, Antler, Glass, Tile, Gourd	8	2 Set	50	100	N.A.	0.00606	0.0121	- Storage Cabinets, Drawers or Shelves	using power machine	3
	EXTENSION														

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	83	**3D Printer**	3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object. 3D printing is the opposite of subtractive manufacturing which is cutting out / hollowing out a piece of metal or plastic with for instance a milling machine. 3D printing enables you to produce complex shapes using less material than traditional manufacturing methods.		Spare Parts for 2 years Maintenance Contract Build Size Medium: 140 x 150 x 140 mm Enclosed Air Filter Assisted levelling Materials PLA Printing Bed Flex Board USB / Wifi Touchscreen Built In Camera	10	3 pcs	500	1500	9.00	N.A.	N.A.	- Ventilation is an important engineering control to help control/reduce emissions from 3D printers - HVAC - Separation - Area B - UPS		3
	84	**Cnc Mill**	CNC milling, or computer numerical control milling, is a machining process which employs computerized controls and rotating multi-point cutting tools to progressively remove material from the workpiece and produce a custom-designed part or product		Spare Parts for 2 years Maintenance Contract 3 AXIS ENGRAVER metallic & non-metallic 1.5KW water-cooled VFD Parameters: X, Y, Z Working Area: 600(Y)*390 (X)*120(Z)mm Lathe structure: 6061/6063 Aluminium alloy Max. Feeding height: ≤100mm.	8	2 pcs	1500	3000	10.00	N.A.	N.A.	- Area B - UPS		3
	85	**Laser Cutting machine**	Laser Cutting is a non-contact process which utilizes a laser to cut materials, resulting in high quality, dimensionally accurate cuts. The process works by directing the laser beam through a nozzle to the workpiece. A combination of heat and pressure creates the cutting action		Spare Parts for 2 years Maintenance Contract Working area 600mmx400mm Engraving Speed 500mm/s Cutting speed 50mm/s Laser Power 100W Laser Type Sealed CO2laser tube Cooling Type Water cooling protection system Water Protection Position Way Red light positioning Locating Precision ≤0.01mm Work Platform Fixed/Honeycomb/Lift platform Lift Range Electric adjustment 300mm AC220V/110V 50HZ Compatible Software Coreldraw	8	2 pcs	2000	4000	10.00	N.A.	N.A.	- Water Supply - Area B - UPS		3

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	86	**Circular Saw**	A circular saw is a power-saw using a toothed or abrasive disc or blade to cut different materials using a rotary motion spinning around an arbor. A hole saw and ring saw also use a rotary motion but are different from a circular saw. Circular saws may also be loosely used for the blade itself.		220 volts AC 2.50 HP Speed 5300 RPM Included Components Circular Saw, 24-Tooth Carbide Blade	5	2 pcs	45	90	N.A.	0.01816	0.0363	- Storage Cabinets, Drawers or Shelves	using power machine	3
	87	**Angle Grinder Tool**	known as a side grinder or disc grinder, is a handheld power tool used for grinding and polishing. Although developed originally as tools for rigid abrasive discs, the availability of an interchangeable power source has encouraged their use with a wide variety of cutters and attachments		Voltage 220 volts	9	2 pcs	40	80	N.A.	0.00492	0.0098	- Storage Cabinets, Drawers or Shelves		3
	88	**Orbital Sander**	Orbital sander is a hand-held sander that vibrates in small circles, or "orbits." The sanding disk spinning while moving simultaneously in small ellipses causes the orbital action that it is known for. Mostly used for fine sanding or where little material needs to be removed		5-Inch Power SourceCorded Electric Voltage220 volts Included Components (1) Sanding Sheet(1) Dust Bag	5	1 pcs	35	35	N.A.	0.00341	0.0034	- Storage Cabinets, Drawers or Shelves	using power machine	3
	89	**table saw**	A table saw (also known as a sawbench or bench saw in England) is a woodworking tool, consisting of a circular saw blade, mounted on an arbor, that is driven by an electric motor (either directly, by belt, or by gears). ... Some earlier saws angled the table to control the cut angle.		aluminum and iron Electric Powered Speed 4800 RPM 1x Saw blades 1x Miter Gauge 1x Push Bar 1x parallel guide 1x Protection Guard	8	1 pcs	300	300	5.00	N.A.	N.A.	- Area C	using power machine	3
	90	**Stand Drilling Machine**	It is a free standing Drilling Machine and is of a far heavier construction able to take larger drills. It has a heavy frame to support a wider range of work. The table height is adjustable and power speed and feeds are available.		220VAC - 250 (350) W Drilling diameter: 1.5-13mm Spindle stroke: 50mm / 2in Spindle speed: 5r/min No-load speed: 1400r/min Swivel radius of worktable: 104mm / 4.1in Table size: 160 * 160mm / 6.3 * 6.3in Base size: 290 * 160mm / 11.4 * 6.3in Maximum distance between spindle end and working table: 210mm Maximum distance between spindle end and base surface: 300mm Column diameter: 46mm / 1.8in	10	1 pcs	250	250	5.00	N.A.	N.A.	- Area C	using power machine	3

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	91	**Mini Lathe Machine**	The 8-in-1 set can assemble 8 different functions of machine tools (wire sawing machines, wood lathes, metal lathes, milling machines, drilling machines, sanders, hand-held machines, indexing drills), machines that can only use one of the functions at a time		8 in 1 Mini Lathe Motor Speed: 20000 rpm Input voltage / current / power: 12VDC / 2A / 24W Switching power supply input voltage: 110V-240V Wire saw table work area: Approx. 90 * 90mm / 3.5 * 3.5 in Maximum diameter of wood lathe processing materials: 50mm, the lathe can be expanded to 100mm Metal lathe and wood lathe processing material length: Approx. 135mm / 5.3in Slider stroke: X-shaft 145, Y-shaft 32, Z-shaft 32 Chuck: 1-6mm Drilling machine table area: Approx. 123 * 100mm / 4.8 * 3.9in The maximum clamping size of the vise: Approx. 50mm / 2in The maximum diameter of the three-jaw chuck that can hold the workpiece: Approx. 50mm / 2in Center height of metal lathe: Approx. 25mm / 1in	8	1	pcs	300	300	5.00	N.A.	N.A.	- Area C		3
	92	**Hot Wire Foam Cutter**	A Hot Wire Foam Cutter is a electrical tool used to cut polystyrene (EPS, XPS) foams and similar materials. The device consists of a thin, taut cutting wire, often made of NiChrome, Titanium, Stainless steel, or a thicker wire preformed into a desired shape, which is heated via electrical resistance to appr. 500°C.		Bow tip: 15cm Straight tip: 13.5cm 12V DC 24W Temp. Adjustment: 30-350℃ Suitable for: Foam cutting, sponge cutting, pearl cotton cutting, punching and slotting	8	3	set	30	90	N.A.	0.00300	0.0090	- Storage Cabinets, Drawers or Shelves		3
	93	**Plastic Bender**	Plastic bender uses heat and little pressure to bend plastic		Thermoforming (Infrared Heating) 220V/110V 800W Temperature range: 0-600 ° adjustable Applicable thickness: 0.1-10mm Applicable length: ≤ 650mm	5	1	pcs	300	300	1.00	N.A.	N.A.	- Area A		3
		ETC														

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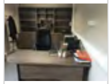
	94	**Workbench**	Workbenches are sturdy tables at which manual work is done. They range from simple flat surfaces to very complex designs that may be considered tools in themselves. Workbenches vary in size from tiny jewellers benches to the huge benches used by staircase makers. Workbenches are made from many different materials including metal, wood, stone, and composites depending on the needs of the work.		- 1600*1600*800 mm - Fire resistant - Water resistant - 6 drawers 800*350*100 mm - Two cabinets 400*350*700 mm	10	6	set	1000	6000	96.00	N.A.	N.A.	- Area A		1
	95	**Stool**	A stool is one of the earliest forms of seat furniture. It bears many similarities to a chair. It consists of a single seat, for one person, without back or armrests, on a base of either two, three or four legs. A stool is generally distinguished from chairs by their lack of arms and a back.		- 40x30x65 cm	10	30	pcs	35	1050	N.A.	N.A.	N.A.	- Area A		1
	96	**Desk**	A desk or bureau is a piece of furniture with a flat table-style work surface used in a school, office, home or the like for academic, professional or domestic activities such as reading, writing, or using equipment such as a computer. Desks often have one or more drawers, compartments, or pigeonholes to store items such as office supplies and papers. Desks are usually made of wood or metal, although materials such as glass are sometimes seen.		- 2200*1000*800 mm - Water resistant - 3 drawers 800*800*200 mm	10	1	set	600	600	12.00	N.A.	N.A.	- Office		1
	97	**Desk chair**	- An office chair, or desk chair, is a type of chair that is designed for use at a desk in an office. It is usually a swivel chair, with a set of wheels for mobility and adjustable height.		- 70x50x110	10	3	pcs	65	195	N.A.	N.A.	N.A.	- Office		1
	98	**Office Cabinet**	A cabinet is a box-shaped piece of furniture with doors and/or drawers for storing miscellaneous items. Some cabinets stand alone while others are built in to a wall or are attached to it like a medicine cabinet. Cabinets are typically made of wood (solid or with veneers or artificial surfaces), coated steel (common for medicine cabinets), or synthetic materials.		- 220x180x50 cm	10	1	pcs	300	300	N.A.	N.A.	N.A.	- Office		1
	99	**Whiteboard**	A whiteboard is a glossy, usually white surface for making nonpermanent markings (an evolved version of the blackboard). Whiteboards are analogous to blackboards, but with a smoother surface allowing rapid marking and erasing of markings on their surface.		- 1800*1200 mm - Mobile - Double Sided - Magnetic	3	6	pcs	200	1200	5.40	N.A.	N.A.	- Area A		1

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	100	**Interactive Board**	An interactive whiteboard (IWB) also commonly known as Interactive board or Smart boards is a large interactive display in the form factor of a whiteboard. It can either be a standalone touchscreen computer used independently to perform tasks and operations, or a connectable apparatus used as a touchpad to control computers from a projector. They are used in a variety of settings, including classrooms at all levels of education, in corporate board rooms and work groups, in training rooms for professional sports coaching, in broadcasting studios, and others.	 	-Size 77"	10	1 set	800	800	1.25	N.A.	N.A.	- UPS for Electrical protection - Area A		2
	101	**Projector & Screen**	A projector is an output device that can take video or images generated by a computer or Blu-ray player and reproduce them by projection onto a screen, wall, or another surface. In most cases, the surface projected onto is large, flat, and lightly colored.		-Size 100"	10	1 set	450	450	1.25	N.A.	N.A.	- UPS for Electrical protection - Area A		2
	102	**Laptop**	A laptop (also laptop computer), often called a notebook, is a small, portable personal computer (PC) with a "clamshell" form factor, typically having a thin LCD or LED computer screen mounted on the inside of the upper lid of the clamshell and an alphanumeric keyboard on the inside of the lower lid. The clamshell is opened up to use the computer. Laptops are folded shut for transportation, and thus are suitable for mobile use.		- CPU: 10th-generation Intel Core i5 – i7 - Intel Iris Plus Graphics - RAM: 8GB - Screen: 15.6" FHD (1920 x 1080) IPS BrightView micro-edge WLED-backlit multitouch – 13.3" diagonal 4K (3840 x 2160) UWVA BrightView micro-edge AMOLED multitouch - Storage: 500GB SSD	10	7 pcs	750	5250	N.A.	0.01500	0.1050	- Storage Cabinets, Drawers or Shelves		2
	FIXTURING														
	103	**Vice**	A machine vice is a clamping device used to hold a workpiece securely when operating a machine tool, such as a drill press or milling machine. It differs from metalworking and woodworking vices as it is mounted to the table of a machine tool instead of a workbench		Model: 4 Inch Vice Jaw Width:80mm Jaw Opening: 100mm Jaw Height:50 Replaceable hardened tool steel jaw faces Durable 360 degree swivel base has bolt lugs for easy mounting on a machine table Two large anvil work surfaces Two lock down bolts are furnished to ensure stability	10	6 pcs	30	180	N.A.	0.00507	0.0304	- Storage Cabinets, Drawers or Shelves		2
	104	**C-Clamps**	A C-clamp is a type of clamp device typically used to hold a wood or metal workpiece, and often used in, but are not limited to, carpentry and welding		pack of 12 C Clamp 2-inch	8	2 set	50	100	N.A.	0.00011	0.0002	- Storage Cabinets, Drawers or Shelves		2

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	105	**Bar Clamps**	A bar clamp features a long, metal bar and is designed to withstand the pressure of holding large and heavy workpieces. ... The length of the bar means the clamp can easily hold long or wide workpieces in its jaws. Bar clamps are usually used in pairs.		Material: Aluminum Alloy + Rubber Handle Size: 560x123mm	6	12	pcs	15	180	N.A.	0.00884	0.1061	- Storage Cabinets, Drawers or Shelves		2
	106	**Needlenose**	Needlenose are pliers with long slender jaws used for grasping small or thin objects.		8 Inch Material: Stainless steel (Cadmium Free) With Spring	10	7	pcs	10	70	N.A.	0.00039	0.0027	- Storage Cabinets, Drawers or Shelves		2
	107	**Locking Pliers**	Locking pliers (or Vise-Grips or a Mole wrench or a vice grip) are pliers that can be locked into position, using an over-center toggle action.		Length: Approx. 10" Straight jaw locking plier wraps Screw adjusts jaw pressure Quick release	8	6	pcs	10	60	N.A.	0.00033	0.0020	- Storage Cabinets, Drawers or Shelves		2
	108	**adjustable wrench**	An adjustable wrench, also called an adjustable spanner or an adjustable crescent is a tool, which can be used to loosen or tighten a nut or bolt. It has a "jaw" (the part where the nut or bolt fits), which is of adjustable size. This will open and closes the jaw of the wrench.		Length: 8'' Straight jaw	6	3	pcs	10	30	N.A.	0.00036	0.0011	- Storage Cabinets, Drawers or Shelves		2
	109	**Wrench**	A wrench or spanner is a tool used to provide grip and mechanical advantage in applying torque to turn objects—usually rotary fasteners, such as nuts and bolts—or keep them from turning		Length 24 inch Pipe Capacity 3 inch Use All types of pipe work Jaw Type Full-floating forged hook jaw with self-cleaning threads	6	3	pcs	15	45	N.A.	0.00446	0.0134	- Storage Cabinets, Drawers or Shelves		2
	110	**Binder Clips**	A binder clip is a strip of spring steel bent into the shape of an isosceles triangle with loops at the apex. Tension along the base of the triangle forces the two sides closed, and the loops prevent the sharp steel edges from cutting into the paper.		200 pcs ASSORTED SIZES CLIPS : 2.4 inch , 2 inch , 1.6 inch , 1.25 inches, 1 inch, 0.75 inch, 0.6 inch	8	1	set	20	20	N.A.	0.00166	0.0017	- Storage Cabinets, Drawers or Shelves		2
		TEXTILE/SOFT CIRCUIT														
	111	**Fabric Scissors**	Fabric scissors or fabric shears as they are more commonly referred to are the main tool used for cutting out your fabric. ... Heavy fabrics such as leather and denim are easier to cut using shears that have longer handles or sharper blades.		Material: Stainless Steel Size: 7 Inch	8	6	pcs	5	30	N.A.	0.00005	0.0003	- Storage Cabinets, Drawers or Shelves		2
	112	**Pinking Shears**	Pinking shears are scissors, the blades of which are sawtoothed instead of straight. They leave a zigzag pattern instead of a straight edge. ... Pinking shears have a utilitarian function for cutting woven cloth. Cloth edges that are unfinished will easily fray, the weave becoming undone and threads pulling out easily.		Meterial : ABS handle & Stainless steel Distance between the teeth for about 5 mm wide	6	2	pcs	7	14	N.A.	0.00027	0.0005	- Storage Cabinets, Drawers or Shelves		2

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	113	**Seam Ripper**	A seam ripper is a small sewing tool used for cutting and removing stitches. The most common form consists of a handle, shaft and head. The head is usually forked with a cutting surface situated at the base of the fork. ... Once the seam has been undone in this way the loose ends can be removed and the seam resewn		4Pcs/Set Plastic Handle Craft Thread Cutter Material: Steel and plastic Metal Part Length: Approx. 3cm/1.2" Total Length: Approx. 8.5cm/3.3"	6	2	set	1	2	N.A.	0.00004	0.0001	- Storage Cabinets, Drawers or Shelves		3
	114	**Cloth Tape Measure**	A tape measure or measuring tape is a flexible ruler used to measure size or distance. It consists of a ribbon of cloth, plastic, fibre glass, or metal strip with linear-measurement markings. It is a common measuring tool.		60-inch (150cm), flexible and durable vinyl tape measure	10	7	pcs	1	7	N.A.	0.00004	0.0003	- Storage Cabinets, Drawers or Shelves		1
	115	**Iron**	A clothes iron is a household appliance used to press the wrinkles out of and creases into clothes. When the iron is turned on, the consumer moves it over an item of clothing on an ironing board. The combination of heat and pressure removes wrinkles		Stainless Steel Soleplate High Steam Rate Variable Temperature and Steam Controls – Volts : 220V. Wattage : 1500W Automatic Shutoff	8	2	pcs	60	120	N.A.	0.00650	0.0130	- Storage Cabinets, Drawers or Shelves		3
	116	**Embroidery Needles**	There are several commonly used embroidery needles. Embroidery (or "crewel") needles have sharp points and slightly elongated eyes. ... They're used for counted work, drawn thread work, canvas work, or other types of needlework in which the point of the needle is not meant to pierce the fabric threads.		30pcs Cross Stitch Needles Craft embroidery Tool Large Eye Sewing Needles Hand Sewing Needle	8	1	set	2	2	N.A.	0.00000	0.0000	- Storage Cabinets, Drawers or Shelves		2
	117	**Snap Setter**	A snap fastener (also called press stud, popper, snap or tich) is a pair of interlocking discs, made out of a metal or plastic, commonly used in place of traditional buttons to fasten clothing and for similar purposes. A circular lip under one disc fits into a groove on the top of the other, holding them fast until a certain amount of force is applied.		Hole punching(4.5mm diameter) and Eyelet setting (4.5mm diameter) With ruler for precisely punching hole Length: 160mm(6")	7	2	pcs	4	8	N.A.	0.00045	0.0009	- Storage Cabinets, Drawers or Shelves		2
		Signage														
	118	Guiding arrows for First Aid kit	First aid station signs point the way to workers, staff and other external helpers. They also remind the entire facility that safety comes first. These signs can prevent confusion and save minutes when it comes to providing medical care, which may in turn save lives.		- 20x20 cm	10	3	pcs	5	15	N.A.	N.A.	N.A.	- Wall Mounted		1

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	119	Guiding arrows for fire extinguishers	Fire Extinguisher Signs are used to help identify the location of a single or multiple fire extinguishers. They are generally mounted 2 metres above floor level for visibility or adjacent to the fire extinguisher.		- 20x20 cm	10	4	pcs	5	20	N.A.	N.A.	N.A.	- Wall Mounted		1

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	Cleaning															
	120	**Automatic Soap / Sanitizer Dispenser**	Automatic soap dispenser is a device which dispense a controlled amount of soap solution (or a similar liquid such as a hand sanitizer). They are often used in conjunction with automatic faucets in public restrooms. They function to conserve the amount of soap used and stem infectious disease transmission.		- 600 / 1000 ml capacity - Sensor - Soap / Sanitizer	10	4	pcs	130	520	N.A.	N.A.	N.A.	- Cleaning Area		1
	121	**Trash Can**	A waste container is a container for temporarily storing waste, and is usually made out of metal or plastic. Some common terms are dustbin, garbage can, and trash can.		Package Includes: 30 x Trash bag - 240 L - 98x56x75 cm	10	5	Packs	60	300	N.A.	N.A.	N.A.	- Area A - Area B - Area C		1
	122	**Broom**	A broom is a cleaning tool consisting of usually stiff fibers (often made of materials such as plastic, hair, or corn husks) attached to, and roughly parallel to, a cylindrical handle, the broomstick. It is thus a variety of brush with a long handle. It is commonly used in combination with a dustpan.		- 32*6.9*150 cm	10	6	pcs	6	36	0.13	N.A.	N.A.	- Cleaning Area		1
	123	**Dust Pan**	A dustpan is a cleaning utensil. The dustpan is commonly used in combination with a broom or long brush. The small dustpan may appear to be a type of flat scoop. Though often hand-held for home use, industrial and commercial enterprises use a hinged variety on the end of a stick to allow the user to stand instead of stoop while using it.		-114.3 x 35.6 x 12.7 cm	10	6	pcs	15	90	0.27	N.A.	N.A.	- Cleaning Area		1

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		Consumable materialslist														
		TAPE/ADHESIVES														
	124	**Wood Glue**	Wood glue is an adhesive used to tightly bond pieces of wood together. Many substances have been used as glues		water based adhesive 500gram	6	3	pcs	4	12	N.A.	0.00125	0.0038	Storage Cabinets, Drawers or Shelves		1
	125	**White Glue**	Polyvinyl Acetate (PVA) glue, more commonly referred to as white glue, or all-purpose glue, is perhaps the most used and beloved glue of kids, crafters, makers, and pros. This glue dries clear, is somewhat flexible, and can be bonded to just about any surface.		1 liter	10	3	pcs	4	12	N.A.	0.00250	0.0075	Storage Cabinets, Drawers or Shelves		1
	126	**Epoxy**	Epoxy is a very strong type of glue. Epoxy is used in the construction of airplanes and cars, among other things. While epoxy can be used for a variety of substances made of a certain chemical compound, from paints to plastics, it most commonly means an industrial-strength adhesive.		Size30ml Included ComponentsPC Products PC-Clear Epoxy Adhesive Liquid, Double Syringe	8	3	pcs	3	9	N.A.	0.00008	0.0002	Storage Cabinets, Drawers or Shelves		2
	127	**Hot Glue Sticks**	Also known as Hot melt adhesive (HMA), is a form of thermoplastic adhesive that is commonly sold as solid cylindrical sticks of various diameters.		100pcs/set 11mm diameter 200mm length	10	2	set	20	40	N.A.	0.00002	0.0000	Storage Cabinets, Drawers or Shelves		1
	128	**Super Glue (Ca) Medium +**	MULTI-PURPOSE" ARTS, CRAFT & HOBBY ADHESIVE: Great for gluing RC car tires, acrylic nails, model airplanes, wooden instruments, wood turning finish, pen making, lapidary applications to treat cracked stones, and bonding close-fitting parts		- 50 ml	8	24	pcs	5	120	N.A.	0.00000	0.0000	Storage Cabinets, Drawers or Shelves		2
	129	**Debond**	Debonder will soften cured CA. If parts are bonded incorrectly or your fingers are stuck together, a few drops of will dissolve the CA in about a minute		20g Liquid Super Glue Debonder	8	24	pcs	2	48	N.A.	0.00000	0.0000	Storage Cabinets, Drawers or Shelves		1
	130	**Ca Glue Thin**	Great for woodturning finish, pen making, hobby, fossil prep, inlays, hardening, stabilizing, and bonding close-fitting parts. Penetrates the finest micro-fractures, pores, and cracks through capillary action		Super Fast Thin, Premium Instant CA (Cyanoacrylate Adhesive) Super Glue Plus Extra Cap and Microtips, 60ml.	8	24	pcs	10	240	N.A.	0.00015	0.0036	Storage Cabinets, Drawers or Shelves		2
	131	**Spray Adhesive**	adhesive for professional artists and designers, most likely due to its adaptability. Spray mount is repositionable until dry – allowing for layout changes to be made and mistakes to be corrected a long time after the glue has been applied		General Purpose 45 Spray Adhesive, 300ml	8	12	pcs	5	60	N.A.	0.00075	0.0090	Storage Cabinets, Drawers or Shelves		2

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty	Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	132	**Pvc Cement**	Polyvinyl chloride (PVC) comes in two basic forms: - rigid (sometimes abbreviated as RPVC) and flexible. The rigid form of PVC is used in construction for pipe and in profile applications such as doors and windows. It is also used in making bottles, non-food packaging, food-covering sheets, and cards (such as bank or membership cards). - It can be made softer and more flexible by the addition of plasticizers, the most widely used being phthalates. In this form, it is also used in plumbing, electrical cable insulation, imitation leather, flooring, signage, phonograph records, inflatable products, and many applications where it replaces rubber. With cotton or linen, it is used in the production of canvas.		- 236 ml/Tin	7	6 Tins	5	30	N.A.	0.00060	0.0036	Storage Cabinets, Drawers or Shelves		2
	TAPE/ADHESIVES														
	133	**Packing Tape**	Parcel tape, colloquially box tape or packing tape, is a simple, medium-strength tape designed for sealing corrugated fiberboard seams. It is widely used in package delivery and mail services, as well as general sealing and enclosing.		- 72Rolls/Box - 4.8cm width - 66m length - Polypropylene or Polyester		1 Box	30	30	N.A.	0.03960	0.0396	Storage Cabinets, Drawers or Shelves		1
	134	**Paper Kraft Tape 2”**	Kraft paper tapes have a natural rubber based adhesive system that makes an excellent bond to most packing products and surfaces. Its tough backing remains strong under moist conditions, and outdoor weathering is good.		- 72Rolls/Box - 4.8cm width - 50m length - Paper		1 Box	30	30	N.A.	0.04356	0.0436	Storage Cabinets, Drawers or Shelves		1
	135	**Electrical Tape**	Electrical tape (or insulating tape) is a type of pressure-sensitive tape used to insulate electrical wires and other materials that conduct electricity. It can be made of many plastics, but vinyl is most popular, as it stretches well and gives an effective and long lasting insulation.		- 72Rolls/Box - 1.7cm width - 9m length - PVC		1 Box	30	30	N.A.	0.00404	0.0040	Storage Cabinets, Drawers or Shelves		1
	136	**Duct Tape**	Duct tape, also called duck tape, is cloth- or scrim-backed pressure-sensitive tape, often coated with polyethylene.		- 72Rolls/Box - 5.0cm width - 50m length - PE		1 Box	45	45	N.A.	0.06084	0.0608	Storage Cabinets, Drawers or Shelves		1

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	137	**Masking Tape**	Masking tape, also known as painter's tape, is a type of pressure-sensitive tape made of a thin and easy-to-tear paper, and an easily released pressure-sensitive adhesive. It is available in a variety of widths. It is used mainly in painting, to mask off areas that should not be painted		- 72Rolls/Box - 4.8cm width - 50m length - Paper		1 Box	20	20	N.A.	0.05184	0.0518	Storage Cabinets, Drawers or Shelves		1
	138	**Scotch Tape**	Scotch tape (Cellotape) is a clear sticky tape that is sold in rolls and that you use to stick paper or card together or onto a wall.		- 72Rolls/Box - 4.8cm width - 66m length - BOPP		1 Box	15	15	N.A.	0.03600	0.0360	Storage Cabinets, Drawers or Shelves		1
		ELECTRONICS			https://us.reddit.com/r/AskElectronics/wiki/starter_components#wiki_circular_connectors										
	139	**Conductive Threac**	Conductive thread is a thread that conducts electricity. Conductive threads are a cross between the world of electric wires and the world of textiles, with attributes of each. ... These core threads typically include cotton, polyester, nylon. 2 Ply		package with 1 roll,the total length is about 1240m, weight about 100g	8	1 pcs	35	35	N.A.	0.00086	0.0009	Storage Cabinets, Drawers or Shelves		1
	140	**Alkaline Batteries AA**	An alkaline battery (IEC code: L) is a type of primary battery which derives its energy from the reaction between zinc metal and manganese dioxide. Compared with zinc-carbon batteries of the Leclanché cell or zinc chloride types, alkaline batteries have a higher energy density and longer shelf life, yet provide the same voltage.		48AA/box	10	1 box	25	25	N.A.	0.00200	0.0020	Storage Cabinets, Drawers or Shelves		1
	141	**Alkaline Batteries 9V**			(24 Battery /box)9V Batteries, Premium Alkaline 9 Volt Batteries	10	1 box	25	25	N.A.	0.00054	0.0005	Storage Cabinets, Drawers or Shelves		1
	142	**Heat Shrink Tubing**	Heat-shrink tubing (or, commonly, heat shrink or heatshrink) is a shrinkable plastic tube used to insulate wires, providing abrasion resistance and environmental protection for stranded and solid wire conductors, connections, joints and terminals in electrical work. It can also be used to repair the insulation on wires or to bundle them together, to protect wires or small parts from minor abrasion, and to create cable entry seals, offering environmental sealing protection.		530pcs/pack Material: Polyolefin Shrinkage Ratio: 2:1 Operating Temperature: -55°C to +125°C Minimum Shrinkage Temp: +70°C Full Shrinkage Temp: +110°C Maximum Tensile Strength: 10.4 Mpa Dielectric Strength:15 kV/mm Flammability: Flame Retardant	8	1 set	10	10	N.A.	0.00112	0.0011	Storage Cabinets, Drawers or Shelves		1
	143	**Jumper Wires MM**	A jump wire (also known as jumper wire, or jumper) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard		- Male to Male - 30 cm length - 40 pins	10	2 set	4	8	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		1
	144	**Jumper Wires MF**			- Male to Female - 30 cm length - 40 pins	10	2 set	4	8	N.A.	N.A.	N.A.			1

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	145	**Jumper Wires FF**	or other prototype or test circuit, internally or with other equipment or components, without soldering.		- Female to Female - 30 cm length - 40 pins	10	2 set	4	8	N.A.	N.A.	N.A.			1
	146	**Wire**	A wire is a flexible metallic conductor, especially one made of copper, usually insulated, and used to carry electric current in a circuit.		4 rolls / set 30 Meters 2pin 20 Gauge AWG Electrical Wire Tinned Copper Insulated PVC Extension LED Strip Cable Red Black Wire 30 meters super flexible 24AWG PVC insulated Wire Electric cable 30 M silicone electronic wire UL3239-24 AWG 200 degrees Celsius high temperature soft wire 30 M copper single strand hard wire PVC insulated wire AV 0.5 mm2 Electric cable	10	2 set	70	140	N.A.	0.00250	0.0050	Storage Cabinets, Drawers or Shelves		1
	147	**Electrical Crimps**	An electrical crimp is a type of solderless electrical connection. Crimp connectors are typically used to terminate stranded wire		270 pcs/set	10	2 set	10	20	N.A.	0.00050	0.0010	Storage Cabinets, Drawers or Shelves		1
	148	**Beeswax**	Beeswax has been used since prehistory as the first plastic, as a lubricant and waterproofing agent, in lost wax casting of metals and glass, as a polish for wood and leather and for making candles, as an ingredient in cosmetics and as an artistic medium in encaustic painting.		- 85 grs/packet	8	3 pcs	1	3	N.A.	0.00032	0.0010	Storage Cabinets, Drawers or Shelves		1
	149	**Leds**	A light-emitting diode (LED) is a semiconductor device that emits visible light when an electric current passes through it.		475 pcs/set 3MM 5MM Led Kit With Box Mixed Color Red Green Yellow Blue White Light Emitting Diode Assortment 20PCS Each	10	1 set	12	12	N.A.	0.00051	0.0005	Storage Cabinets, Drawers or Shelves		1
	150	**Glass Fuses**	In electronics and electrical engineering, a fuse is an electrical safety device that operates to provide overcurrent protection of an electrical circuit. Its essential component is a metal wire or strip that melts when too much current flows through it, thereby stopping or interrupting the current.		300 pcs/set assorted	10	2 set	15	30	N.A.	0.00032	0.0006	Storage Cabinets, Drawers or Shelves	Safety	1
	151	**Solder Tip Tinner**	Tip tinner is composed of a mild acid, it helps remove baked on residue and helps prevent oxidation that accumulates on soldering tip when not in use		- 20 grs	8	6 pcs	4	24	N.A.	0.00003	0.0002	- Storage Cabinets, Drawers or Shelves	Soldering / welding	1

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	152	**Solder Wire**	Solder is a fusible alloy used to join less fusible metals or wires, etc. ... Solder wire is comprised of different alloys, or of pure tin. Each metal requires a certain type of soldering wire to create strong bonds, because the combinations of metals that comprise soldering wire melt at different temperatures.		0.6 mm 100grm	10	6	pcs	1	6	N.A.	0.00081	0.0048	- Storage Cabinets, Drawers or Shelves	Soldering / welding	1
	WOOD															
	153	**Wood Plank**	A wood plank is timber that is flat, elongated, and rectangular with parallel faces that are higher and longer than wide. Used primarily in carpentry, planks are critical in the construction of ships, houses, bridges, and many other structures. Planks also serve as supports to form shelves and tables.		- 2”X4”X96”	10	12	pcs	6	72	N.A.	0.01259	0.1510	Storage Shelves		1
	154	**Plywood**	Plywood is wood veneers bonded together to produce a flat sheet. An extremely versatile product, plywood is used for a wide range of structural, interior and exterior applications - from formwork through to internal paneling.		297x210x6mm super quality Aviation model layer board basswood plywood plank	10	12	pcs	5	60	N.A.	0.03742	0.4491	Storage Shelves		1
	155	**Balsa Wood**	A very lightweight wood used chiefly for making models and rafts.		10pcs/Set 200*100*1.5mm	10	12	set	5	60	N.A.	0.03000	0.3600	Storage Shelves		1

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	FLUIDS															
	156	**Small Plastic Syringe**	A syringe is a simple reciprocating pump consisting of a plunger (though in modern syringes, it is actually a piston) that fits tightly within a cylindrical tube called a barrel. The plunger can be linearly pulled and pushed along the inside of the tube, allowing the syringe to take in and expel liquid or gas through a discharge orifice at the front (open) end of the tube. The open end of the syringe may be fitted with a hypodermic needle, a nozzle or tubing to direct the flow into and out of the barrel. Syringes are frequently used in clinical medicine to administer injections, infuse intravenous therapy into the bloodstream, apply compounds such as glue or lubricant, and draw/measure liquids.		3/5/10/20/50/100ML Reusable Small Hydroponics Plastic Nutrient Sterile Health Measuring Syringe	10	6	set	12	72	N.A.	0.00111	0.0067	Storage Cabinets, Drawers or Shelves		3
	157	**Plastic Tubing**	A pipe is a tubular section or hollow cylinder, usually but not necessarily of circular cross-section, used mainly to convey substances which can flow liquids and gases (fluids), slurries, powders and masses of small solids.		2meters, The diameter of the hose（plastic tub）is 6mm (outer), 4mm(inner).	10	6	pcs	5	30	N.A.	0.00052	0.0031	Storage Cabinets, Drawers or Shelves		1
	158	**Luer Connectors**	Luer Adapters are specifically designed to work in a variety of applications by securely connecting a male or female luer to each other. These products allow you to connect and disconnect quickly to fluoropolymer tubing without the use of barbs or nuts.		5pcs Disposable three-way valve connector t tee medical Disposable blue three-way plug valve syringe adapter of drug dispenser	10	12	set	4	48	N.A.	0.00003	0.0004	Storage Cabinets, Drawers or Shelves		1
	159	**1-Way Valve**	A check valve, clack valve, non-return valve, reflux valve, retention valve or one-way valve is a valve that normally allows fluid (liquid or gas) to flow through it in only one direction.		4mm Plastic One-Way Non-Return Water Inline Fluids Check Valves for Fuel Gas Liquid	10	12	pcs	1	12	N.A.	0.00000	0.0000	Storage Cabinets, Drawers or Shelves		1
	HARDWARE															
	160	**Hack Saw Blades**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on.		10pack Bi-metal Blades 12" Hacksaw Blades	10	2	pkts	15	30	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		3
	161	**Jig Saw Blades**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on.		25 PCS Metal/Wood/Plastic Jig Saw Blade	10	2	pkts	15	30	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		3

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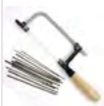
	162	**Deburring Blades**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on.		- set of 10 pieces (2 pcs from each type) - M2 HSS material - Deburring blades-BS3010: HSS M2 HRC63 Angle40° Using for the inner and outer edges of the hole(not for stainless steel) - Deburring blades-BK3010: HSS M2 HRC63 Angle45° Using for small holes with a diameter of not less than 1.5 mm(not for stainless steel) - Deburring blades-BK1010: HSS M2 HRC63 Angle45° Using for the thin edge of most materials(not for stainless steel) - Deburring blades-BS3510: HSS M2 HRC63 Angle55° Using for right-angled edges (not for stainless steel) - Deburring blades-BS6001: HSS M2 HRC63 Angle40° Using for hard-to-reach hole edges(not for stainless steel)	5	1 pkts	10	10	N.A.	0.00005	0.0001	Storage Cabinets, Drawers or Shelves		3
	163	**U-shape Saw Blades**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on.		Package:144pcs/bag , Length: 130mm. Thickness(mm) Width(mm) 0.26 0.52 0.24 0.48 0.22 0.44 0.20 0.40 0.18 0.36 0.17 0.34 0.16 0.32	10	1 pkts	25	25	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		3
	164	**Planer Blade**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on.		- Depend from the Planer	8	3 Pcs	8	24	N.A.	0.00001	0.0000	Storage Cabinets, Drawers or Shelves		3
	165	**Circular Saw Blade**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on.		- Depend from the Saw	5	3 Pcs	5	15	N.A.	0.00040	0.0012	Storage Cabinets, Drawers or Shelves		3

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	166	**Cutting Disc**	Often cutting discs or (cut-off wheels), are made from a solid abrasive disc. These discs are often used for cutting metal; they are composed of an abrasive mix of grit and adhesive that is formed into a rigid and thin disc with fiber webbing running through it for strength. Some discs used for cutting ceramic tile or stone are made from a solid disc with an edge coated with a diamond grit.		- Depend from the Angle Grinder Machine	9	12 Pcs	5	60	N.A.	0.00265	0.0317	Storage Cabinets, Drawers or Shelves		1
	167	**Grinding Disc**	A grinding wheel is a wheel composed of an abrasive compound and used for various grinding (abrasive cutting) and abrasive machining operations. Such wheels are used in grinding machines.		- Depend from the Angle Grinder Machine	9	12 Pcs	5	60	N.A.	0.00265	0.0317	Storage Cabinets, Drawers or Shelves		1
	168	**Jewelers' Saw Blades Lubricant**	A lubricant is a substance, usually organic, introduced to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move.		30 gram	8	2 Box	8	16	N.A.	0.00500	0.0100	Storage Cabinets, Drawers or Shelves		1
	169	**X-Acto Blades**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on.		50 Blades Per Pack Blade length: 60mm Blade width: 18mm Blade thickness: 0.6mm	10	3 pkts	5	15	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		3
	170	**Utility Knife Blades**	A blade is the portion of a tool, weapon, or machine with an edge that is designed to puncture, chop, slice or scrape surfaces or materials. Blades are typically made from materials that are harder than those they are to be used on		10 Blades per pack	10	6 pkts	1	6	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		3
	171	**Lubricant**	A lubricant is a substance, usually organic, introduced to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. Lubricants Multi-Use Product protects metal from rust and corrosion, penetrates stuck parts, displaces moisture and lubricates almost anything. It even removes grease, grime and more from most surfaces.		- 310ml - 6 Tins/Box	8	2 Box	25	50	N.A.	0.00750	0.0150	Storage Cabinets, Drawers or Shelves		2
	172	**Acid Brushes**	An acid brush is a small disposable multi-purpose brush. it can used to apply glue, or other liquids and [certain] chemicals, and for quick small-area cleaning or wiping applications.		36pcs/set, 1/2 Inch Boar Hair Acid Flux Brushes	10	2 pcs	8	16	N.A.	0.00003	0.0001	Storage Cabinets, Drawers or Shelves		1

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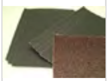
	173	**Popsicle Sticks**	Popsicle Sticks or tongue depressor (spatula) is a tool used in medical practice to depress the tongue to allow for examination of the mouth and throat. The most common modern tongue depressors are flat, thin, wooden blades, smoothed and rounded at both ends. Hobbyists and teachers have found a multitude of uses for tongue depressors in their projects.		- 5.8"*1.2" - 100 pcs/packet	8	2	pkts	3	6	N.A.	0.00100	0.0020	Storage Cabinets, Drawers or Shelves		1
	174	**Paper Mixing Cups**	Medicine Cups are portion cups, soufflé cups, or measurement cups that are used for dispensing medications. Made of Paper. They are small cups that often hold only 1 to 3 fluid ounces.		- 90ml - 100cups/paket	8	2	pkts	8	16	N.A.	0.00150	0.0030	Storage Cabinets, Drawers or Shelves		1
	175	**Plastic Mixing Cups (Medicine)**	Medicine Cups are portion cups, soufflé cups, or measurement cups that are used for dispensing medications. Made of Plastic. They are small cups that often hold only 1 to 3 fluid ounces.		- 90 ml - 100 cups/packet	8	3	pkts	6	18	N.A.	0.00100	0.0030	Storage Cabinets, Drawers or Shelves		1
	176	**Toothpicks**	A toothpick is a small thin stick of wood, plastic, bamboo, metal, bone or other substance with at least one and sometimes two pointed ends to insert between teeth to remove detritus, usually after a meal. Toothpicks are also used in other applications like holding aome light designed papers in decoration.		- 65*2.2 mm	8	9	pkts	1	9	N.A.	N.A.	N.A.	N.A.		1
	177	**Digital Caliper**	The Digital Caliper is a precision instrument that can be used to measure internal and external distances extremely accurately.		- 150 mm	10	7	pcs	10	70	N.A.	0.00025	0.0018	Storage Cabinets, Drawers or Shelves		2
	ABRASIVES															
	178	**Sandpaper (80/200/400/600)**	Sandpaper is produced in a range of grit sizes and is used to remove material from surfaces, either to make them smoother (for example, in painting and wood finishing), to remove a layer of material (such as old paint), or sometimes to make the surface rougher (for example, as a preparation for gluing).		90 Pack waterproof silicon carbide sandpaper sheets -400 to 800 Grit Sandpaper for final finishing before painting -1000 to 1200 Grit Sandpaper for light sanding between coats of finish and to sand metal -1200 to 1500 Grit Sandpaper for sanding between coats -2000 to 3000 Grit Sandpaper for buffing	10	2	pkts	15	30	N.A.	0.00050	0.0010	Storage Cabinets, Drawers or Shelves		2

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	179	**Sanding Discs**	One of the most common uses of abrasive discs is in sanding applications. Such discs remove surface materials such as metal, ceramics, glass, plastics, and paint, as well as burrs and other imperfections.		- 80pcs/Set	5	1	Set	20	20	N.A.	0.00008	0.0001	Storage Cabinets, Drawers or Shelves		2

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	FASTENERS														
	180	**Fasteners (Bolts and Nuts, Screws, Nails, Etc.)**	A fastener (US English) or fastening (UK English) is a hardware device that mechanically joins or affixes two or more objects together. In general, fasteners are used to create non-permanent joints; that is, joints that can be removed or dismantled without damaging the joining components.		Set of Bolts, nuts, screws, nails, Washers...... 5000 pcs	10	1 set	250	250	N.A.	0.25000	0.2500	Storage Cabinets, Drawers or Shelves		1
	181	**Staple Gun Staples**	A staple is a type of two-pronged fastener, usually metal, used for joining or binding materials together. Large staples might be used with a hammer or staple gun for masonry, roofing, corrugated boxes and other heavy-duty uses. Smaller staples are used with a stapler to attach pieces of paper together.		- 3/8 in (10 mm)	10	3 Box	6	18	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		1
	182	**Pop Rivets**	A POP Rivet is a blind fastener which can be inserted and set from one side of the work piece. it is tubular and comprised of a hat and mandrel; the length of the mandrel is snapped off when installed. POP rivets are used to connect two pieces of material, as replacements for welds, adhesives, screws, nuts and bolts, in a quick efficient manner with a hand riveter or pneumatic rivet gun.		1/8” 5/32” 3/16”	8	6 Box	5	30	N.A.	0.00025	0.0015	Storage Cabinets, Drawers or Shelves		1
	183	**Plastic Rivets**	reusable plastic connectors that make building fantastic cardboard creations quick & simple.		100pieces 3/4" X 11/32" (19mm X 8.7mm)	8	3 Box	10	30	N.A.	0.00040	0.0012	Storage Cabinets, Drawers or Shelves		1
	184	**Zip Tie Assortment**	A cable tie (also known as a hose tie, zip tie, or by the brand name Ty-Rap) is a type of fastener, for holding items together, primarily electrical cables or wires. Because of their low cost and ease of use, cable ties are ubiquitous, finding use in a wide range of other applications.		500pcs 3x60 3x80 3x100 3x120 3x150mm	10	1 set	8	8	N.A.	N.A.	N.A.	Storage Cabinets, Drawers or Shelves		1

Color Code	#	Tools & Materials	Description	Figure	Size / Specifications	Import-ance (1-10)	Min Qty		Estimated U.Price [$]	Estimated T.Price [$]	Required Working Area [m2]	Required Storage Volume [m3].U	Required Storage Volume [m3]. Total	Extra Installation Requirements	Acquired Skills	Required Trainning / Risk Level
	TEXTILES															
	185	**Sewing Thread**	Sewing thread is the yarn used to combine two or more fabric pieces together in garments, accessories, and other textile products. Thread may be comprised of the same construction and fibre content as the garment, but is often different.		- Different Colors - Different Sizes	8	1	Box	3	3	N.A.	0.00500	0.0050	Storage Cabinets, Drawers or Shelves		1
	186	**Adhesive Tape double sided**	Adhesive tapes is a combination of a material and an adhesive film and used to bond or join objects together instead of using fasteners, screws, or welding. Applying adhesive tapes in lieu of mechanical fasteners enables you to use lower temperature applications, which can simplify the manufacturing processes.		- 2 mm Thickness - 8 m Length - 2 cm Width - 72 Rolls/Box	8	2	Box	125	250	N.A.	0.23805	0.4761	Storage Cabinets, Drawers or Shelves		1
	187	**Sewing Machine Needles**	A sewing machine needle is a specialized needle for use in a sewing machine. Domestic sewing machines, designed for use in homes as opposed to commercial sewing operations, use a common needle type referred to as "Groz-Beckert 130 / 705," "HAx1" or "15x1" needles. Needles labeled as "universal" needles are of this type and are generally the type of needles found in retail sewing supply shops.			8	3	set	4	12	N.A.	N.A.	N.A.	N.A.		2
	188	**Felt**	Kind of cloth made by rolling and pressing wool or another suitable textile accompanied by the application of moisture or heat, which causes the constituent fibres to mat together to create a smooth surface.		3mx0.85mx 1mm Polyester Cloth Non Woven Felt Synthetic Fur Fabric	8	12	pcs	5	60	N.A.	0.00255	0.0306	Storage Cabinets, Drawers or Shelves		1
	189	**Fabric**	Fabric is cloth or other material produced by weaving together cotton, nylon, wool, silk, or other threads. Fabrics are used for making things such as clothes, curtains, and sheets.		- Different Colors - Different Thicknesses - Different Materials - Different Widths	8	200	m2	5	1000	N.A.	0.11250	22.5000	Storage Cabinets, Drawers or Shelves		1
	190	**Sewable Battery Holder**	A battery holder is one or more compartments or chambers for holding a battery. For dry cells, the holder must also make electrical contact with the battery terminals.		- Different Battery Sizes	5	7	pcs	2	14	N.A.	N.A.	N.A.	N.A.		1
	191	**Snaps**	A snap fastener (also called press stud, popper, snap or tich) is a pair of interlocking discs, made out of a metal or plastic, commonly used in place of traditional buttons to fasten clothing and for similar purposes.		200pcs 9.5mm 10 Colors Metal Prong Snap Button Grommets Fasteners Kit	5	1	set	16	16	N.A.	N.A.	N.A.	N.A.		1

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	192	**Bobbins**	A bobbin is the part of a sewing machine on which the lower thread is wound. The machine makes a stitch by catching the bottom thread, from the bobbin, with the top thread, from the needle.		36 Pcs Sewing Thread Bobbins with Bobbin Case Sewing Thread Kit	5	1	set	10	10	N.A.	N.A.	N.A.	N.A.		1
	193	**Metal Beads**	Small pieces of metal, often round in shape, with a hole in the center for threading, which are used for making objects such as jewelry.		1000pcs 2.4/3.2/4.0mm Gold/Silver/Bronze Color Metal Beads Round Ball Loose Spacer Beads	5	2	pkts	5	10	N.A.	0.00013	0.0003	Storage Cabinets, Drawers or Shelves		1
	194	**Plastic Beads**	Small pieces of plastic, glass or wood, often round in shape, with a hole in the center for threading, which are used for making objects such as jewelry.		1000pcs 8mm Round Plastic Beads Spacer Loose Beads	5	2	pkts	3	6	N.A.	0.00195	0.0039	Storage Cabinets, Drawers or Shelves		1
		MISC														
	195	**Shapelock (Or Instamorph)**	Caprolactone Thermoplastic (also commonly called ShapeLock, Friendly Plastic, Instamorph or Polymorph) is a biodegradable polyester plastic with a low melting point of around 60°C. When solid it has physical properties of a very tough, nylon-like plastic, but it will melt into a putty-like consistency at only 60°C. PCL is easily worked by hand when molten and can be shaped into a variety of useful objects, used to repair broken parts, or can be used as an adhesive for 3D printed parts.		100g polymorph and 5 color Kits Moldable Plastic	8	12	pkts	3	36	N.A.	0.00033	0.0040	Storage Cabinets, Drawers or Shelves		1
	196	**Nichrome Wire**	Nichrome (NiCr, nickel-chrome, chrome-nickel, etc.) is any of various alloys of nickel, chromium, and often iron (and possibly other elements). The most common usage is as resistance wire, as heating elements in things like toasters and space heaters, although they are also used in some dental restorations (fillings) and in a few other applications like foam cutters.		1kg 0.4mm	8	2	pcs	12	24	N.A.	0.00357	0.0071	Storage Cabinets, Drawers or Shelves		1
	197	**String**	String (structure), a long flexible structure made from threads twisted together, which is used to tie, bind, or hang other objects.		200M 12-Ply Cotton Twine String,Craft String	6	2	pcs	10	20	N.A.	0.00040	0.0008	N.A.		1
	198	**Rope**	A rope is a group of yarns, plies, fibers or strands that are twisted or braided together into a larger and stronger form. Ropes have tensile strength and so can be used for dragging and lifting. Rope is thicker and stronger than similarly constructed cord, string, and twine.		100yard 4mm Nylon Paracord 7strands	8	2	pcs	12	24	N.A.	0.00156	0.0031	N.A.		1

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	199	**Whiteboard marker**	Dry-erase markers are non-permanent markers that contain erasable ink that adheres to whiteboards without binding to or being absorbed by them. This allows them to be used on whiteboards without requiring messy clean-up. With a simple wipe of an eraser, cloth, or paper towel, dry-erase markings are gone!		4 assorted Colors WhiteBoard markers,Thick Barrel Design, Low-Odor	10	6 pkts	4	24	N.A.	N.A.	N.A.	Whiteboard		1
	200	**Paint**	Paint is any pigmented liquid, liquefiable, or solid mastic composition that, after application to a substrate in a thin layer, converts to a solid film. It is most commonly used to protect, color, or provide texture to objects. Paint can be made or purchased in many colors—and in many different types, such as watercolor or synthetic. Paint is typically stored, sold, and applied as a liquid, but most types dry into a solid. Most paints are either oil-based or water-based and each have distinct characteristics		- Water Based - 5 Liters per Gallon	8	12 Gls	30	360	N.A.	0.00500	0.0600	Storage Cabinets, Drawers or Shelves		1
	201	**Filter or Dustbag**	Vacuum cleaner have filters to prevent dust escaping back to the air. At the point when a vacuum pulls in air it likewise sucks in earth particles of different sizes. Since the air that is taken in must be removed retreat from the vacuum without the dirt going along with it, a filter is set up.		- proper to the vacuum machine purchased - 10 pcs/set	10	2 set	20	40	N.A.	0.00428	0.0086	Storage Cabinets, Drawers or Shelves		1
	202	**Orbital Sander Dustbag**	Orbital Sander have filters to prevent dust escaping back to the air.		- proper to the orbitalsander machine purchased - 5 pcs/set	5	2 set	8	16	N.A.	0.00000	0.0000	Storage Cabinets, Drawers or Shelves		1
	203	**3d Printer Filament**	3D printing filament is the thermoplastic feedstock for fused deposition modeling 3D printers. There are many types of filament available with different properties, requiring different temperatures to print.[1] Filament is commonly available in the two standard diameters of 1.75 mm and 2.85 mm.[		- Filament Diameter as per machine purchased.	10	12 Rolls	20	240	N.A.	0.00200	0.0240	Storage Cabinets, Drawers or Shelves		1
		Safety kits													
	204	**First aid kit**	A first aid kit is a collection of supplies and equipment that is used to give medical treatment. It is mounted in a clear and easy to access area.		- 38x14x52 cm - Attached List	10	1 set	45	45	1.00	N.A.	N.A.	N.A.		2

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	205	**Fire Extinguisher**	A fire extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situations. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent that can be discharged to extinguish a fire.		- 5 CO2 10 lbs between machines - 5 ABC 20 lbs near doors	10	1	set	300	300	10.00	N.A.	N.A.	N.A.		2
	206	**Gloves**	A glove (Middle English from Old English glof) is a garment covering the whole hand. Gloves usually have separate sheaths or openings for each finger and the thumb. Gloves protect and comfort hands against cold or heat, damage by friction, abrasion or chemicals, and disease; or in turn to provide a guard for what a bare hand should not touch.		12Pairs/box Rubber Latex Coated Work Gloves for Construction, Blue, Crinkle Pattern, XLarge	10	12	box	12	144	N.A.	0.00288	0.0345	Storage Cabinets, Drawers or Shelves		2
	207	**Nitrilegloves**	Nitrile is a synthetic rubber compound that is commonly used as a disposable glove material. Nitrile has been around for a while, but only recently it's become more affordable, which explains why it's gaining popularity throughout medical, food and cleaning industries. Nitrile has a higher puncture resistance than any other glove material. Nitrile also has a better chemical resistance than Latex or Vinyl gloves.		Nitrile Disposable Gloves, Powder Free, Latex Free, 100 Pc. Dispenser Pack, Many Size, Blue	10	3	box	15	45		0.00100	0.0030	Storage Cabinets, Drawers or Shelves		2
	208	**Dust Masks**	A dust mask is a flexible paper pad held over the nose and mouth by elastic or rubber straps for personal comfort against non-toxic nuisance dusts. They are not intended to provide protection from toxic airborne hazards.		Disposable Dust Mask, Box of 50 (RWS-54001)	10	12	box	20	240	N.A.	0.00312	0.0374	Storage Cabinets, Drawers or Shelves		2
	209	**Safety Glasses**	Goggles, or safety glasses, are forms of protective eyewear that usually enclose or protect the area surrounding the eye in order to prevent particulates, water or chemicals from striking the eyes. They are used in chemistry laboratories and in woodworking. They are often used in snow sports as well, and in swimming. Goggles are often worn when using power tools such as drills or chainsaws to prevent flying particles from damaging the eyes. Many types of goggles are available as prescription goggles for those with vision problems.		Color: Transparent, Material: Polycarbonate Size: 157x130x60mm	10	38	pcs	1.5	57	N.A.	0.00097	0.0369	Storage Cabinets, Drawers or Shelves		2

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		Cleaning														
	210	**Handwash Gel**	Soap is a salt of a fatty acid used in a variety of cleansing and lubricating products. In a domestic setting, soaps are surfactants usually used for washing, bathing, and other types of housekeeping.		- 4 ltrs/Gallon - 4 Gallons/Box - Antibacterial	10	1	Box	45	45	N.A.	N.A.	N.A.	N.A.		1
	211	**Sanitizer**	Hand Sanitizer is an alcohol-based gel that kills most common germs that may cause illness by means of its active ingredient, ethyl alcohol. The product is placed on the hands, and when hands are rubbed together briskly, the alcohol sanitizes and then evaporates.		- 4 ltrs/Gallon - 4 Gallons/Box - Antibacterial	8	1	Box	70	70	N.A.	N.A.	N.A.	N.A.		1
	212	**Detergent**	Detergent is a water-soluble cleansing agent which combines with impurities and dirt to make them more soluble, and differs from soap in not forming a scum with the salts in hard water. Detergents can be categorized into cationic, anionic, nonionic, and ampholytic detergents.		- Housekeeping detergents		2	Box			N.A.	N.A.	N.A.	N.A.		1
	213	**Trash Bags**	A bin bag, rubbish bag, garbage bag, bin liner, trash bag or refuse sack is a disposable bag used to contain solid waste. Such bags are useful to line the insides of waste containers to prevent the insides of the receptacle from becoming coated in waste material.		30 rolls / box XL 50L-20 bags/roll	10	60	pcs	80	4800	N.A.	N.A.	N.A.	N.A.		1
	214	**Paper Towel**	A paper towel is an absorbent, disposable towel made from paper. In Britain, paper towel for kitchen use is also known as kitchen roll, kitchen paper, kitchen towel, and poly roll. ... Unlike cloth towels, paper towels are disposable and intended to be used only once.		10 Rolls/bag Type: 4 Ply C fold Paper Tissues / Towels Colour: White Sheet size: 100mm x 150mm Type: Enviro friendly Recycled tissue	10	6	bags	10	60	N.A.	N.A.	N.A.	N.A.		1
		Building														
		Electrical														
		ELECTRICAL														
	215		An on-line UPS is an electric/electronic device which uses a "double conversion" method of accepting 230 VAC as input power, rectifying it to 12/24 or 48 VDC for passing through the rechargeable battery, then inverting it back to 230 VAC for		- Output Signal: Pure Sine Wave. - Continuous Power >= 600 W	10	1	pcs	300	300	N.A.	N.A.	N.A.			
	216				- Output Signal: Pure Sine Wave. - Continuous Power >= 800 W	10	3	pcs	350	3500	N.A.	N.A.	N.A.			

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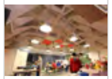
	217	**On-line UPS**	powering the protected equipment. It is an electrical apparatus that provides continuous power to a load even when the input power source or mains power fails. And also to protect the equipment from high or low voltage supply which may affect the motors and electronic boards.		- Output Signal: Pure Sine Wave. - Continuous Power >= 1000 W	10	2 pcs	450	900	N.A.	N.A.	N.A.			
	218				- Output Signal: Pure Sine Wave. - Continuous Power >= 1800 W	10	2 pcs	500	1000	N.A.	N.A.	N.A.			
	219	**Thermomagnetic Circuit Breaker**	Thermomagnetic circuit breaker is an electrical protection device equipped with two tripping mechanisms: + the temperature-dependent part of the mechanism which causes the switching mechanism to switch off when the consumed current exceed its nominal current. The response to overload currents is time-delayed. + the magnetic tripping mechanism which causes the switching mechanism to switch off when the consumed current exceed suddenly its pre-defined current. The circuit breaker responds to short-circuit currents and overload currents which are too high within three to five milliseconds.		- Operating voltage up to 400V AC - Rated Current (In): Depeding from the load - Tripping characteristics: C Curve - High breaking capacity throughout the range 6kA, 10kA	10	24 pcs	7	168	N.A.	N.A.	N.A.	- Cabling - Electrical Panel		
	220	**Earthing**	In an electrical installation, an earthing system (UK) or grounding system (US) connects specific parts of that installation with the Earth's conductive surface for safety and functional purposes. An earth ground connection of the exposed conductive parts of electrical equipment helps protect from electric shock by keeping the exposed conductive surface of connected devices close to earth potential, when a failure of electrical insulation occurs. When a fault occurs, current flows from the power system to earth. To protect equipment from damage due to leakage current, residual-current sensing circuit breakers detects the leakage current and interrupt the circuit.		- Good electrical conductivity. - Conductors capable of withstanding high fault currents. - Long life – at least 40 years. - Low ground resistance and impedance < 5 Ohm.	10	1 set	100	100	N.A.	N.A.	N.A.	- Cabling - Earthing Rods		
	Lights and Sockets														
	221	**Lights**	Lighting or illumination is the deliberate use of light to achieve practical or aesthetic effects. Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight.		- Illuminance level > 750 lux	10	1 set	1500	1500	N.A.	N.A.	N.A.	- Cabling		

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	222	**Emergency Lights**	An emergency light is a battery-backed lighting device that ensure the lighting is provided promptly by switching on automatically, for a suitable time, when the normal power supply to the lighting fails.		- LED - 230 VAC - 20 W	10	10	pcs	35	350	N.A.	N.A.	N.A.	- Cabling		
	223 224	**Electrical Outlet and LAN Port post**	An electrical socket outlet is a female socket connected to the power wiring in the building and will accept the male plug attached at the end of the flexible cord of an appliance such as a vacuum cleaner, electric fire or electronic equipment. LAN port. Alternatively referred to as an Ethernet port, network connection, and network port, allows a computer to connect to a network using a wired connection.	 	- 4 Electrical Outlets 230 VAC - 2 LAN Port - 2 USB outlet 5VDC - Pendant	10	7	set	100	700	N.A.	N.A.	N.A.	- Cabling, cable racks		

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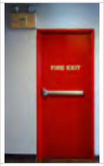
	Air Handling															
	225	**HVAC system with HEPA filters**	Heating, Ventilation, and Air Conditioning (HVAC) is the technology of indoor and vehicular environmental comfort. The main components of HVAC system are: Thermostat, Furnace, Heat Exchanger, Condenser, Evaporator Coil, Ducts, Air filters,... Its goal is to provide thermal comfort and acceptable indoor air quality. It is used to filter and change or replace air in any space to control temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria, or carbon dioxide, and to replenish oxygen. HEPA (High Efficiency Particulate Air), is a filter able to trap over 99.97 percent of particles that are 0.3 microns. This system, which is more efficient than normal exhaust fans, uses less energy for air conditioning because it recycles most of the conditioned air. It also gives better air quality because it filters fresh and recycled air.		- Air flow [m3/hr] = 10*Rooms Volume. - Fresh Air [m3/hr] = 30*Nbre of Persons. - Negative Pressure in soldering, machines and Power Tools sections. - Low Risers: used to suck the dust and smoke from a low level. - Air inlets: on top to push dust and smokes down. - Size and Number of HEPA filters depends from the Air Volume and Pressure	6	1	set	10000	10000	15.00	N.A.	N.A.	- AHU unit. - Ducts, Air Grids and HEPA filters		
	Layout															
	226	**Emergency Exit Door**	An emergency door is a door opening onto an emergency exit that is a clear and safe way to get out of a structure or building. It provides fast exit in case of emergency such as a fire.		- must open outwards - must not be revolving or sliding - easily visible - easy accessible - have a crash bar - free area around	10	3	pcs	300	900	12.00	N.A.	N.A.	N.A.		
	227	**Emergency Exit Sign**	An exit sign is a device in a public facility (such as a building, aircraft, or boat) denoting the location of the closest emergency exit in case of fire or other emergency. Exit signs must be properly illuminated by a reliable light source.		- Always on - guiding toward the exit doors	10	4	pcs	15	60	N.A.	N.A.	N.A.	N.A.		
	228	**Accessibility**	Accessibility in the sense considered here refers to the design of products, devices, services, or environments so as to be usable by people with disabilities.		- Ramps, elevators and easy access to the working areas.	10	1	set	1000	1000	N.A.	N.A.	N.A.	N.A.		

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	229	**Floor and Walls**	The floors and walls that make up the makerspace area are subject to dirt and dust. We must keep it clean and pollution-free.		- Smooth, Monolithic, cleanable, chip resistant with minimum seams, joints and no cervices. - Epoxy or polyester coating with raised floor and round corners.	5	1 set	2900	2900	N.A.	N.A.	N.A.	N.A.		
		Subdivisions													
	230	**Area A**	Students Workbenches Area. Where all the projects are designed and assembled.		- Low Noise - Low Dust - 4 m2/Student		1 set			140.29	m2		- HVAC - Negative Pressure 1		
	231	**Area B**	Small Machines Area. Where some parts of projects are prepared using light machines, like 3D Printers, CNCs, Laser Engravers, Sewing Machines,.........		- Medium Noise - Medium Dust - 5m2/Machine		1 set			55.42	m2		- HVAC - Negative Pressure 2		
	232	**Area C**	Big Machines Area. Where some parts of projects are prepared using high power machines, like Power Grinders, Band Saws, Welding Machines		- High Noise - High Dust - 10m2/Machine		1 set			27.92	m2		- HVAC - Negative Pressure 3		
	233	**Cleaning area**	The cleaning area is the area prepared with water, soap, disinfectants, etc. to be used for cleaning hands and tools. It is also urgently necessary, in the event of an accident of injury or chemical touching the body or the eyes, in order to clean the affected area.		- size 200x400 cm - 4 Kitchen sink 61x56 cm - 1 mop sink basin 110x50x40 cm		1 set			10.79	m2		- HVAC - Negative Pressure 1 - Water Supply - Drainage - Kitchen sink - Mop Sink		
	234	**Store Room**					1 set			0.86	m2				
	235	**Locker room**	A room attached to an athletic, recreational, or workplace facility, filled with lockers for storage of clothing and equipment.		- lockers - table 160x80 cm		1 set			18.56	N.A.		- HVAC - Negative Pressure 1		
	236	**Office**					1 set			15.00	m2				
	237	**AHU**					1 set			18.75	m2		- Installed Outside		
	238	**Storage**	Cabinets Drawers or Shelves				1 set			51.15	m3				

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