EDUBOX:
A SELF-CONTAINED ENGINEERING LEARNING ENVIRONMENT FOR UNDERSERVED COMMUNITIES

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ABSTRACT

Education represents one of the essential building blocks of society. As soon as basic needs such as security, water, food and energy are secured for underserved communities and displaced people, education must be arranged to facilitate continuous growth of the community at multiple levels: from primary education to Vocational and Educational Trainings (VETs) to Higher Engineering Education.

Since the primary efforts of humanitarian aid are always invested in addressing the aforementioned basic needs, investment in education infrastructure is challenging owing to the expenses involved. This affects access to education, and consequently the quality of life of persons, especially the underserved. To address this challenge, a flexible classroom is proposed for fostering access to engineering and technical education by the underserved. The idea aligns with the UN Sustainable Development Goals 4 – Quality Education.

The design of a “learning environment”, hereafter called EduBOX in this paper is discussed. The learning environment is essentially a retrofitted shipping container, designed to suit varying learning environments and deployed to regions affected by crisis and other adverse events including war. The classroom facilitates learning activities in the field of engineering education. The first concept for a learning environment for refugees in camps in Lebanon and Jordan is discussed in this paper as a starting point. Furthermore, the design phases of the innovative learning environment are explored, starting with a review of related solutions, and innovative design spaces. Secondly, needs and requirements of the EduBOX are explored, looking at different aspects such as engineering educational needs, learning outcomes, cultural factors and technical constraints. This step is carried out in collaboration with relevant stakeholders, including the host community. Finally, design concepts are generated, and an

innovative design is explored for further detailing and prototyping. The selected concept is further evaluated, and showed a positive outlook considering usability, and from a didactic perspective.

KEYWORDS

Engineering Education, Underserved Communities, Learning Experience, Sustainable Development Goals 4 – Quality Education, EduBOX, Standard 6.

INTRODUCTION

The research project mission contributes to increasing the quality of education and vocational training for refugees and internally displaced persons in host communities. Jordan and Lebanon case were considered as a testing environment (University of Twente, 2020). The goal is to help students from underserved communities and refugees living in camps to access quality engineering education, resulting in better integration with the labour market. As defined by the UNHCR, "a host community refers to the country of asylum and the local, regional and national governmental, social and economic structures within which refugees live" (UNHCR Resettlement Service, 2011).

Problem Statement

Although the right to receive an education is included in the human rights of the United Nations (United Nations, 2021), higher education is perceived as a luxury for refugees. In humanitarian crises, most attention concerning education is often directed towards the primary and secondary school levels. Refugees above the age group of secondary school level (age 12 to 18) are considered less vulnerable than school-age children. However, higher education for refugees is argued to be of high importance, since it enables individuals and societies to rebuild their lives and fosters peaceful post-conflict reconstruction (Sheehy, 2014). Jordan and Lebanon host a disproportionate number of Syrian refugees lacking adequate infrastructure and resources. This has been compounded by the arrival of more than a million Syrian refugees, thereby placing great pressure on public services including the education system. Limiting access especially to technical and vocational education.

NEEDS OF EDUCATION FOR UNDERSERVED COMMUNITIES

Needs of the target group related to education in underserved communities

Jordan has been hosting many refugees throughout its history, of which most people are from Syria. Syrians are the newest group of refugees to come to Jordan or Lebanon as a host country. The total number of registered refugees is approximately 655,000 Syrians, 67,000 Iraqis, 15,000 Yemenis, 6,000 Sudanese, and 2,500 refugees from a total of 52 other nationalities (UNHCR, 2019).

To foster access, the EduBOX was conceived as part of an international cooperation project, between the Netherlands, and higher education institutions in Jordan, and an agency working with refugees in Lebanon. The prototype of the project targets beneficiaries in three refugee camps; Zaatari, Marjeeb AL Fhood, and Azraq, which are all located in the north of Jordan. Currently, refugees live and study in tent camps, with limited access to permanent education infrastructure, including classrooms. This motivated the need for a dynamic learning environment inside these camps should be mobile as well. Moreover, the mobile learning environment should be deployable outside refugee camps, where the majority of refugees live.

Together, this led to the following criteria for the learning environment shipping container:

- A learning environment that should fit the needs of Syrian refugees in Jordan and Lebanon.

- The learning environment should be designed to be easily transported and deployable to different locations where refugees require access to engineering education.
- The design should be easily deployed and fit in refugee camps, as well as in urban areas to educate the underserved.

What type of education do Syrian refugees currently follow in Jordan?

To understand the educational needs, we explored together with the host community challenges accessing education. Since the beginning of the Syrian conflict, Syrian refugees have received free access to public primary schools regardless of their official status as asylum seekers. The only consideration is having a service card issued by the Ministry of Interior (Beste, 2015). As may be expected, this has placed great pressure on the education infrastructure of the Jordanian public education system (Beste, 2015). This has had an undesired effect of forcing some primary schools to operate on double shifts, a morning shift for Jordanian children, and an afternoon shift for Syrian refugee children (Human Rights Watch, 2016).

Access to vocational training and higher education is a very relevant need for Syrian refugees, especially because of interests to access the labour market in Jordan. This includes training to gain skills in aspects such as coding, cookery, and artisanship that are very relevant from an entrepreneurship perspective. However, accessing vocational training and higher education is still a challenge, especially because of limited infrastructure capacity, limited of laboratories for engineering education and competition for limited slots with the local communities (Human Rights Watch, 2016).

Moreover, certification of vocational training and higher education programs is challenging, because of the often stringent requirements needed for non-Jordanians to enroll, creating a barrier of access to STEM skills training for the underserved in the community, including refugees. This is one of the overriding motivations for the EduBOX that attempts to fill this gap to provide certified vocational training, to enhance access to the job market by graduates.

What problems does this target group experience concerning education?

From initial need assessment prior to developing the EduBOX concept, challenges facing refugees were mapped and included:

- ***Infrastructure and quality of education***

Because of the pressure on the education system, lack of classrooms presents an important problem, with the Jordanian Government already adopted a double shift learning principle. Already this dates back to the 1960’s owing to regional instability and conflicts and worsened by the influx of Syrian refugees. With the growing number of students (UNICEF, 2020), students study fewer hours, influencing negatively the quality of education, for instance, compared to schools operating a regular schedule (Human Rights Watch, 2016).

- ***Poverty, child labour and child marriage***

80% of the Syrian refugees are living in poverty, which results in most refugees being financially dependent on support from humanitarian agencies for survival. Many Syrian refugees families in Jordan have resorted to child labor to increase their income and child marriage to decrease the number of dependents needing support (Human Rights Watch, 2020). Moreover, a disproportionate number of children from 12 years too early adults continue to lack access to education, influencing negatively their future quality of life (Human Rights Watch, 2020).

- ***Jordanian labour market***

Syrian refugees are not allowed to apply for work permits with wages exploitatively low for the informal job market where often many refugees search for opportunities. Refugees must also show that they have specialized skills to access the skilled job market. Accessing low-skilled jobs is significantly more difficult compounded by inability to obtain work permits (International Labour Organization, 2015). Many such jobs are in sectors such as agriculture, construction where they often contend with low and often poor working conditions (Human Rights Watch, 2016). Skills from vocation training presents an opportunity for refugees to improve access and leverage on their skills to earn an income, e.g. cookery, coding, or internet-based outsourcing jobs. These courses were mapped as much needed skills from a need analysis perspective.

- ***Limited vocational training programs in host communities***

Several international humanitarian agencies and non-governmental organizations (NGOs) run vocational training programs in host communities. However, approval of their programs is skewed because of political sensitivities around the integration of Syrians in the Jordanian labour market (Human Rights Watch, 2016). This influenced several needs and access-related criteria for the EduBOX including:

- Enhancing access to educational infrastructure, while providing high-quality vocation training facilitated by online, blended learning activities and supported remotely by highly educated teachers.
- Should include basic infrastructures, such as windows, electricity, lighting, heating and cooling.
- Provide vocational training programs approved by the Jordanian authorities, with the programs fulfilling employment prospects of refugees.

Although approval of up-skilling courses is an important barrier for access to vocational training, this relates largely to formal skills training. For instance here, training requiring certification. For tertiary training, e.g. artisanship skills, the thresholds are much lower, with explicit need for certification not mandatory and training often requires proof of participation. The EduBOX therefore complements well up-skilling for lower-level vocational training, an important benefit for the community.

REQUIREMENTS OF LEARNING ENVIRONMENTS FOR UNDERSERVED COMMUNITIES

1. *What are the basic requirements for a classroom in underserved communities?*

There are no legal minimum space requirements concerning classroom dimensions. However, the Building Bulletin 103 (Department for Education, 2014) does set out that a general classroom should be around 55 m² per 30 students, but depending on the activities that take place in them, more space might be required. Therefore, an average classroom for 30 students should be around 70 m².

Together, these results led to the following criteria for the learning environment shipping container:

- The container should hold at least 30 students to maximize availability and minimize costs.
- The learning environment should be around at least 70 m² per 30 students.

Based on a field guideline report from the UNHCR about education for refugees, there are a few guidelines for education for refugees concerning the infrastructure and equipment, which should be met by the learning environment shipping container (UNHCR, 2003).

2. *How can a modern and mobile classroom be redesigned to facilitate the most effective environment for learning?*

The EduBOX should be a transportable and flexible space, which can be used for different educational programs. Throughout the existence of classrooms, they appear mainly in the same shape with forward-facing furniture (Cornell, 2003). Even though this set up of a classroom is still widely used, is it highly immobile and encourages ‘passive learning’, which is defined by Basye et al. (2015) as “transmission of knowledge” where teachers “passed on information that students learned, often by recitation and repetition, sufficient to prepare them for the lives they would lead" (Basye, 2015).

Over the last decades, the instructional practices have shifted towards a new style of 'active learning, which is defined by Brooker (2011) as "the antithesis to passive learning, wherein students construct their knowledge by engaging in educational tasks themselves" (Fehlandt, 2017). Students are stimulated to work more independent, think critically, collaborate and move. 'Active learning' is stimulated when flexible furniture can be adapted to change the learning environment to a new arrangement (Fehlandt, 2017). This includes adaptable furniture to enhance student collaboration and active learning (Basye, 2015). Table 1 offers an overview of the requirements needed to provide reliable and effective solutions and to guide the design process through the different needs of the final users.

Table 1. Self-Contained Engineering Learning Environment for Underserved Communities

Type of requirement	**Specific Requirement**
Functional requirements	• The architecture of the container should be modular, adaptable to adjust based on the local needs. • The container should be efficient to transport, install and operate. • The design of the container should ensure natural lighting and ventilation and usable in all weather conditions. • All components within the container must be accessible for quick maintenance or replacement.
Technical requirements	• Should have a correct size according to the ISO measurement and only contain a door on one side. • Should offer a similar ratio of 70 m² per 30 students.
Educational requirements	• The inside layout of the container should be flexible to adapt to different education programs. • Should include all necessary facilities to follow online classes plus a learning lab. • Should include basic furniture (chairs, tables, desks etc…) and either laptops or tablets.

Moreover, collaboration between students is further enhanced by the shape, size, orientation and clustering of tables and desks (Cornell, 2003). Fehlandt (2017) discusses three themes, including space, flexibility and mobility, that attribute to the achievement of an effective learning environment.

- **Space:** Duncanson (2014) associates a physical space to a classroom and argues that increasing the area by a little less than 1 m² per student, promotes 'active learning' leading to fewer distractions and a cleaner classroom organization (Duncanson, 2014).
- **Flexibility*:*** Focuses on space utilisation hence allowing a variety of learning opportunities adapting to the individual needs of a student (Basye, 2015). This allows students to adjust to an endless amount of educational activities and collaboration in the form of group work (Fehlandt, 2017).
- **Mobility:** Cornell (2003) states that to facilitate this multipurpose classroom with a variety of educational opportunities, classrooms will need to be reorganized regularly (Cornell, 2003). To allow this, the content within the classroom should be mobile, including the ability for movement in the furniture itself which supports more engagement and higher achievement (Fehlandt, 2017).

These insights leads to the following criteria for the learning environment shipping container:

- A learning environment that should be flexible enough to adapt to different teaching approaches and educational programs.
- Furniture that should be adaptable which allows for different setups, as well as creating more physical space.

3. *Alignment with the CDIO (Conceive-Design-Implement-Operate) framework?*

The EduBOX project is working with educators, to develop innovative learning content to suit the needs of the underserved communities. This is a particular challenge and needs of underserved communities are diverse, influencing CDIO (Conceive-Design-Implement-Operate) standards, including:

- Standards 1, 2 & 3: Defining concretely the education needs of the underserved and designing education curricula with clear learning outcomes to suite defined needs.
- Standards 5: Design-implement experiences, including innovative delivery of education, through blended learning, interactive micro-lectures, and tailored teaching.
- Standard 6: Optimising learning spaces, to improve the learning experience.

DESIGN OF THE SELF-CONTAINED ENGINEERING LEARNING ENVIRONMENT

The final design of the self-contained learning environment exists of two main parts; the first part includes opening sidewalls to expand the classroom's area while the second part includes a small lab in the back of the container behind a separating wall (Figure 1). Figure 2 illustrates the outside dimensions of the EduBOX.

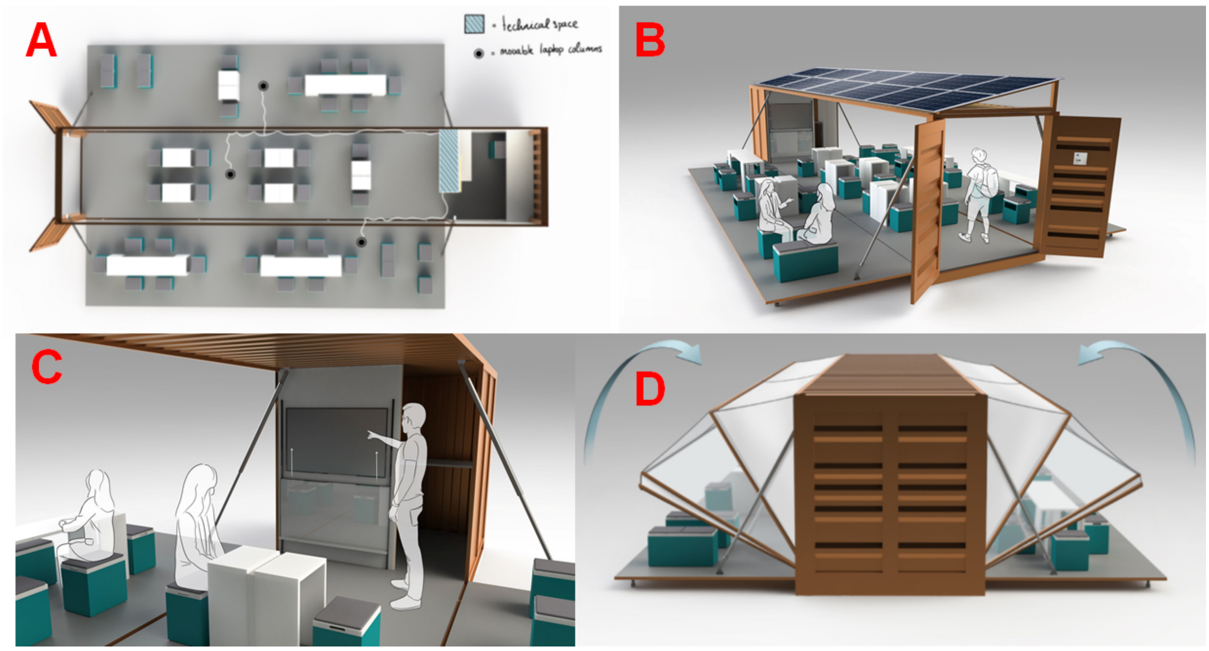

Figure 1. A: top view of the EduBOX; B, C: 3D view of the EduBOX; D: view of the canopy structure.

When closed, all furniture inside the container can be stacked together compactly, leaving enough space for the solar panels and its mounting system. To use the learning environment, the container must be unfolded actuated by four linear actuators. When closed, the learning environment could still be used since there is provision of artificial lighting, though this is not optimal from a functional perspective due to space limitations when closed. Solar panels are mounted to ensure energy independency for off-grip applications (Figure 1B). The side part of the space created unfolding the side walls (Figure 1D) will be protected using a canopy system mounted on the frame of the container. This system will be able to let the sunlight illuminate the learning environment, offering a better experience to the users.

The Lab

As said, in the back of the container there is a small lab (Fig. 1A and Fig. 2) that can be used also for Technical Vocational Education and Training (TVET). The lab is closed off by a separating wall and a sliding door, to avoid interruptions with the classes given at the same moment in the classroom. Inside the lab, two workbenches face each other to make the best use of the available space. The tables are at a standard standing table height of 110 cm, which enables the students working at the lab to stand while working, or stack two chairs on top of each other to create a barstool. The lab can be used by two people at the same time for different purposes, and also different variations of this lab can be designed and implemented in the EduBOX. As an example, the lab could include one or two additive manufacturing printers, that can be placed on the smaller table against the separating wall.

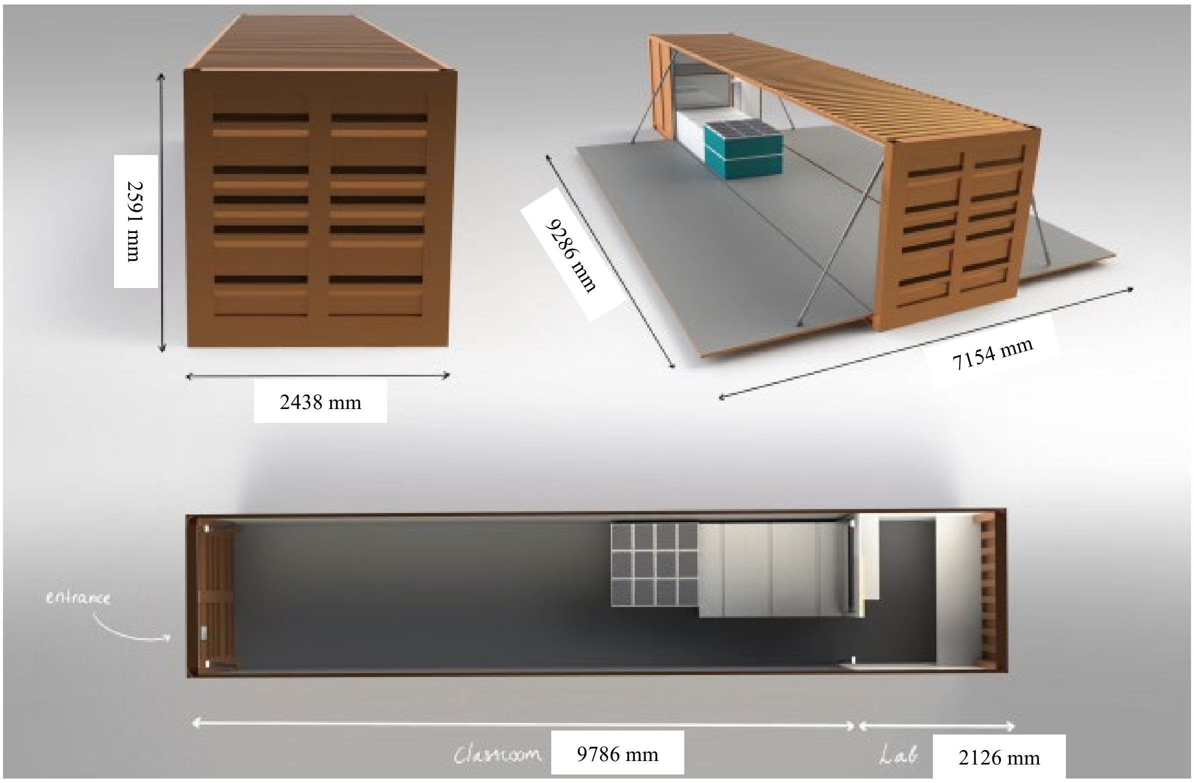

Figure 2. External dimensions of the EduBOX.

Teaching materials

On the other side of the separating wall, a monitor is attached that can be used for online classes or digital teaching material. Below the monitor, there is a whiteboard, which can be pulled upwards in front of the monitor by a sliding rail. This way, the two main components used for teaching can be attached using as little space as possible. Apart from the teaching boards, there will be tablets available for the students in the EduBOX, which allows them to work also independently. Most likely there will be a few spare tablets in case one break or runs out of battery. The tablets contribute to the flexibility of the learning environment, as books and other teaching material can be uploaded and used on the tablets. This way, most education programs can make use of the EduBOX without necessarily having to bring their material.
To provide an internet connection for all tablets and laptops, the container will include a Wi-Fi router.

Work-in-process

Figure 3 shows images of the prototype currently being constructed at the University of Twente. It includes a lab that can be customized to match varying engineering education skills.

DISCUSSIONS AND CONCLUSION

The overall goal of the research project was to offer refugees and people in underserved communities a chance at a better life. Refugees in Jordan, as well as other countries, are currently not enrolled in higher education. The EduBOX project offers these refugees and other people in underserved communities a chance at a better life by providing a learning environment. The EduBOX is a shipping container that has been redesigned into a self-contained, flexible and modular learning space that can easily be transported to places in need. The container is completely self-sufficient, which makes it a great fit for remote, developing and disaster-affected areas. It offers places in need, such as refugee camps or underserved communities, a place that can be used as a learning environment by different TVET or higher education programs. Although the focus throughout this project has been on the implementation of the EduBOX in Jordan, the design is universal and therefore can be used in a different context.

The final design of the EduBOX consists of two unfolding sidewalls, which will increase the usable space within the EduBOX. A canopy structure will unfold with the sidewalls, which completely closes off the container, or can be used as a sunshade when partly opened. This flexibility allows the container to perform in different weather conditions. The lab space is customizable to suit alternative applications for engineering education. It's external dimensions are within those of the international standard which allows it to be transported on top of a flat rack container (ISO,1995). This aspect results in flexibility and ease of transportation and set-up.

The EduBOX is moreover flexible enough in use, so different educational programs will be able to use the EduBOX as a learning environment. Research shows that the rate at which teaching methods change due to societal transformations is different from the rate at which school design can change (Fehlandt, 2017). The design of the EduBOX meets this requirement through flexible furniture that can completely be arranged based on the preferred teaching methods.

This way, it will fit most education programs and can evolve with the societal transformations, which will make the design more durable.

Fig. 3: Prototyping of the EduBOX

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BIOGRAPHICAL INFORMATION

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He is the founder of the Humanitarian Engineering action at the University of Twente and founder and chairman of the NGO EduBOX.
https://www.utwente.nl/en/humanitarian-engineering/projects/EduBOX/

Peter Chemweno is an Assistant Professor in Advanced Manufacturing, University of Twente. He graduated with a PhD in Mechanical Engineering, from KU Leuven, Belgium in 2016. His doctoral work focused on developing maintenance decision support models for managing failure risks of thermal power plants. For recognition of his PhD work, Peter emerged as the Belgium winner and nominee for the PhD thesis excellence award. After his PhD, Peter worked as a postdoctoral researcher at KU Leuven and diversified his research to focus on the assessment of safety hazards of collaborative robots. During his post-doc stay, he developed innovative generic models for anticipating the safety hazards of collaborative robots.

Eva de Wit is currently a master student of the master track Management of Product Development of the programme Industrial Design Engineering at the University of Twente. She is focusing her research work on Design for Education and is involved with the project management of EduBOX. She set up a textile prototyping workshop at the DesignLab of the University of Twente.

Joëlle Steendam is currently a master student in Industrial Design Engineering at the University of Twente. She has generated a conceptual design for EDUbox as a modular classroom in a shipping container for her bachelor thesis.

Ayat Nashwan
Dr. Ayat Jebril Nashwan is an Associate Professor in the Department of Sociology and Social Work at Yarmouk University, in Irbid, Jordan. She was the first female director of Refugees, Displaced Persons and Forced Migration Studies Center at Yarmouk University from 2018 to 2019. Dr Ayat received her PhD in Social Work from the University of Tennessee, Knoxville, College of Social Work. The main research interest area for her is social work with immigrants and refugees. In addition to her teaching responsibilities, Dr. Nashwan has worked in leadership positions with Disaster Health Care clinics that serve Syrian refugees in and outside the camps, presented research at several local and international conferences.

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