



The Portable Portal: An Ecological Approach to Technology-Enhanced Learning in Bangladesh

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May 2021

Abstract

This thesis is an interdisciplinary scoping study of a proposed distance-teaching device and system (the Portable Portal), designed for use in rural Bangladesh. Conceived in collaboration with the Bangladesh-based non-profit Speak Up For The Poor, the system addresses primarily the problem of a lack of qualified English tutors for the charity's approximately 1400 participating young girls and women, distributed amongst some 30 villages.

While this problem is relatively straightforward on the surface, the track record of technology-enhanced learning (TEL) initiatives in Bangladesh is not particularly good, prompting a deeper dive into the historical, environmental, and cultural reasons this is so. This ecological approach draws from the disciplines of engineering and technical development, STS (science and technology studies), and development/education studies to focus on design strategies that don't just produce a working system, but one that creates value in the lives of its users.

Conclusions drawn from this study reveal that although TEL aid initiatives are highly context-dependent, requiring understanding of their unique ecological environment, they are also subject to complex webs of interrelated, "wicked" problems that can derail even the most well-thought-out projects. Long-term monitoring of the impacts of these initiatives is therefore imperative, as is a willingness to adjust and correct course when needed.

Blog Post: a post on the MCT Blog summarizing this thesis, and including a video illustration of the Portable Portal device can be found at: <https://mct-master.github.io/masters-thesis/2021/05/15/paulgk-portable-portal.html>

Acknowledgments

Completing this thesis would have been immeasurably more difficult, if not impossible, without the engagement of numerous actants in my heterogenous network. Some of these (human) actants I single out here for special thanks:

My thesis advisor, Kyle Devine, for guidance throughout, and for introducing me to tools and methodologies that just made sense. Thank you.

Stefano Fasciani, for bringing order to chaos.

Troy Anderson of Speak Up for the Poor, for providing the inspiration for this whole project. Your selflessness and bravery is startling. Thank you for what you do.

Gaute Dahl Wardenær, my MCT colleague, for friendship, conversation, and for being a literal waterfall of brilliant ideas.

Ditto Aleksander Vassdal of Ekko Lydfirmaet, for helping to cut through the clouds in my brain.

All my colleagues in the MCT program. These last two years I have alternated between despair and overwhelm, inspiration and awe. Thank you for helping me understand. I look forward to knowing you all forever.

Erin. My wife, girlfriend, co-conspirator, doctor, guidance counselor, and personal Xanadu. Thank you for patiently listening as I blather on and on about literally everything.

And to my kids, River and Zevon. Sorry dad's been so preoccupied. Let's play!

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1. Introduction

The rise of ICT (Information and Communication Technology) use in education has long been heralded as a transformative revolution in the way students learn, and teachers teach (Young et al 1980; Simpson et al 1998; Goodchild and Speed 2019). In the global North, TEL (Technology Enhanced Learning) has become the norm in many schools, with projectors, computers, digital whiteboards, and other ICT part of the daily classroom routine. While these technologies have yet to become commonplace in countries like Bangladesh, the global spread of internet access via cellular networks coupled with the rapid adoption of smartphone technology has begun pushing the theoretical reach of TEL out from the major cities and into the rural countryside (see: 4.7).

In 2011, the Human Rights Council of the UN declared that, as a catalyst for human development, the internet should be regarded as something approaching a human right, making universal access a priority (UN Human Rights Council 2011). The Sustainable Development Goals (SDGs) of the UN carry this idea further, making ICT a key component of several of its 17 goals, including Goal 4, Quality Education (UNESCO 2015).

The government of Bangladesh, as an active contributor to the SDGs through its involvement in the UN, has integrated the SDGs into its own national agenda. The ruling Awami League party, in fact, has made TEL an ongoing pillar of its platform since its victory in the 2008 national elections (Centre for Policy Dialogue 2007; Bangladesh Development Forum 2010; Islam and Grönlund 2011). Accordingly, the government and international aid organizations have contributed considerable resources to the realization of “Digital Bangladesh” in the nation’s schools. However, problems have plagued the program, including infrastructure (power and internet) unreliability, low technological literacy, equipment maintenance issues, digital exclusion of marginalized groups, language and cultural barriers, corruption, and others (Islam and Grönlund 2011; Khan et al 2012; Rashid 2016; Aziz 2020).

It is into this environment that the central proposal of this thesis is placed. The Portable Portal (PP) is a videoconferencing solution developed in consultation with the educational nonprofit Speak Up For The Poor, to enable distance teaching between a tutor and the many dispersed students served by the charity. While seemingly a straightforward problem, the literature shows that far too many aid projects fail due to poor design, poor oversight, or a combination of both. Therefore, this thesis is undertaken as a scoping study to fully assess the long-term feasibility of the PP system, taking into account the environmental and ecological factors affecting the use of ICT in the educational setting in Bangladesh, and set against a backdrop of intensive engagement from international development agencies, foreign governments, and NGOs. The overwhelming influence of these actors has caused Bangladesh to be characterized as something of a laboratory for the modern aid industry. Despite this, there is a decided lack of systematic research on the long-term effects, outcomes, and implications of all this aid.

1.1 Objective and research questions

The objective of this study is to research and design a self-contained videoconferencing device to be used for distance teaching in rural Bangladesh by the Bangladesh-based nonprofit Speak Up For The Poor. Ample consideration will be given to important contextual information affecting ICT use in Bangladesh, including the country's unique history and relationship with the international aid industry, its government, ecology and environment, cultural factors, and others.

Research questions are as follows:

- What is the architecture of the device? How is it made and used?
- What are the potential pitfalls of deploying ICT such as the Portable Portal in Bangladesh, and how, using knowledge gained from the study, can we avoid or mitigate these effects?

How these questions have been addressed is discussed in the next section, Method and Theory, followed by a summary of the results.

1.2 Method and Theory

This thesis is conceived as a scoping study to ascertain the likelihood that the Portable Portal project could be successfully implemented in Bangladesh. It is interdisciplinary in nature, combining elements of engineering and technical development, STS (science and technology studies), and development/education studies, in an attempt to present a holistic view of the issues surrounding the deployment of educational technologies in the developing world. In this study, the Portable Portal is developed and evaluated as a “virtual” prototype. The construction and evaluation of a physical prototype is to be considered as future work.

Literature from a range of disciplines have influenced and guided the development of this thesis. In the field of post-colonial thought and critical pedagogy, Paulo Freire’s “Pedagogy of the Oppressed” (Freire 1970) has been influential. The main assertion of Freire’s work is that education can, and should, act as an instigator of social change, but only if the education model is broken free from the influence of colonialist models. He strongly rejects what he terms the “banking model” of education, in which students are empty vessels to be passively filled with information, and links it to colonialist models, in which teachers act as oppressors and students as the oppressed. This model persists in Bangladesh today, in which students are not encouraged to take an active role in their own education, merely memorizing facts and figures in order to pass the all-important national tests (see: 4.9). Increased TEL use in the classroom can help to change this paradigm to a more student-centered approach, informing the development of the Portable Portal.

Another important insight from Freire’s work that is quite relevant to this thesis relates to his discussion of oppressors (or, those from the global North, i.e. former-colonist countries; this researcher among them) and their role in helping to liberate

the oppressed. To wit, if an “oppressor” is truly committed to helping, they must make self-reflection an ongoing practice, remaining aware of the presence of unconscious bias and the tendency to impose a colonialist model on the oppressed. At the same time, he calls upon the oppressed to take an active role in their own liberation, while not blindly following the example of colonialist role models (and becoming oppressors themselves, in turn). In this way they can transform education from within, re-forming the relationship between teacher, student and the greater society.

Taking further the necessary roles of both oppressors and the oppressed in co-creating a new reality, Amartya Sen’s capability approach has also proven influential. In “Development as Freedom” (Sen 1999), Sen argues that economic development must include the development of political freedoms, protection from poverty, and other liberties in order to afford human beings the capability to create a life worth valuing. It is not enough to merely look to GDP or rising average incomes as a general indicator of aid success. When developing technological solutions as a means of development, therefore, we must ask whether our solutions enable the growth of capabilities for the recipients of such aid, increasing their ability to achieve value (not primarily *monetary*) in their lives. By introducing ICTs such as the PP into the lives of aid recipients without honoring and involving them in the process, we run the risk of unintended consequences, as will be explored in greater detail in the Evaluation (see: 6).

The idea of co-creation between teacher and student, oppressor and oppressed, aid-giver and aid-receiver that is explicit in the work of both Freire and Sen find resonance in the field of Science and Technology Studies (STS). A central idea of STS, expressed by Madeleine Akrich in her classic essay “The De-Description of Technical Objects” (Akrich 1992) is that our technologies are inseparable from us, and therefore are invested with moral power. Because this is true, we are obligated to not only actively participate in the “scripting” of our inventions, but to actively invite and involve the participation of users, in a process of co-creation. This concept is further elaborated by Peter-Paul Verbeek in “Moralizing Technology” (Verbeek 2011), who goes on to outline three levels of technological

mediation analysis for evaluating a developing technology's impact on its users and their ecology, as follows:

1. Anticipate potential mediating effects
2. Systematically evaluate-from-within
3. design mediations into the technology itself

These guidelines have been used extensively both in the design process and the evaluation of the Portable Portal (see: 5; 6).

Also important in the evaluation of the PP is the ethical-constructive technology assessment (eCTA) framework devised by Kiran, Oudshoorn, and Verbeek, elaborating on Verbeek's three levels of technological mediation and described in the essay "Beyond checklists: toward an ethical-constructive technology assessment" (Kiran et al 2015). eCTA illustrates a method for evaluating the PP system through identifying its hard and soft impacts, both short-term and long-term, to reveal areas where the design may fail its users. This will be discussed at length in the Evaluation (see: 6)

Other works that have informed and influenced this thesis, particularly on the subject of development and its impact on Bangladesh, are Naomi Hossain's book "The Aid Lab: Understanding Bangladesh's Unexpected Success" (Hossain 2017) and Rashedur Chowdhury's essay "(In)Sensitive Violence, Development, and the Smell of the Soil: Strategic Decision-Making of What?" (Chowdhury 2021). In "The Aid Lab", the author explores the roots of the so-called "Bangladesh paradox", explaining Bangladesh-based NGO's success in the face of weak government and recurrent environmental disaster (see: 3.1). Conversely, Chowdhury's excellent essay reveals the dark underbelly of the aid world, describing the visible and invisible violence done to rural farming populations as a alliance of multi-national corporations, government, and NGOs conspire to "develop" their land (see: 3.4).

The evaluation of the Portable Portal concept from a historical, humanitarian, ecological, and environmental standpoint is perhaps the most important aspect of

this study. Recognizing that our technologies do not exist separately from the society in which they are embedded, but are rather part of what Madeleine Akrich terms a “heterogenous network” of many actors (human and non-human), each capable of scripting unintended consequences (Akrich 1992), provides the inspiration for closer examination of the pre-script we are imposing on our supposed beneficiaries. This is undertaken as a systematic analysis of a wide range of literature to identify key issues, obstacles, and gaps in the research, and to better understand the context into which we propose placing our technology. In addition, informal discussions with the founder of Speak Up have been conducted throughout this study to exchange ideas, developments, and knowledge about the specific use-case for which the PP has been designed. More on Speak Up and its role in this work can be found in section 4.10.1.

1.3 Results

It is clear from this study that educational aid solutions can be highly context-dependent, requiring understanding of their unique ecological environment. What works in the global North will quite often not work in the South. Too often aid programs are not well-targeted to their recipients, leading to failure. Even though this study and subsequent development of the PP system has been undertaken with care to attempt to eliminate obstacles to success, analysis of the technology using the eCTA framework reveals numerous weaknesses in the design. These include potential loss of “warmth” via direct interaction between teacher and student, erosion of traditional relational norms in village life, digital exclusion of certain groups, and long-term negative effects related to changing cultural norms in Bangladeshi society in general (see: 6).

Some of these impacts can be mitigated to an extent through redesign or additions made to the design of the PP. Other impacts require long-term monitoring and study by both creators and users, adjusting and correcting course as needed.

1.4 Relevance to MCT

A central component of the Music, Communication and Technology (MCT) master's program is the Physical-Virtual Communication and Music course. This course primarily takes place in the "Portal", a laboratory containing a range of audio-visual communication technology for exploring network-based musical collaboration and communication. This course is compulsory throughout the program with the exception of the last semester, which is dedicated to the Thesis. It is in this course that the concept of the Portable Portal has its roots, and this thesis finds its relevance.

While the focus of this thesis is not explicitly on telematic music, networked musical collaboration, or music education, the technology of the Portable Portal could certainly be used for these ends, particularly in rural and remote areas that suffer from poor power and internet infrastructure. The reason that it is not the focus of this thesis is simply that online musical collaboration is not a major area of concern for Speak Up For The Poor, whereas passing national English language exams is (see: 4.10.1). It is felt that the importance of this mission overshadows the potential musical uses of the PP, though any musical applications are, of course, a welcome byproduct of this work.

1.5 Impact of this study

Access to ICT-enhanced education is widespread in the global North, but this is not the case in many countries like Bangladesh, where even an overhead projector is rarely seen or used in the classroom (Khan et al 2012; Iqbal 2017; Sultana and Haque 2018). The reasons for this, particularly in light of the government's very TEL-positive education policy, are many (see: 4). By studying the complex, contradictory, and often seemingly intractable problems with ICT deployment in Bangladesh's educational environment, those of us proposing to offer solutions can make more informed choices about the design of these technological interventions, and stand a better chance of our inventions actually having a net-positive impact on the lives of

those we seek to help. The Portable Portal system's design is informed by many of the insights gained from this study, though there are undoubtedly many devils still hidden in its numerous details. The only way to reveal and correct these faults is through ongoing evaluation throughout the project's lifetime, from this initial scoping study onward through its subsequent prototyping, field testing, and deployment. Simply dropping more ICT into an educational system ill-equipped to receive it and calling the project a success is all too common in the aid industry (see: 3.4). The time has come to correct this mistake. The impact of this thesis, then, is not primarily to develop a particular technological solution, but to attempt to provide a cogent ecological framework for one.

1.5.1 A note on Success

Declaring an aid project a "success" is a tricky proposition, as the question of what constitutes success is subject to interpretation and can vary considerably depending on the perspective of the various stakeholders. A perhaps better question to ask is whether the project, ultimately, improved the lives of its supposed beneficiaries. To provide just one example, the Makoko Floating School in Nigeria was a rousing success for its designer, lauded for its innovative design and becoming something of a sensation in the international aid arena. However, for the community it was designed to serve it was an abject failure, never hosting a single student and collapsing in a rain storm a few years later (Riise and Adeyemi 2015; The Atavist 2018).

In light of the incompatibility of these evaluations, it can be said that the guiding principle of this work is reflected in the Hippocratic oath: "first, do no harm". The first, last, and most important stakeholder in the process of designing an aid project is the one whom the intervention is meant to help. It is accepted that a successful implementation of technology can have a transformative effect on not only individuals, but on villages, regions and entire societies, as one need only to observe the varied impacts of inventions such as the printing press, silicon chips, and the internal-combustion engine on our world to recognize this truth. Whether

these impacts are good or bad, however, requires further reflection. In many cases, outcomes are a variable mix of both. It is with this understanding that this study is undertaken on the Portable Portal and its potential impact.

1.6 Structure of this thesis

This thesis is conceived in two interrelated parts. Part One presents a thorough overview, discussion, and criticism of the context in which aid is delivered in Bangladesh, particularly in the realm of ICT and TEL. This depth of background information is crucial for gaining a deeper understanding of the unique ecology of the Portable Portal's setting, as this ecology forms a fundamental part of its heterogenous network of actors, both human and non-human (Akrich 1992). Insights are gained from this knowledge that would otherwise be impossible to acquire. Furthermore, taking to mind Freire's elucidation on the role of the oppressor in development (Freire 1970), it is considered imperative to attempt, with humility, to gain some understanding of who the Bangladesh people are, through studying their history, values, and daily reality.

Part Two draws on that knowledge, plus insight gained from discussions with Speak Up leadership to inform the design of the PP. A complete description of the device is made, followed by an evaluation of the design using tools derived from STS described above in section 1.2. It is hoped that by making a thorough analysis of the full problem space affecting the deployment of ICT-as-aid in Bangladesh, the likelihood of a successful implementation of the Portable Portal is increased.

Part One

2. Bangladesh: Background

Understanding a little of Bangladesh's unique history, government, and physical environment is an essential first step to an appreciation of its people, their strengths and challenges. In doing this work, we are better able to perceive our own challenges, through a greater empathetic understanding of cultural norms that affect our project.

In chapter 2, we lay a bit of this groundwork, with a short overview of Bangladesh's history, government, environment, and challenges related to each. This sets the stage for subsequent discussions in chapters 3 and 4 dealing with post-colonialism, development, and education in Bangladesh, before moving on to the Portable Portal system itself.

2.1 The emergence of the independent state of Bangladesh

The modern independent state of Bangladesh emerged in late 1971 after a short but bloody war for independence from Pakistan. With a population greater than 164 million living in a space of 148,460 square kilometers, it is both the world's eighth most populated country as well as one of the most densely-populated.

Bangladesh has a largely homogenous population consisting of 98 percent native Bengalis, the last two percent made up by scattered tribes and ethnic minorities known as Adivasi, a collective term denoting various indigenous tribes of the Indian subcontinent. The dominant language is Bengali, also called Bangla, which is spoken by more than 98 percent of the population as their mother tongue. The dominant religion is Islam, practiced by 90 percent, though Bangladesh is nominally politically secular, with equal recognition for all faiths (Bangladesh Bureau of

Statistics 2011). The ethnic-religious factor is important here, as Speak Up works primarily with the minority Hindu population, and additionally with the Dalit caste (the “untouchables”) within that group (see: 4.10.1), and further with girls and young women. Knowing that we are designing technology for a marginalized group existing inside a marginalized group, with continued marginalization up the line, prompts reflection on the impact of our technology on relational and cultural norms (see: 6).

Traditionally agricultural, the country is rapidly urbanizing as rural populations flock to the industrial centers drawn by manufacturing jobs, particularly in the burgeoning ready-made garment (RMG) textile industry. Bangladesh is currently the world’s second largest exporter of textiles. Other predominantly urban industries include pharmaceuticals, electronics manufacturing, information and communication technology, and ship-building and ship-breaking (or, recycling), all but the first of which strongly affect the state of e-waste in Bangladesh, and hence our approach to designing the PP (see: 2.3.3; 5.5). Outside of the cities, agriculture still dominates, accounting for the bulk of rural jobs.

2.2 Government

While the constitution of 1972 mandates a parliamentary-style democratic government with an elected prime minister and president, the path to true democracy has been rocky. Various coups, periods of martial law, and bitter fighting between the two main political parties has created a great deal of political instability, opening the door to rampant corruption and increasingly authoritarian tendencies on the part of the ruling Awami League (AL) party, in power since 2008.

Corruption in government is endemic to Bangladesh, and its effect on civic life and the environment will be discussed in upcoming sections (see: 2.4; 4.5). Its pervasive influence touches virtually everything in Bangladeshi life, and therefore our project.

2.3 Environment

Here we take a look at Bangladesh's geographical position and topography, and how this creates enormous challenges for its people and government. It can be said that the environment drives policy in Bangladesh, with the result that disaster mitigation efforts by the government have been largely successful (Hossain 2017), but challenges remain, particularly the climate's effect on infrastructure, agriculture, migration patterns, and other impacts. Infrastructure, in particular, affects technological affordances in both cities and rural areas (see: 4.6; 4.7). This has fundamentally affected the design of the PP, as accommodations have to be made to compensate for infrastructure deficits.

2.3.1 Geographical Profile and Challenges

Surrounded by India on the west, north, and east, and sharing a short border with Myanmar to the southeast, the country is predominantly situated on the broad and fertile alluvial plain created by the convergence of the Ganges, Brahmaputra, and Meghna rivers, making up the world's largest river delta. The majority of this land lies less than 12 meters above sea level, making Bangladesh highly susceptible to flooding from calamities such as tropical cyclones and tidal bores.

The effects of rising sea levels and increasing extreme weather events due to global warming combined with high population density, environmental degradation and Bangladesh's natural geographic features have caused the country to be recognized as one of the world's most vulnerable to the effects of climate change (Xenarios et al 2014; Huq et al 2019).

2.3.2 Bangladesh and Climate Change

As Bangladesh emerges as an economic force in South Asia and the world, its fragile environment is of major concern. Its susceptibility to flooding and natural

environmental disasters combined with high population density makes it highly vulnerable to the effects of climate change. It is estimated that sea level rise will displace over 25 million people in the coming decade, depleting former agricultural areas and swelling the already-overburdened populations of megacities like the capital, Dhaka (Rakib et al. 2018).

While the government of Bangladesh has taken steps to mitigate the effects of climate change (MoEF 2009; Bangladesh Department of Environment 2018; Kuylenstierna et al 2020) with some good effect, earning it recognition from the UN Environment Programme, World Bank and others (World Bank 2016; UNEP 2018), rampant corruption has continued to undermine the potential effectiveness of these measures. Recovery efforts are often marred by the misuse of resources, and the already-stricken population additionally burdened by demands of bribes in exchange for services from local officials (Mahmud and Prowse 2012; Rahman 2018).

In the face of disaster the poor take the brunt of the impact, and are the least able to recover from the loss of shelter, land, and livelihood brought on by climate change effects (Rakib et al. 2018). The pressure placed on a chronically exposed population by environmental disaster combined with subsequent exploitation by corrupt officials underlines the ongoing seriousness of the situation.

Corruption and its impacts will be further discussed (see: 2.4; 4.5), but first we will look at the epidemic of e-waste in Bangladesh, itself affected by corruption and “back-room” deals that work to increase the flow of e-waste into the country, and fail to address its environmental impacts.

2.3.3 The Impact of E-Waste in Bangladesh

According to the World Economic Forum, e-waste is “the fastest growing waste stream in the world”, with approximately 50 million metric tonnes of e-waste produced worldwide in 2018. If current growth rates are maintained, this figure will increase to 120 million tons annually by the year 2050. Only an estimated 20 percent of this waste is recycled appropriately (Perkins et al 2014; WEF 2019).

A large part of these growing figures is due to ever-increasing uptake of cell phones, computers and other tech in developing countries. Bangladesh, as a growing economy, is doubly hit by increasing domestic usage and disposal of these technologies, and the import of end-of-life electronics from other countries, which are often imported illegally from developed countries as “second-hand” electronics (Alam and Bahauddin 2015; Mihai and Gnoni 2016). In reality, most of these goods are non-functioning and unrepairable, and end up in the informal recycling economy. This industry employs large numbers of poor people, who break apart the defunct electronics by hand to extract their valuable metals, usually concentrated in circuit boards and their components (Olowu 2012; Rifat et al 2019). These metals, however, are not easily liberated from their circuits without sophisticated recycling apparatus unavailable to those working in informal recycling. The typical method for metals recovery is to either set fire to large mounds of old electronics to burn off non-metallic casings and plastic components, or to dip extracted circuit boards into acid solutions to dissolve them, leaving the metals behind. Both methods are highly inefficient and expose workers, neighborhoods, and the environment to poisonous waste streams of smoke, particulates, and liquid effluent (Olowu 2012; Mihai and Gnoni 2016).

As usual, the poor take the brunt of this toxic stew. Waste dumps are invariably located in poor neighborhoods and those who work in the informal recycling industry are inevitably poor people with few options other than to take the most dangerous work available. The women and young children that make up 30 percent of this workforce are particularly vulnerable, as the accumulation of toxins in the tissues of growing children, in or out of the womb, can have a wide range of extremely deleterious effects (Rifat et al. 2019).

Bangladesh is buried under a mountain of e-waste, and the problem is only getting worse. The growth of the ship-breaking industry has itself led to serious human and environmental consequences due to weak regulation, and further exacerbates the e-waste problem as these incoming ships are loaded with electronic waste, POPs (persistent organic pollutants) and other toxic hazards, while government looks the

other way (Alam and Bahauddin 2015; Nøst et al 2015). Bangladesh's growth as a lower-middle class country with a burgeoning IT sector will only add to the problem, as domestic e-waste streams swell.

2.4 Corruption in Bangladesh, an Overview

According to figures from Transparency International's global Corruption Perceptions Index, Bangladesh ranks as the second-most corrupt nation in South Asia, bested only by Afghanistan (Transparency International CPI 2020). This near-bottom ranking has persisted for decades, despite strong economic growth and generally rising standard of living (Blair 2020).

The current reign of the Awami League (AL) party, under the autocratic leadership of prime minister Sheikh Hasina Wajed, has worked to consolidate its power since its election win in 2008, undermining or abolishing democratic institutions designed to hold back the rise of authoritarian, one-party rule. Harassment, intimidation, and jailing of political opponents, dissidents and journalists, undermining of anti-corruption efforts, control of media and elections, and selective justice favoring the party loyal are the reality in today's Bangladesh (Blair 2020).

The payment of bribes at all levels to "get things done" is endemic and very difficult to root out, making the cost of doing business in Bangladesh one of the highest in the region. Still, there has been tremendous success in the manufacturing sector, driven primarily by the garment industry, though other manufacturing and the technology sector are making gains. However, the high cost of doing business in Bangladesh has the effect of suppressing the entrepreneurial spirit of the people and exacerbating inequality, as only the wealthy can afford to start a business in the first place (Asadullah and Chakravorty 2019).

Studies of governmental corruption's effect on the economic growth of countries strongly suggest that Bangladesh's current growth could be even stronger if corruption were excised or greatly reduced. It is estimated that a reduction in

corruption to the level experienced by Poland or Hungary could increase the growth rate in Bangladesh by more than two percentage points (Kisunko and Kapoor 1999). The resilience and sustainability of Bangladesh's roaring economy is impacted negatively by the effects of widespread corruption, leaving it vulnerable to changing conditions in the international marketplace and the environment (Mahmud and Prowse 2012; Asadullah and Chakravorty 2019).

Whether the negative effect of entrenched corruption will impact Bangladesh's growth in the future is somewhat of an open question, but the past history of economies in East Asia suggest that as a country grows in wealth, incentives to root out corruption grow concurrently, as shown by the example of Japan and South Korea, both of whom grew from autocratic regimes into relatively stable, prosperous democracies as material wealth increased. (Asadullah and Chakravorty 2019).

The pervasive reach of corruption extends to the development sector as well, driving its growth due to the failure of government to provide basic services, but also affecting aid projects directly through corrupt practices in aid itself (see: 3.2; 3.4). Designing technological mediations directly into the PP to mitigate the impacts of corruption is a difficult task, but by making our technology open-source, available to all, and monitoring its impacts, we can make a start.

Next we consider the aid industry itself, its successes and failures, and its relationship to our project.

3. Post-colonialism and development work

In the years since the retreat of colonialism, formerly-colonized countries around the world have regained their statehood, but the after-effects of years of subjugation continue to reverberate. Having been stripped of their resources, self-agency and institutions and then summarily abandoned, the descent into some sort of chaos was all but inevitable (Betts 2004). Not surprisingly, problems of poverty, violence,

political instability, corruption, and environmental degradation plague many former colonies to this current day.

A full accounting of the abuses of colonialism goes well beyond the scope of this section; we will focus on aid in Bangladesh with the understanding that the impact of colonial modes of engagement are still quite relevant in the aid industry today, affecting the flow of resources from “fat” countries to “lean”.¹ This includes the project of the Portable Portal. Being aware of the colonial bias implicit in certain exclusionary practices in aid (see: 3.2) is critical to the way we approach our project.

3.1 The role of aid in Bangladesh

Bangladesh is home to a huge number of non-profit organizations that provide essential services to the population that the government is unable, for various reasons, to deliver (Zohir 2004). The number of NGOs working formally and informally in the country is in the tens of thousands, with a range of objectives including micro-finance, education, gender equality, food security, health, and sanitation (Smillie 2009; Islam 2016b). The sector is particularly robust in Bangladesh, with the poor, in particular, relying on various NGOs for a wide variety of services.

¹ When discussing the relationship between formerly-colonized countries and their former colonizers, it quickly becomes apparent that the usual terms such as “third world”, “developing world”, “global South”, and “low-income countries” all have problems, being either imprecise, stigmatizing, or outright offensive to many of the citizens of countries these terms attempt to describe. While there may be no perfect terminology, acceptable to all, we like Nigerian-American journalist Dayo Olopade’s way of describing countries as “fat” or “lean”. In Olopade’s view, A “lean” country can be thought of like a tech startup with limited finances. This perspective opens the way toward innovation, empowering those dealing with scarcity to seek the maximum impact from minimal resources (Olopade 2014)

Famously labeled “an international basket case” by an unsympathetic U.S. State Department (in a quote incorrectly attributed to Sec. of State Henry Kissinger²) after its war of independence from Pakistan (Keys 2010), Bangladesh has international aid largely to thank for its current state of success (and also, failure. See 3.2). Creating the conditions in which aid could thrive, however, wasn’t necessarily a given; some credit has to be given to the government and the country’s elites for opening the door to international aid by liberalizing the economy and embracing the World Bank and the UN’s progressive mandates. The mechanics of how this came about is known (Zohir 2004; Lewis 2010; Islam 2016a), but exactly *why* Bangladesh became the international poster child for aid success hasn’t been widely studied. In “The Aid Lab”, Naomi Hossain argues that the single biggest factor driving Bangladesh’s pivot toward the international development community in the 1970’s was the extreme sensitivity of its large population to environmental disaster, food insecurity, and famine (Hossain 2017). After the devastating famine of 1974 in which up to 1.5 million of the country’s rural population starved to death, followed by political unrest, assassinations, and a period of military rule, the country’s elites came to a consensus that the price of famine and catastrophe to their own interests was too high to allow to happen again. This consensus has survived despite the highly toxic political atmosphere and extreme rivalry between the two main political parties (Hossain 2017).

The role that NGOs play in Bangladesh has an undeniably large impact on the life of its people, much of it positive. That is not to say that there are not negative effects. In the next section we will discuss the downside of the aid industry, its negative impacts on both governmental accountability and the personal agency of the population in general. In the final section of this chapter, “Cautionary Tales”, we look at a variety of examples illustrating the ways in which poorly-designed aid projects can fail their recipients.

² It was Undersecretary for Political Affairs U. Alexis Johnson, though Kissinger added, “but not necessarily our basket case” (U.S. National Archives 1971).

3.2 Criticism of foreign aid, power relationships

The grand experiment of Bangladesh as a laboratory for NGOs has not been without criticism. The question of accountability has been raised in light of the tremendous growth and influence these organizations, with their reliance on foreign donors and the government itself for funding, leading to possible conflicts of interest between donors and the beneficiaries of the NGO's actions (Ahasan and Gardner 2016). Rarely are beneficiaries given a say into how the NGO conducts itself (Khan 2003).

In the relentless drive for development, NGOs often find themselves caught between donors and supposed beneficiaries. Multinational corporations (MNCs), seeking to acquire land for extractive development, seek partnerships with NGOs to help them present their objectives as beneficial for the communities these developments will disrupt. MNC funding of the NGO is accompanied by the promise of jobs, health centers, schools, electrification and prosperity, and the negative social and environmental consequences of, for example, open-pit strip mining are downplayed and minimized. The result of this kind of MNC-NGO partnership is very often extremely destructive to local communities, leaving social and environmental devastation in its wake, and very little prosperity for any but the MNC (Ahasan and Gardner 2016; Chowdhury 2021). In this case, the NGO's pursuit of development as a kind of holy grail for poverty relief doesn't reflect the lived reality of those actually living in poverty.

The foreign aid programs of former-colonizer governments, international agencies like the IMF and World Bank, and NGOs alike have been criticized for preserving the colonizer-colonized status quo through practices that deny the personal agency of those they are presumed to help. The over-reliance of "lean" countries on the the financial support from "fat" creates a dependency relationship that mirrors the old colonial bonds. (Bandyopadhyay 2019). Furthermore, the near-impenetrability of aid bureaucracies renders the efficient disbursal of aid to where it is most needed nearly impossible, creating a system that wastes billions of dollars a year with little to show for it (Easterly 2002; Chowdhury 2021).

The pressure on aid agencies to have something to “show” for their effort can also have the effect of agencies funneling money into projects that have maximum visibility, such as building schools and hospitals, and ignoring less-visible but no-less-important tasks such as ensuring students have textbooks and medical professionals have needed equipment and other supplies. Grand infrastructure projects are often initiated, such as building roads and bridges. This makes for great optics but all too often these structures, once completed, are left to simply dissolve back into the jungle, with no resources allocated to their repair and upkeep (Easterly 2002).

Most egregious in the development aid arena is the failure, on the part of aid organizations, to fully involve the aid's recipients in the design and implementation of projects meant to benefit them (Freeman and Schuller 2020; Chowdhury 2021). One of the more pernicious residues of colonial thinking is the idea that the global poor must be rescued from themselves. Because their condition must be due to some deficiency in ability, it is therefore necessary for the aid-giver to act as a kind of benevolent parent and “guide” them into a correct way of being. The effects of this paternalistic attitude are solutions that are not well-fitted to the unique needs of a community, and are often doomed to failure (see: 3.4).

3.2.1 Aid and the white savior complex

One particularly noxious problem with the modern paradigm of international development aid is what Nigerian-American novelist Teju Cole termed the “White Savior Industrial Complex”³ (Cole, 2012). Cole describes an environment in which aid organizations and the media, through depictions of the global South and its inhabitants as hopelessly backward, terminally impoverished, and inherently helpless reinforce the idea that they must be saved from themselves. This flawed perspective gives rise to the idea that the only thing that can “save” the global South is the privileged North, with its superior ideas, education, and technology.

The rise of so-called volunteer tourism or “voluntourism”, which encourages a kind of shallow, temporary engagement with the global South, amounts to little more than a selfie and a self-administered pat on the back on the part of its practitioners with very little positive result for the supposed recipients of this benevolence. The most visible offenders of this approach are easily satirized (for an example, see “Barbie Challenges the ‘White Saviour Complex.’”), but the lack of nuance can do real harm (Richter and Norman 2010; Wearing et al 2018; Bandyopadhyay 2019).

The one-sided depiction of a savage world of starvation, deprivation, and despair may make for good fund-raising optics, but it does a tremendous disservice to the people actually living and working in lean countries. Their contributions, successes, resourcefulness and ingenuity is simply ignored, as is their personal dignity and fundamental right to choose their own path. In this scenario, rather than embodying Amartya Sen’s ideal of development as being rooted in allowing people the capability of choosing their own destiny (Sen 1999), development becomes just another tool of oppression.

It is true that a great deal of aid, whether it be money, goods, or “expertise”, tends to flow from global North to South, fat to lean, former-colonizer to the formerly-colonized. However, this vast river of aid carries with it certain expectations on the part of the aid-giver, not least of which is the expectation of unquestioning compliance (Kanbur 2006). The tendency of aid organizations to not actively involve the recipients of aid in the design and implementation of programs for which they are (or should) be the primary stakeholders is a direct consequence of a savior

³ While undoubtedly most of those whom fit the description of Cole’s “White Savior” are in fact caucasian, the unifying component is more about background, i.e. coming from a global North perspective marked by certain privileges, and not taking the time to reckon with this privilege and how it colors one’s perspective on the developing world. Cole, in his original series of tweets introducing the term “White Savior Industrial Complex”, notes Black media personality Oprah as a participant in the “Complex”.

mindset. This mindset denies aid recipients their personal agency, and reinforces the old colonizer-colonized bonds in which Eurocentric domination of the colonized is justified as a moral right (Flaherty 2016).

For global-North individuals working in the aid arena, coming to terms with the implications of the so-called white savior complex involves a journey into what the Brazilian philosopher and educator Paulo Freire called “critical consciousness”, an process of reflection in which the practitioner calls into question her own privileged mindset (Freire 1970). This is not a one-time practice, but an ongoing pursuit for those committed to the service of a community whose culture and capabilities are different from one’s own. Even for those practitioners committed to Freire’s concepts, it is a lifelong process of continual learning, with many mistakes, new insights, and corrections along the way (Straubhaar 2015).

While it is a complex problem with many facets and a deep historical context, and one reaction might be to ignore the problem or even simply give up, raising the issue of White Saviorism is not meant as a self-defeating incentive to not help when help is due. As an ethnically white member of the global North, it is this researcher’s view that the proposal of the Portable Portal, a technology developed in the North but intended for use by the South, would be incomplete without a thorough evaluation of the full problem space, including the unconscious but very real biases of its creators. This evaluation is not, however, to be considered complete. The PP is only a proposal, having not yet been deployed in the field. Without the input, guidance, and criticism from those for whom it is intended, the technology cannot be considered fully evaluated. This input should be regarded as essential to the success of any aid project, even if it ultimately results in the project’s rejection. This is not to be seen as failure, as technological innovation is an iterative process everywhere except, it would seem, in international aid projects where the pressure to show “positive results” overpowers the actual needs of a community. For the PP, rejection is merely a confirmation of the need to evaluate, with the full involvement of all stakeholders, and refine our technologies until the true solution is revealed.

3.2.2 The Problem of Evaluating Aid Projects

Returning to Verbeek's three levels of technological mediation analysis discussed in the Methodology, we can note number two in the list, "systematically evaluate-from-within" (Vebeek 2011). We consider this a central value to the PP project, as it is only through thorough evaluation that we can truly know if our interventions produce value for their recipients. Unfortunately, for many aid projects, proper evaluation is lacking as there are strong disincentives to filing negative reports. The transformation of international aid from financial support given to governments to the modern form in which aid projects are controlled and curated from beginning to end by the aid-giver(s)⁴ has resulted in the growth of an ecosystem within the aid arena entirely dedicated to the maintenance of relationships between donors, NGOs, and/or sub-contractors that carry out the work of the project. In order to secure funding, NGOs and sub-contractors must be able to prove their ability to carry out the project successfully. Success is "proven" through documentation, both internal and external, i.e. from inspections coming from the donor network (Easterly 2002; Freeman and Schuller 2020).

Generally, a project will be deemed "successful" if its most visible element is completed, i.e. the school building or public toilet was physically built. As a successful project becomes a prerequisite for future consideration for more projects, this leads to the near-fetishization of documents as perhaps the most valuable product produced in the process. The *actual* success or failure of the project itself is much less important than the *appearance* of success (Freeman and Schuller 2020), never mind that the World Bank-funded, award-winning school building collapsed in a rain storm after sitting unused for several years, in the case of the Makoko Floating School in Nigeria (Riise and Adeyemi 2015; The Atavist 2018) or the new public

⁴ This transformation arose largely from the perception (true in some cases) that aid funds were being misused by corrupt governments (Freeman and Schuller 2020), but the well-worn colonial themes of control and dominance are clearly present here as well.

toilets stopped working after a few months and the building was repurposed as an ad hoc church, in the case in Kibera, Kenya (Devex 2019).

Often it is left to independent journalists to uncover the truth about these failed projects (see *The Atavist*, *Devex.com*, *Givewell.org*, etc.) as it is simply not in the interests of aid organizations to admit it when things aren't working, when time, effort, and vast sums of money come to naught. However, studying failure is one of the most important things the international aid community can do in order to better serve the world moving forward.

There are some scholarly research papers from independent sources, critical of aid programs, from various sources that makes for arresting reading (see Easterly 2002, Husain and Kolesar 2018, Freeman and Schuller 2020, Chowdhury 2021). Hopefully the future will see more research of this nature, as it is essential to the survival of international development aid, not to “wallow in negativity”, but to make a clear-eyed assessment of the weaknesses of their programs so as to make the necessary changes to strengthen them.

3.3 Corruption, capacity, and incompetence in local governments

The blame for the failure of development aid to hit its targets is not to be borne by aid agencies alone. Many lean countries suffer from weak institutions, government corruption and lack of skilled ministers and bureaucrats, in addition to limited budgets. These factors make the administration and delivery of basic services an ongoing challenge. Adding in the bureaucratic requirements of international aid coordination, which typically involves negotiating a bewildering and impenetrable thicket of paperwork, reports, and other bureaucratic machinations, and the already-overburdened governmental clockworks are liable to grind more than a few gears into oblivion in the process (Easterly 2002).

The problem of capacity development can be attributed, at least partially, to the perverse effect of NGOs on the functioning of local government. By operating as a

kind of “shadow government”, NGOs lift much of the burden of providing services to citizens. This effect is particularly true in Bangladesh, with its huge number of NGOs (Riddell 2011).

3.4 Cautionary tales

A thorough consideration of potential pitfalls is essential before embarking on any aid project, particularly when failure could be detrimental to the health and well-being of its presumed beneficiaries. Looking under the cheerful surface of many aid projects reveals a darker reality, where failed aid projects do far more harm than good. In Africa, an initiative to install “PlayPumps”, a merry-go-round-style water pump that was intended to make pumping the village’s water literally child’s play resulted in conditions more akin to child abuse than play, as the pumps were inefficient, difficult to operate, and not at all fun (Graham Saunders and Borland 2013). In Bangladesh, thousands of water wells were drilled to provide the population with clean drinking water and save them from microbe-contaminated surface water, resulting in the largest-scale arsenic poisoning in history as the wells were not tested for arsenic (Smith, et al 2000).

Darker still, researcher Rashedur Chowdhury describes the actions of a large multinational corporation as it attempts to claim the land of village farmers in rural Bangladesh for a strip-mining operation. Working in tandem with government agencies and NGOs recruited to sell the supposed benefits of “development” to the villagers, he traces the visible and invisible violence done to communities as their way of life is destroyed and the promise of a better life never materializes (Chowdhury 2021).

The potential failure of a project such as the Portable Portal could seem benign by comparison, but ICT-as-aid is not immune to negative effects. Numerous potential negative outcomes or side effects from ICT initiatives can be identified (this is not intended as a comprehensive list):

- Misappropriation of educational tech for unintended purposes
- Unwanted marketing-to by multinational corporations
- Digital exclusion
- Online exposure to misinformation, exploitation, pornography, and violent content
- Tech addiction
- Mental health issues
- Environmental damage from e-waste

Many, if not all of these outcomes have the potential to inflict real damage on the end user if not fully understood and controlled.

3.4.1 Misappropriation, marketing, and violence

Two large-scale initiatives that attempted to integrate ICTs into educational settings, Computers for Education and One Laptop Per Child (OLPC), clearly illustrate the downside of introducing computers into classrooms (Ames 2016; Barrera-Osorio and Linden 2009). In both cases, computers were donated with the express purpose of enhancing learning. The end results show that they were used for anything but actual learning, at least of the academic kind. The most common outcome of OLPC, among the 1/3 of laptops that didn't quickly stop working or were rarely or never used, was that they were repurposed as media machines for downloading video games, music videos, and the like. As the laptops had relatively small hard drives, children simply deleted the educational content to make room for more media. The children using the machines also found themselves being marketed to by transnational corporations such as Nestle and Nickelodeon, the latter of which even entered into a content-creating agreement with OLPC. Older children visited pornographic or violent websites, and shared the content with other children (Ames 2016). This last point, especially, was raised as a concern by Speak Up's founder, as the device is to be used in the context of conservative village culture, and the danger from the perception of there being "immoral content" associated with the PP and Speak Up could be a serious problem.

In the case of Computers for Education a more limited engagement with computers was designed, where computers were directly installed in classrooms. In this case, the main outcome (or perhaps, lack of outcome) was that the computers had no statistically-meaningful effect whatsoever on learning. Teachers and students simply didn't use them for their intended purpose, though the most corrosive effects apparent in the OLPC project were avoided as the computers were used only at school, not owned by the children themselves (Barrera-Osorio and Linden 2009).

3.4.2 Environmental impacts

The fact that a majority of these computers either broke early on or were not used at all underscores the problem of e-waste, which is an issue worldwide but especially in lean countries, where this waste invariably comes to rest. An unused ICT is not merely a benign lump of plastic and metal; it represents a long and tangled chain of extractive industries, high-polluting smelters, refiners, and component manufacturers, energy and transportation infrastructure, and wasted human labor. This chain finally nears its end in the scrap-pile, where e-waste slowly leaches toxins into the environment while it waits to be burned or otherwise "recycled".

Most of this long chain of extraction is invisible to the consumer, as the actual use of an ICT for its designed purpose is only a small fraction of its life cycle. Certainly, one way to cut down on the damage inflicted by this chain of extraction is to not create artificial demand for ICTs in the first place. Unused ICT should be seen as something approaching a tragedy: a squandering of multiple finite resources coupled with incalculable environmental damage (see sections 2.3.3 and 5.5, respectively, for more on the impact of e-waste and possible strategies to mitigate this impact in our design of the PP).

3.4.3 Mental health and tech addiction

The subject of “screen time” and its effect on mental health, particularly with children, has received a lot of press in the developed world in recent years. Trouble with cognition, depression, poor health, behavioral problems, sleep problems, and anxiety are among many documented effects (Domingues-Montanari 2017; Hutton et al 2019; Wong et al 2020). It is no surprise that the negative effects being observed in the developed world are spreading to other countries that have begun their adventure with ICT. Several recent studies in Bangladesh reveal a familiar litany of negative effects arising from ICT and internet usage, including addiction, depression, poor sleep, and antisocial behaviors (Khan 2017; Khan et al 2018; Akhter et al 2020; Sayeed et al 2020).

3.4.4 Misinformation and hate speech

The upward trend noted in mental health issues, associated with increasing screen time, extends beyond the individual and into society with the rise in online misinformation and hate speech. The creators of social media technologies have only begun a (forced) reckoning with the impacts of their inventions, with various digital policy reforms being proposed in the E.U., the U.S. and elsewhere. However, the spread of misinformation through social media has by now well-known negative impacts in the developed world. Studies have shown that a lie, disseminated via social media, will travel significantly faster, farther, and penetrate deeper than the truth, in particular if it provokes fear and outrage (Vosoughi et al 2018). This trust-eroding phenomenon, brewed in the digital cauldrons of the global North, is now being unleashed on the South.

In 2017, just across the southeastern Bangladesh border in Myanmar, a brutal genocide against the Rohingya ethnic group and the resulting refugee crisis was driven by online hate speech and false information propagated by the country’s military rulers (primarily on Facebook), only a few years after the country “came online” after a loosening of its repressive telecommunications laws. A UN Human

Rights Council report released the following year highlighted the role social media played in the crisis (Human Rights Council 2018).

It is of utmost importance that the potential for the dangerous spread of misinformation be addressed by those who create ICTs for new markets. This includes the PP, which, while unable to access social media by design, nevertheless has the potential be misappropriated and made into a media device, as happened with the children's laptops in the OLPC project.

The question of how, or whether, we protect new users from the pitfalls of online misinformation and hate speech is more relevant than ever. In October of 2020, this author took part in UNESCO's online conference "Beyond Disruption: Technology Enabled Learning Futures". Given the opportunity to ask questions of the panelists, he directed the following question to Paola Leoncini Bartoli (Director, Cultural Policies and Development, UNESCO): "How do those of us working in technology-enabled learning reconcile respect for cultural diversity with online misinformation and hate speech?" Her response follows:

P.L.B.: "Starting from the point that digital development should be for all with a policy of open access, the ways that we can counter hate speech and misinformation are multi-dimensional. The first one is certainly through education. Education, education, education. The second is, of course, upholding democratic values. Democratic values run against hate speech, against rejection of the other..."

There are three more pragmatic dimensions that have to be taken on board, in particular by governments but not only them, but by civil society and by the private sector. These are the role of the media - what is the role of the media in being able to fight hate speech? Media plays a very important role. Together with this, there is the principle of media literacy. Avoiding stereotypes . . . media literacy should embed respect for cultural diversity. Cultural diversity does not mean the violation of human rights, individual and collective, and so again, education means also enhancing awareness to what are the fundamental human rights.

And lastly, the famous buzzword which is regulation. Regulation needs to follow.”

It would seem that the use of ICT in education entails yet more education, not only on the basics of digital literacy but on a litany of concomitant dangers such as hate speech, misinformation, tech addiction, and many others. Expecting the media and civil society to police itself on misinformation is a very tall order, considering the potential power, political and otherwise, that can be harnessed by a well-placed lie.

This leaves us with the final point, regulation. Presuming that Ms. Bartoli means governmental regulation, exactly what that looks like, how it is implemented, and what it affects largely remains to be seen. But clearly, governmental regulation has its limits, in light of situations like that in Myanmar in which misinformation and hate speech are central to the government’s own objectives. In more open societies, regulators must walk a careful line between the often-competing interests of free speech and public safety when developing rules to govern the online world.

For those working in technology-enabled learning, the path forward is not always clear. Many codependent factors can present both positive and negative aspects, depending on the angle from which they are viewed. Many effects are difficult to predict, and causes only become obvious in the aftermath. In the social sciences, this is often referred to as a “wicked” problem. When developing ICTs for education, being conscious of the problem’s wicked roots does not always mean that ill effects can be avoided, but with preparation and follow-through the worst effects can perhaps be anticipated and alleviated to some degree.

3.4.5 Digital exclusion

Equality of access to ICTs is found to mirror existing power structures in many countries, with power elites enjoying the great majority of the access. In Bangladesh, the digital exclusion of women and the poor only serves to widen the

social-capital gap between the powerful and the powerless (Rashid 2016; Ullah 2017).

Since equality of access for all citizens, with special attention to women and girls, is a pillar of Bangladesh's policy on ICT (not to mention the UN's Sustainable Development Goals, on which it is at least partially based), this problem is of particular concern. Ensuring that women and girls enjoy equal access to technologies is not simply a matter of opening another Union Digital Centre (UDC) in another village, and calling the matter settled. Despite progress, social and cultural factors in Bangladesh still largely serve to reinforce the idea that computers are for boys, not girls, discouraging many females from attempting to gain access (Hossain and Beresford 2012; Saifuddin et al 2019). Being poor and low-caste in addition to female almost guarantees digital exclusion regardless of how much ICT is promoted by the government.

Overcoming this bias takes time. Presenting school-age girls with opportunities to increase their digital literacy, while not a direct goal of the Portable Portal, is a desirable side effect. Its utility, approachability, and bespoke design is hoped to encourage regular use, and through that use engender a comfort with ICT, leading to greater confidence with technology in general.

3.4.6 The myth? of TEL

For the last several decades, technology enhanced learning, or TEL, has been held up as the gold standard of education toward which all educational systems must strive (Young et al 1980; Simpson et al 1998; Goodchild and Speed 2019). The legitimacy of this standard is nearly unquestioned, as the benefits of TEL in the classroom are accepted by most as a matter of settled science. The push toward ICT-enabled classrooms forms a fundamental pillar of the UNESCO implementation of the UN Sustainable Development Goals on education (UNESCO 2015) and is a key component of education policy in Bangladesh and many other countries.

But is all this TEL-evangelism actually improving educational outcomes? It depends on who you ask. Notably, the most glowing reports come from the purveyors of ICT themselves, as a cursory glance at the web page of any educational technology provider will reveal. Most academic studies of ICT adoption in the classroom blame the poor outcomes on external factors, including those studies cited in this report (see sections 4.4, 4.8, 4.9). Most commonly, teachers and students themselves take the blame for failing to properly understand and implement ICTs. Rarely is TEL itself taken to task. Only one recent study attempts to break the silence on TEL criticism, interviewing both teachers and students at a UK university (a fully TEL-equipped environment) on their views toward technology in the classroom. None of the subjects could describe any way in which TEL definitively enhanced the learning experience, only vague notions such as “it’s expected” and “it’s always been this way” (Goodchild and Speed 2019).

ICT in education is often portrayed as a disruptive force, poised to revolutionize and positively transform the very underpinnings of education, but the old pedagogical challenges seem quite resistant to change. After all, students are still required to apply themselves to learning, and teachers must still teach, regardless of whether they use an interactive whiteboard or old-fashioned analog chalk. The technology can either assist, or get in the way.

Clearly, more systematic study in this area is urgently needed. The vast resources being bent to the task of single-mindedly putting a computer into the hands of every student in every country of the world is no doubt cause for celebration in the boardrooms of multinational corporations around the globe, but should give every serious aid worker and pedagogue pause, if not heartburn.

3.4.7 Wicked problems

In the prior sections, we have considered many potential negative impacts arising from technological aid interventions. Circling back to the theme of identifying pitfalls in ICT aid projects, the dangers inherent in technology could seem overwhelming.

But nascent Luddism aside, it is imperative that those working on any kind of aid project make themselves aware of the issues and, like a good doctor, first strive to do no harm.

Solving the educational crisis for the poor and marginalized has proven to be resistant to easy solutions. It is one thing to dream up a marvelous solution to a wicked problem and quite another to implement it successfully, as we have seen from the above examples. Many have fallen into the trap of reductive thinking, overlooking the complexity of a given problem which leads to the formation of what Gras refers to as “non-opportunity beliefs” (Gras, et al 2020). These beliefs lead one down the path of failure, creating solutions to problems that lie on top of problems for which there are no solutions.

The question of “who’s lives are we improving?” should lie at the top of the list of questions we ask when evaluating any aid project. If the answer isn’t first and foremost the poor, the overlooked and marginalized, we must reassess. Furthermore, if we simultaneously provide aid while systematically denying the agency of those we presume to be helping, our grand solutions will fail and our wicked problems will persist.

4. Education in Bangladesh

In this chapter, we turn our attention to the subject of education in Bangladesh. As the Portable Portal is an ICT device expressly designed for technology-enhanced learning, it is essential that we gain an understanding of Bangladesh’s educational system and its challenges. By connecting educational issues back to the cultural, governmental, environmental, and infrastructure challenges described previously, we begin to “connect the dots” relating to the PP and its ecological setting within Speak Up’s GEP (see: 4.10.1). We start with what could be regarded as a rhetorical question, “why educate girls?”, but the answers to this question go beyond just fairness or economic advantage, with impacts that extend deep into the core of a prosperous, sustainable society.

4.1 Why educate girls?

The education of girls and women is often held up as the key to progress, economic and otherwise, for the developing world. Entities such as the UN, World Bank and others have made girls' education a cornerstone of their development goals. The World Bank, for example, has identified numerous positive effects arising from girls' education, particularly at the secondary and tertiary level. These include increased earnings and standard of living; better physical and psychological health; reduced child marriage, early childbearing, and overall fertility; greater agency and decision-making ability; and increases in altruistic behaviors and political capital (Wodon et al. 2018).

The UN has identified gender equality and universal education as two of its 17 Sustainable Development Goals (SDGs). The SDGs are a framework of broad, interdependent goals toward a more sustainable, equitable world, intended to be achieved by the year 2030. Equity in education is highlighted as integral to achieving a "better and more sustainable future for all" (UN General Assembly 2017).

There have been many studies over the years attempting to gauge the impact of female education on the GDP of countries, with widely varying results from negative or no correlation (Barro and Lee 1994; Pegkas and Tsamadias 2017) to very positive correlation (Oztunc, Oo, and Serin 2015; Hassan and Rafaz 2017). The reasons for this discrepancy may have to do with faulty statistical methodologies in some earlier reports, or from other extenuating factors such as a country's overall poor economic performance resulting in a lack of available high-skill jobs for an overeducated workforce (Pegkas, P. and C. Tsamadias 2017). Regardless, GDP is only one part of the overall picture.

Indeed, when considering the overall impact of female education on a country, it is not sufficient to focus only on the metrics of workforce participation and increases in GDP. The costs of low educational attainment go well beyond loss of financial productivity, with strong negative effects on fertility, maternal and childhood mortality, psychological health, personal agency, and other factors that create drag on a

country's wealth engine (Sheikh and Loney 2018; Bhowmik et al. 2019; Zafar 2019). Even if an educated woman chooses (with an emphasis on the *choice*) to marry, "stay at home" and assume the traditional role of mother and home-maker, the chances are good that her education and its positive effects on female empowerment will result in better health for herself and her family, greater decision-making ability, lower fertility, and even reported increases in altruistic behaviors; these factors make her an equal partner with her (presumably) bread-winning husband, supporting him in his traditional role as provider.

The creation of an equitable society can therefore be seen as a prerequisite to a maximally profitable and, more importantly, sustainable one.

4.2 A note on empowerment

When talking about the effect of education on disadvantaged women, the term "empowerment" is often used, but care must be taken with this term. In "Western" society, an empowered woman is typically seen as independent, powerful, and the equal of men. The way this state of parity is achieved is through education and the elimination of barriers that reinforce gender disparities. However, it is not always so clear-cut in traditional South Asian societies. Independence is a relative concept here. Because of the powerful role that family plays in a young woman's life, no level of education will likely replace the sense of duty that many feel toward their family. In particular, duty toward one's parents is particularly strong, as the support of the parents is absolutely critical to enabling a woman (in particular, a poor woman) to achieve high education. Parents that place a priority on education for their daughters are rare, as it often entails a sacrifice in the near term of both money, social capital, and lost labor. This has the effect of putting great pressure on their educated daughters to perform in the long term. The sense of indebtedness and obligation to "repay" her family felt by the educated woman can result in seemingly-paradoxical feelings of disempowerment, although this is balanced to a degree by the increased trust, power, and respect she wields in the family (Guinée 2014).

It can be said that with the Portable Portal, we wish to empower poor and marginalized women in Bangladesh's rural villages. But what, exactly, is meant by the term "empowerment" depends on one's cultural perspective. As noted in 4.1, studies of education's effects on women show strong positive correlation in the areas of fertility, maternal and childhood mortality, psychological health, personal agency, familial health, and others (Sheikh and Loney 2018; Bhowmik et al. 2019; Zafar 2019). We can certainly regard this as a kind of empowerment, though it may come at the price of greater indebtedness to one's parents. We can also observe that, in the Guinée study cited above, the subjects were all relatively young women in Bangladesh and Nepal, between the ages of 10 and 34. As we will see in the following section, educational attainment positively correlates with increasing life satisfaction as one ages. We can draw a strong inference here, deducing that increasing life satisfaction correlates with increasing feelings of empowerment, however one defines it.

4.3 Education and life-satisfaction

Research on life satisfaction often shows no correlation (or sometimes, negative correlation) between educational attainment and happiness, which is often attributed to increased expectations (both internal and external) that can be challenging to fulfill. However, recent research suggests that life satisfaction builds over time, and that well educated subjects report increasing life satisfaction throughout their lives, as opposed to generally-decreasing happiness among the uneducated (Nikolaev and Rusakov 2016).

While education and monetary income are often correlated, and higher income is positively associated with increased happiness, this is only one factor contributing to life satisfaction. Education and its positive effects on personal autonomy, social capital, connection to one's community and to the wider world, and greater understanding of one's place in history all contribute to greater feelings of life satisfaction (Chen 2012).

4.4 Digital Bangladesh in the educational sector

Moving on from the more abstract considerations in the prior sections, we now get to the nuts-and-bolts of Bangladesh's educational sector. First, we discuss the government's vision of Digital Bangladesh and its broad impacts on the educational sector, then, in subsequent sections, take a closer look at the cultural, infrastructural, and knowledge-deficit impediments to its widespread success.

The ruling Awami League's "Vision 2021" was a central part of its platform prior to its victory in the national elections of 2008 (Centre for Policy Dialogue 2007). This ambitious plan envisioned the country attaining middle-income status and eradicating poverty by the year 2021, the 50th anniversary of Bangladesh's independent statehood. Among its goals was universal access to education and gender equality. By improving access to education for women and girls, the government hoped to leverage the untapped potential of half of the nation's population.

As part of Vision 2021 the phrase "Digital Bangladesh" (DB) was introduced (Bangladesh Development Forum 2010). While perhaps a catchy slogan, it did not initially represent a specific policy, leading to some confusion about its meaning other than a general sense that the government intended to modernize the country with computers. In subsequent years, the government has crystallized the vision of DB into four "pillars": digitizing government services, human resource development (through education), promoting IT industry, and connecting the country's citizens (Islam and Grönlund 2011).

Looking at Vision 2021 and Digital Bangladesh in the year 2021, it is clear that the loftiest goals of the government's plan have not come entirely to fruition, though there has been measurable success. According to government figures, the literacy rate for females in Bangladesh has grown significantly, from 39 percent in 1999 to 70 percent in 2017. The gender gap has decreased as well, with males currently besting females by only four percent, at 74 percent literacy. Life expectancy has increased from 45 years in 1960 to 72 years today (Blair 2020).

The strong performance in the areas of food security, education, and public health has made Bangladesh something of a paradox, as this growth has occurred despite dysfunctional government and rampant corruption (Asadullah and Chakravorty 2019; Blair 2020).

Still, deep inequities still persist, particularly in poor and marginalized populations. In the context of Digital Bangladesh, the equal distribution of technology and its benefits has been difficult to achieve, with the majority of benefits primarily going to the already-privileged (Aziz 2020). For example, the government-supported rural telecenters (so-called Union Digital Centers, or UDCs), designed to extend digital services to rural and marginalized citizens have performed poorly, with one-quarter closing down within three years and many of the rest suffering from low engagement on the part of those they are intended to serve (Faroqi and Collings 2020). As has been discovered, simply dropping ICTs into a rural village without committed follow-up, training, and support will not have the desired effect. Without proper support, UDCs in rural areas suffer from unreliable power, poor internet access, equipment problems, low income for operators, and low expertise on the part of operators as well as the public (Faroqi and Collings 2020).

Many of the same problems faced by the UDCs also plague Digital Bangladesh initiatives in the public schools. The government has made significant investments in equipment and training to integrate ICTs in the classroom, with 85 percent of secondary schools having at least some ICT infrastructure and hardware (Lim et al. 2020), but many schools still suffer from power and internet blackouts, unreliable/insufficient equipment and training, and resistance from teachers and administrators that prefer to do things in the traditional way (Khan et al. 2012; Iqbal 2017; Lim et al. 2020).

Furthermore, serious language and cultural barriers exist that interfere with the implementation of ICTs in the classroom. Most of the available digital resources use English as an instructional medium, and are biased toward a culturally “fat” mindset. With only around 18 percent of the population speaking English, and Bangladesh

being a lean country with a very different cultural perspective, it is difficult to imagine a smooth, trouble-free transition to Digital Bangladesh in the classroom (Lim et al. 2020).

The necessity of good English language instruction in Bangladesh is to be emphasized here, as the language barrier is simultaneously an impediment to the adoption of ICT and the 'raison d'être' of the Portable Portal, an ICT. This will be discussed at length in section 4.10.

4.5 How corruption affects education

As will be seen in this section, the demographic most affected by corruption in the educational system corresponds precisely with the target beneficiaries of the Portable Portal: girls from poor, less-educated households. We now see how pervasive corruption in government tends to infect everything it touches, and how the educational sector in Bangladesh is not immune.

While education in Bangladesh is nominally free for all, the reality is that corrupt teachers and schools often demand payments in exchange for educational services (Choe et al 2013; Habib et al 2017). This extortion disproportionately affect poorer households, less educated households, and, notably, households with girls in school. Poverty and low educational attainment of the parents correspond to lower social status, reducing the family's leverage and influence with school officials. Higher social status families are often able to use their relatively higher status to avoid paying illegal fees or lowering their amounts, while low-status families' inability to either pay the fee(s) or influence school officials to reduce or eliminate them often results in the disadvantaged child being withdrawn from school altogether, further exacerbating the socio-economic divide (Choe et al 2013).

This corruption at the local level doesn't exist in a vacuum, as it can be seen as a logical by-product of corruption throughout the educational hierarchy, up to the highest levels of government. The corruption of some teachers is just the final step in

a long chain of rent-seeking, bribery, and extortion that has become a significant obstacle to educational equity in Bangladesh (Karim et al. 2004; Choe et al. 2013).

Misdirection of funds earmarked for the development of ICT in education further reduces the effectiveness of the government's initiatives. Money that should have gone toward improving student access to ICTs instead winds up in the pockets of corrupt officials (Khan et al. 2012). Somewhat paradoxically, greater implementation of ICT in some areas of the educational sector could have the effect of *reducing* corruption, for example if student fees were paid online through a government portal rather than through government intermediaries, thereby removing one of the links in the chain where illicit fees are extracted (Habib et al 2017).

4.6 Infrastructure and ICT availability

While most secondary schools in Bangladesh are equipped with at least some ICTs as a result of governmental and NGO initiatives, there has been a lack of comprehensive planning for the maintenance and troubleshooting of this equipment. Few schools have the resources to hire a full-time (or even part-time) IT technician, with the result that schools often end up with a room full of unusable ICT. With no money to repair equipment or replace broken or missing items, something as simple as a burnt-out bulb or missing power cable can cause a piece of otherwise-useful gear to sit idle (Iqbal 2017).

The break-neck pace of innovation in technology makes the necessity of keeping hardware and software up-to-date essential for institutions that engage in ICT, but for developing countries like Bangladesh the relative costs are very high (Khan et al. 2012). This makes it quite difficult for schools to contemplate upgrades when they are already struggling to maintain current equipment.

When there are not enough ICT resources to go around, there is no guarantee a teacher will have what they need in order to make a technology-dependent presentation or demonstration in the classroom. This makes planning lessons

substantially more difficult for many teachers, who are already dealing with a full day of classes with up to 100 students per class. Going in search of an available projector, computer, and necessary peripherals that may or may not work as expected when brought to the classroom adds time and complexity to an already overburdened day. Even technology-adept and interested teachers are challenged by the difficulties, and many simply default to traditional teaching methods (Khan et al 2012; Iqbal 2017).

When designing ICT for the classroom, it is important to recognize the difficulty and expense educational institutions encounter when dealing with their technologies. This has become an important design consideration of the PP (see: 5.2.2; 5.5.3; 5.5.4), as a non-working ICT is worse than merely useless, constituting an egregious waste of resources.

4.7 Electrical and Internet reliability

One essential component of ICT utilization is reliable electrical power. The power sector in Bangladesh has struggled to keep up with rising demand, but steady improvement has been made over the last few decades. According to a 2020 government report, 96 percent of the population has access to electricity, with total generative capacity at 19,630 MW, up from 12,893 MW in 2019 (Ebn Sharif 2020). This level of power generation should meet current demand, but bottlenecks in high-use periods still result in unreliable power in many areas. Blackouts have always been an expectation in rural areas lucky enough to have power at all, but even in the big cities rolling blackouts and brownouts have been a way of life. For those with sensitive electronics in their homes, an uninterruptible power supply (UPS) device is essential equipment (Taheruzzaman and Janik 2016). Typically, these devices can stabilize current flows during voltage dips and spikes, and allow enough time (10-15 minutes) for the user to back up their data and shut down in the event of a blackout. Unfortunately, it is rare to find a school in Bangladesh that has power backup capability that would enable ICTs to continue to be used in the event of a blackout (Iqbal 2017).

Exactly what the current electrical-consumer experience is in Bangladesh is somewhat difficult to access, as the situation keeps changing, and data from only a few years ago are quite obsolete. Recent discussions with the founder of Speak Up, an NGO with offices in Khulna and operations in over 30 rural villages, indicates that the situation has indeed steadily improved over the past few years, although power interruptions are still common particularly in the villages. If the pace of grid development continues in the coming years, the reliability of the power supply will no doubt continue to improve.

Access to the internet has increased rapidly in the last few years, accelerating even faster than the power grid thanks to the rise of the telecom industry. While broadband service is available in the big cities, mobile internet is king. Data posted online by the Bangladesh Telecommunication Regulatory Commission (BTRC) show almost 112 million internet subscribers in December 2020, approximately 67 percent of the population (btrc.gov.bd). Of that number, approximately 103 million were mobile internet subscriptions.

While 3g service is widespread, 4g service was launched in 2018 and has gained a lot of ground, at least in big cities and along major corridors. Figures posted by mobile analytics company opensignal.com show that users in Bangladesh were able to connect to a 4g network 83 percent of the time in the period between October 1, 2020 and December 29, 2020.

Like electrical power access, the internet situation in Bangladesh is changing rapidly. The government has initiated plans to roll out 5g in 2023, though it is unlikely this will have a dramatic effect in the near term, as the vast majority of handsets in use in the country are not compatible with 5g, or even 4g at this point. Again, it's difficult to assess such a fast-changing situation, but through conversations with Speak Up we can be fairly confident that a minimum 3g connection can be maintained in most rural areas, enabling video conferencing at acceptable resolution. 4g or better connectivity may be possible as well in many areas.

As power and internet connectivity are essential to the operation of the PP, designing flexible power options and cellular internet connectivity is core to the original parameters discussed for the device (see: 4.10.1; 5.1). How these features actually perform in real-world conditions will be obviously fundamental to future evaluations of a physical prototype; for now we must proceed on the assumption they will work as intended.

4.8 School administration and the training of teachers

Because ICT use in education is a comparatively new concept in Bangladesh, integration is not simply a matter of dropping some technology into a school and expecting teachers to know what to do with it. Even if the ICT works perfectly and is available, many teachers avoid bringing technology into their classrooms because they have no skillset to use it. Additionally, there is no financial incentive for them to do so, and no time in their busy schedules to dedicate to learning about ICT. Therefore, many teachers in Bangladesh tend to keep to what they know, especially older teachers with long experience in the classroom (Khan et al. 2012; Iqbal 2017).

To counter this, initiatives have been launched by the government and some NGOs to train the county's teachers on the use of ICTs in the classroom. Because Bangladesh is a very high-population country, with nearly 23,000 secondary schools, typically only a few teachers from each school will be sent for training, with the expectation they will then return to train others. Success of this scheme varies according to the motivation of the teacher and the interpersonal politics of each school, with some reporting success and others relative failure. In some cases, teachers are willing and interested, but are stymied by school administration officials who don't see the value in the program and put resources elsewhere (Iqbal 2017).

4.9 Social/Cultural factors

As previously discussed, corruption in Bangladesh's government has become so pervasive as to be virtually embedded in the culture. This affects everything in daily life, including education (see: 2.4; 4.5).

The pedagogical culture in Bangladesh is traditionally teacher-centered, in which the students have little input and are not encouraged to participate except to memorize the lecture (Ali and Hamid 2020). Attempts to modernize education with a more interactive, student-led approach including the use of ICTs have run up against the reality of a chronic teacher shortage and class sizes of 50-100 students or even more. In a reality of overworked teachers and class sizes too large to support an interactive approach, the old teacher-centered model persists (Khan et al 2012; Iqbal 2017).

Another significant cultural factor affecting ICT use in Bangladesh is the traditionally low status of girls and women (Khan et al. 2012; Sultana and Haque 2018). Technology is widely perceived to be a man's domain, and therefore not suitable or necessary to be taught to girls (Saifuddin et al 2019). Although this has changed somewhat in recent years due to the government's campaign toward gender equality, this culture persists. In a recent multi-country study of digital inclusion, Bangladesh was something of an outlier in its extreme levels of exclusion of women, with a majority of its female population excluded from the use of ICTs (Rashid 2016).

Making the PP accessible to its intended recipients involves overcoming these cultural factors. Doing so requires sensitivity to cultural norms that can be slow to change, particularly in conservative rural villages. Ways that we can help ensure success for the PP in light of cultural norms are discussed in the evaluation (see: 6).

4.10 The Language barrier

Many researchers studying ICT uptake in developing countries have noted low English proficiency as a barrier to ICT integration (Khan et al. 2012; Lim et al. 2020; Aziz 2020). In Bangladesh, although there is a long history of English use as a consequence of British imperial rule, only 18 percent of the population actually speak the language (Lim et al. 2020). With independence, Bangla was rightfully recognized as the official national language, and the use of English in governmental sectors was gradually phased out. However, the government has recognized the importance of English as the “lingua franca” of international business and technology, and so have placed a strong emphasis on English instruction in schools. Curriculums and textbooks were revised, and mandatory English instruction was instituted from grade one. Despite this, results have been disappointing. Lack of properly trained teachers is identified as an ongoing problem, especially in the rural areas. Rather than an emphasis on speaking and listening comprehension, students are encouraged to “study for the test”, with an emphasis on rote memorization (Rahman et al. 2019; Ali and Hamid 2020).

When it comes to ICT integration in the classroom, many teachers that are not proficient in English avoid ICT altogether, particularly software and internet applications, since there are few Bangla-language tools available (Khan et al 2012). At the same time, ICTs are rarely used by teachers of English classes, who may not be as technologically proficient as teachers of science and math (Iqbal 2017). This leads to poor outcomes in both technological and English proficiency for the students.

4.10.1 Speak Up and the need for English teachers

Speak Up for the Poor is a nonprofit organization working primarily in Bangladesh. It advocates for girls and young women coming from one of the poorest and most marginalized minority segments of Bangladeshi society, the Dalit, considered “untouchable” by Hindus⁵. Through its Girls’ Education Program (GEP), Speak Up works to keep girls in school, and away from child marriage and other exploitation.

Over the last eight years of operation, the GEP program has seen hundreds of young women finish high school and progress to university studies. These young women come from villages where virtually no one, and particularly, no woman had previously completed higher education.

In conversations with the CEO of Speak Up, strategies were discussed to address what was felt to be one of Speak Up's major challenges, that of English language tutoring support in their village learning centers (some of the issues surrounding English language learning and use in Bangladesh are covered in the previous section, 4.10). Competent tutors of English are difficult to find in the rural areas. Furthermore, because the charity serves around 1400 students spread out over 30 villages, it is difficult to effectively reach every student through traditional means, even if suitable teachers could be found.

Because of these obstacles, a videoconferencing device for distance teaching was perhaps an obvious potential solution, but designing for Speak Up's unique use-case required some thoughtful consideration of the environment into which the system was to be deployed. Initial parameters for the device were as follows:

- Rugged, durable, and portable construction to be used in rural villages
- Flexible power options to deal with power grid unreliability
- Ability to operate satisfactorily on a 3g/4g cellular network
- Simple to operate for those with low technological competence

These initial parameters are still central to the design of the PP. Other features, such as those relating to environmental concerns (see: 5.5) were added as this study has progressed, with the realization that in order to serve this project's presumed recipients, a consideration of the full impact of such an intervention was essential. In the next section, "The Portable Portal", this proposed intervention is described in full.

⁵ Hindus, in turn, are the minority in Bangladesh, which is 90 percent Muslim (Bangladesh Bureau of Statistics 2011).

Part Two

5. The Portable Portal

The following sections describe the Portable Portal system. Refer to the Appendix for further documentation of functional requirements and workflows.

5.1 System description

The Portable Portal System consists of both a bespoke website containing embedded video conferencing tools, archived lecture videos, a calendar for scheduling sessions, and other necessary information, and a hardware device (the Portable Portal, or “PP”) purpose-built for accessing this website. Together, these elements constitute a system for distance teaching that is accessible to non-technically adept users. In addition, the system has been designed to be durable, repairable, and as environmentally friendly as possible.

The purpose of the system is to implement simple videoconferencing tools for distance teaching in rural areas of Bangladesh. The project was conceived and developed to address a need expressed by the founder of the Bangladesh-based humanitarian organization Speak Up For The Poor, specifically to find a solution to help students served by the organization (some 1400 girls spread over 30 villages) with their English homework (see: 4.10.1).

The eco-design aspect of the device addresses the very real threat of e-waste in Bangladesh and many other lean countries in the global South. The toxic repercussions of the illegal dumping and informal “recycling” of cast-off, disposable electronic goods is having a profound and negative impact on the health of ecosystems and human beings in the very places that can least afford it (see: 2.3.3). By incorporating a modular, repairable design into the concept of the PP, we seek to

provide a small example of how thoughtful design of electronic goods can help further the goal of a circular economy that benefits all (See: 5.5).

By keeping the system “on task” and simple to operate, we ensure that it will stand a good chance of being used often, and as intended. Other functionalities can be added to the system if deemed necessary, and system software can be updated via IoT tools from the Administrator’s dashboard, as described in the next section.

5.2 Components of the system

5.2.1 Website

The website contains three main pages, as follows:

1. Landing page. This page displays the calendar of all upcoming lectures. In addition, a countdown timer displays the time remaining until the next lecture begins. When logging on with the PP, this page will display first, unless a lecture is imminent. If lecture is imminent (within 60 seconds), PP automatically navigates to the Videoconference page.
2. Videoconference page. This page displays the embedded videoconferencing portal.
3. Lecture Archive page. This page contains all past video lectures that have been archived. Lectures are recorded automatically. The instructor can review and edit (if necessary) the lecture after its conclusion, and then fill out a form to categorize the lecture by date, subject, and corresponding textbook chapter before posting it to the web page.

Student users logging on to the website with a PP device will be automatically logged on with access to the basic functions described herein and in the Student/ User workflow and workflow diagram (see Appendix D and figure 5).

Instructors logging on with instructor credentials allow additional functions, mainly the ability to initiate sessions and edit/post video via the instructor dashboard, as described in the Instructor Workflow and Instructor workflow diagram (see Appendix D and figure 6).

Administrator credentials allow the above functions plus access to tools for scheduling lectures and implementing software upgrades to the fleet of dispersed PP units.

5.2.2 Physical device

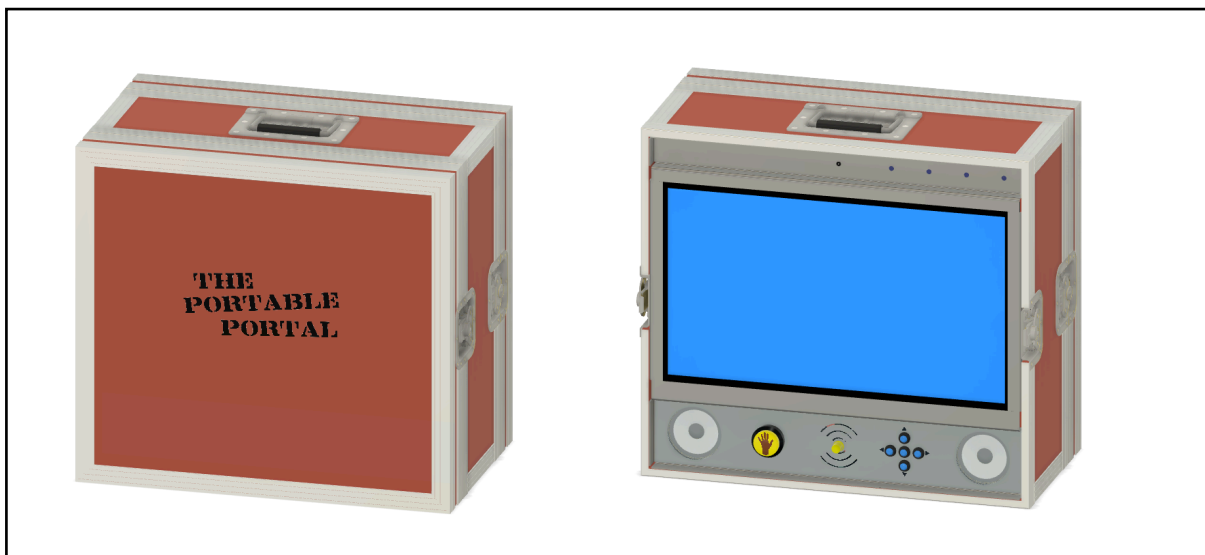


Figure 1: The Portable Portal

The PP (fig. 1) is a ruggedized, self-contained, portable videoconferencing device intended to be used for distance teaching in rural areas with poor access to electrical power, sub-par internet connectivity, and low levels of technological expertise.

Physically, the PP consists of a heavy-duty road case containing a monitor screen, webcam, microphones, cellular modem, audio amplifier and speakers, a battery-backup UPS (uninterruptible power supply), and a micro-computer.

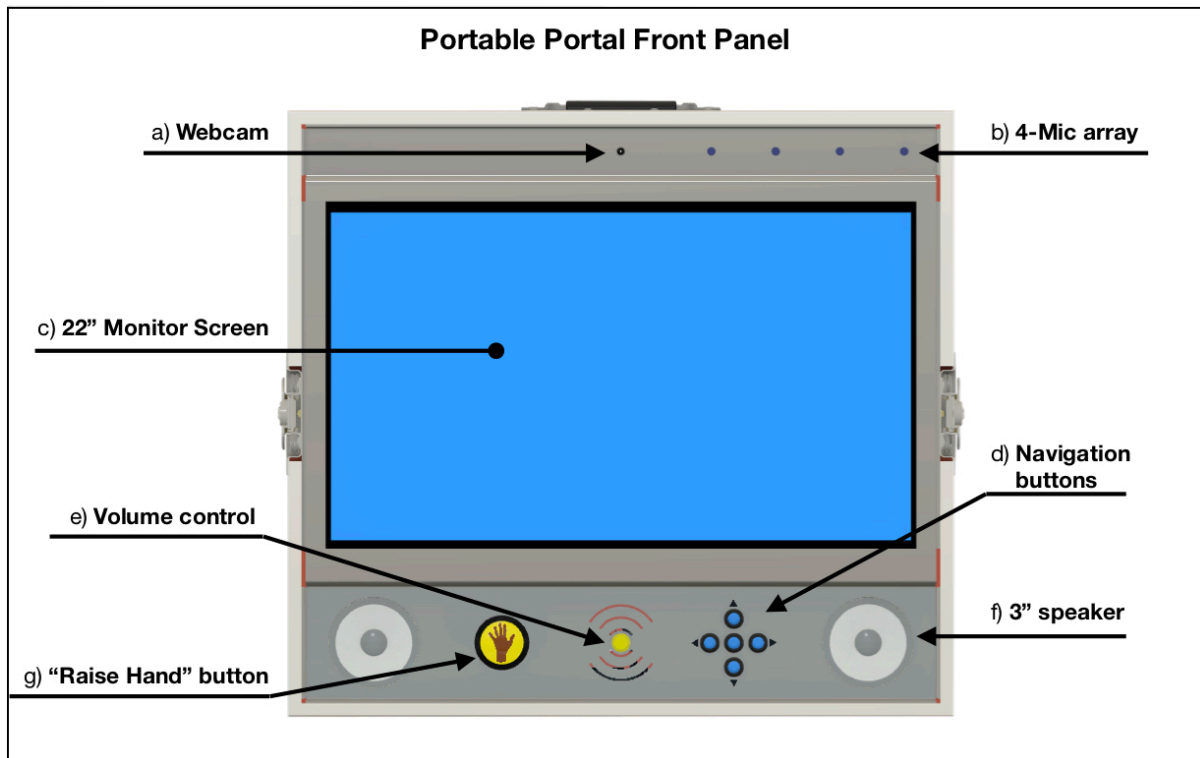


Figure 2: Front Panel

Figure 2 shows the front panel of the PP with the cover removed, revealing the monitor screen (c), webcam (a), mics (b), speakers (f), a volume knob (e) for the audio system, the “raise hand” button (g), and a 5-button keypad (d) for navigating the website. Controls are kept very simple by design, making the PP friendly to users with low technological expertise.

Behind the rear cover of the device (figure 3) is revealed the options for powering the device (i); a standard wall plug for when grid power is available, and a pair of screw terminals for attaching to a 12 volt DC source such as a standard car battery for use when grid power is unavailable or unreliable. The device will prioritize grid power if connected to both. A green led lights to indicate that the unit is properly connected, while red indicates a problem such as insufficient battery power or a reversed polarity connection (not visible in figure 3). Powering the device on is a simple matter of plugging it in or attaching to a battery, switching the unit on, and affirming that the led has lit green. To power down, the user has to simply turn off and unplug the unit. An internal UPS assures that the micro-computer shuts down properly.

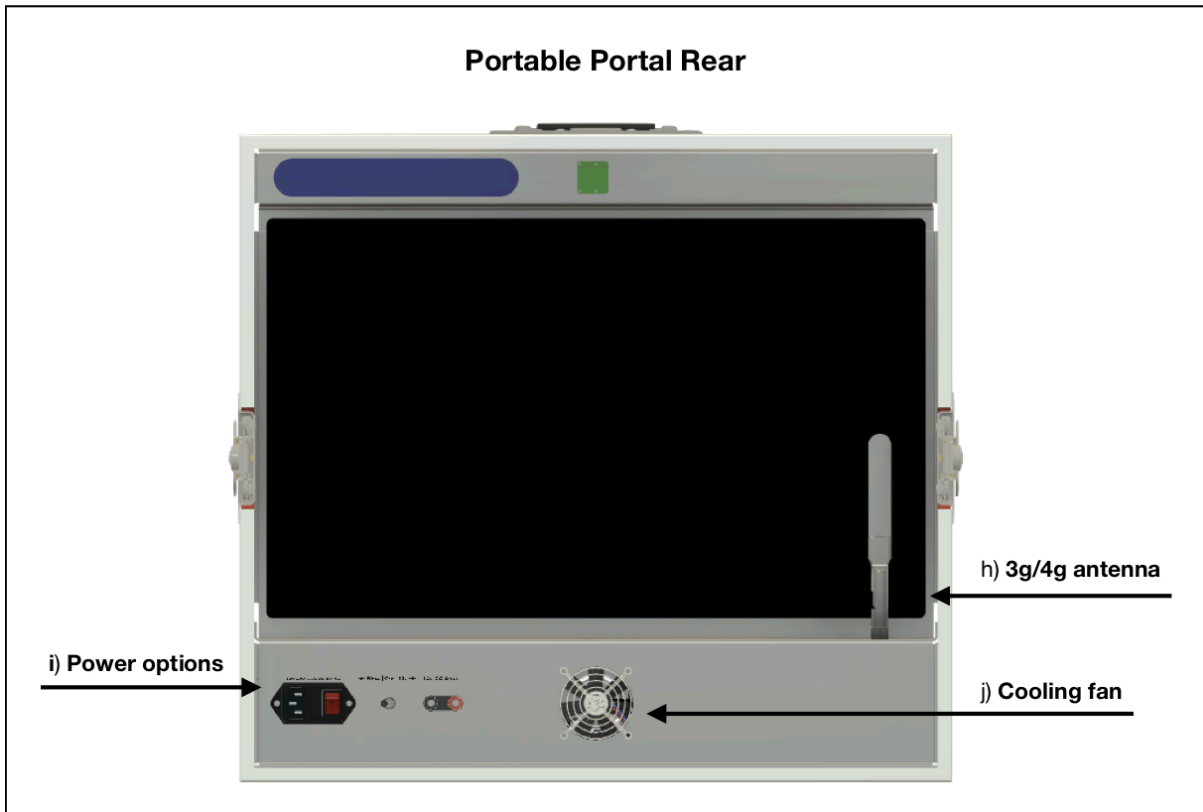


Figure 3: PP Rear

All other components of the system are protected by a shroud that attaches via screws to the inside of the case. The shroud can be easily removed for service.

Appendix B contains a list of all the major internal components of the PP, along with their prices (this should be considered a rough guide, as component prices fluctuate).

The system is designed to be modular and easy to repair/maintain. The processor, webcam, microphone system, and cellular modem are all based on products in the well-known and widely available Raspberry Pi ecosystem. The audio system consists of commonly available and inexpensive parts that can be easily exchanged in the event of failure. The road case is constructed identically to cases commonly manufactured to transport musical instruments, audio equipment, electronics, etc. and can be built by any competent carpenter.

It is expected that construction of the device will eventually be fully documented with a complete parts list and assembly instructions via text, diagrams, and assembly videos. Software will be open-source and can be downloaded and implemented by anyone with reasonable technological confidence, by following the provided instructions. By encouraging local construction, we bring down costs, aid the local economy, and keep the product closer to its users. Since many of the components can be sourced locally or in nearby countries like China, the environmental impact of shipping components to Norway (where this research has been conducted), building the device, then shipping the finished unit to Bangladesh is avoided.

5.3 Use cases

Although the PP concept has been designed around a relatively narrow use case to address a specific need (see figure 4), namely to deliver real-time video lecture capability to students that are a part of Speak Up For The Poor's GEP in Bangladesh, the need for distance teaching tools in lean countries (and especially in rural areas of those countries) seems to indicate that the PP could have applications outside of the area studied for this proposal.

The Covid-19 pandemic of the past year has emphasized the need for digital solutions for education. As children around the world have shifted to online learning, the gap in educational access between rich and poor, urban and rural populations has only widened. While distance teaching can have many benefits for students that cannot attend in-person classes, the benefits are heavily weighted toward students that come from relatively affluent backgrounds, that have familiarity with and access to ICTs.

According to figures from UNESCO, some 888 million children worldwide face continued disruptions in their schooling due to school closures during the pandemic (UNESCO 2021). In addition, 500 million children worldwide have no access to distance learning tools. With distance teaching methods becoming ever more

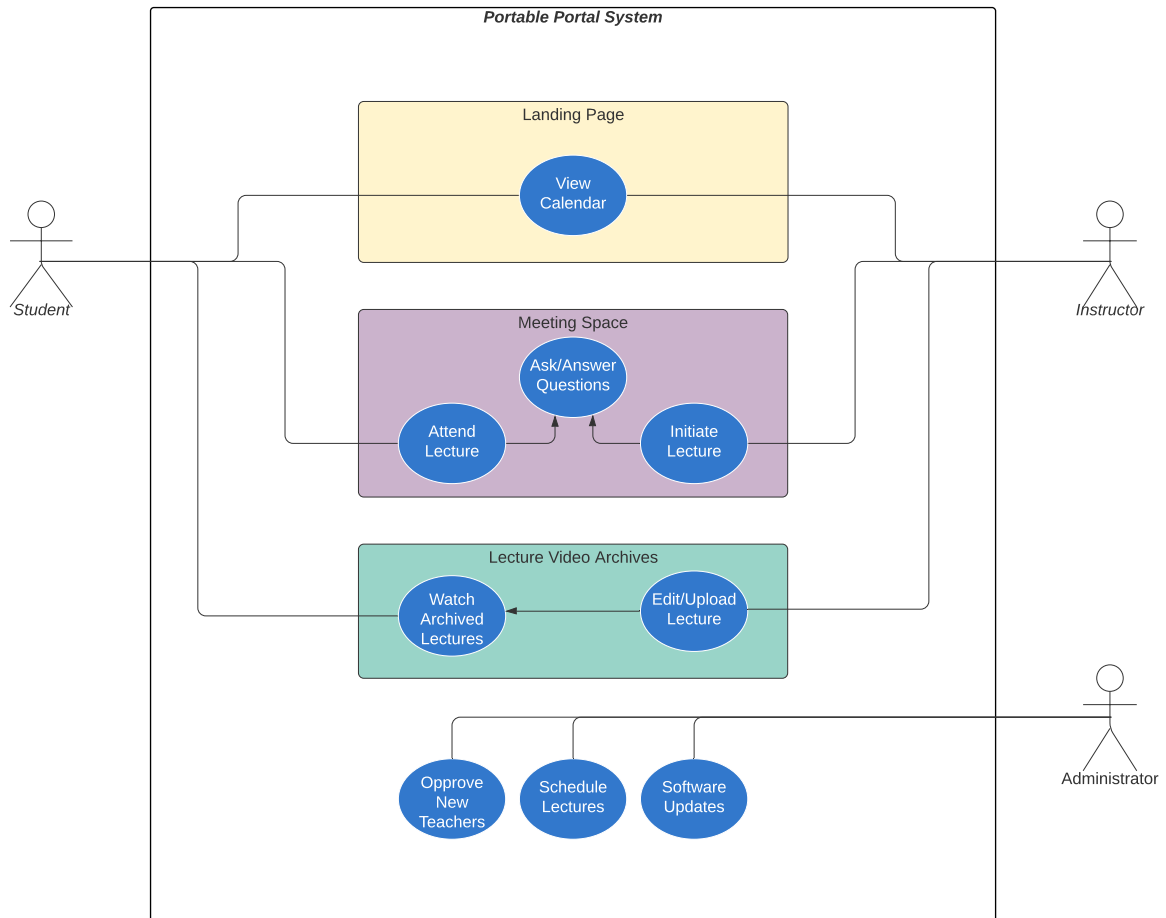


Figure 4: Portable Portal Use Case Diagram

relevant, the PP can help to address that gap, especially for poor, rural students that do not have access to digital tools at home.

Many other uses can be imagined for the PP, making it a resource that could be of value to poor communities around the world, not only in Bangladesh. Other subjects can of course be successfully taught via distance methods, and others in the community can benefit from this, including adults. One-on-one tutoring sessions could keep struggling students from dropping out of school altogether. Medical consultations could be undertaken via the PP, when no doctor can be found nearby. New information on agricultural techniques could be disseminated to local farmers via a monthly seminar. Sharing of artistic performances could help draw disparate communities together, fostering greater appreciation of cultural differences.

The intention is that the PP will be not only easy to use and understand, but that it will be durable and repairable so that it can last as a resource for potentially a whole community. Other uses will no doubt arise over time, and the device can be upgraded and modified as is fitting to its evolving use-case.

5.3.1 Why not a laptop? Portable Portal vs. commercial ICT

Laptops break, and are still not commonly owned by the primary stakeholders for this project, impoverished young women and girls in Bangladesh. Smartphones have very small screens and speakers, which are hard to share with a group. Other ICTs are fragile and difficult to repair even if parts can be found. Software is almost always in English, rarely Bangla, and is developed from a “global North” perspective. Modern computers present a confusing array of possibilities that can be bewildering to someone who has never even touched one before. Powering and charging ICTs is a challenge in many areas. Pouring more future e-waste into already overburdened ecosystems is, arguably, a bad idea.

These ideas have been touched on elsewhere in this report (see section 2.3.3; 3.4; 4.10, etc.). To condense many points, in short: commercial ICT is simply ill-suited for the use-case scenario envisioned by this proposal.

The idea behind the PP is not to re-invent the wheel. Clearly, the technology for videoconferencing already exists on virtually every laptop and smartphone in existence today. These technologies are having an impact in countries like Bangladesh, but for now benefits are mostly concentrated at the top of the social ladder. The poor, the rural, and in particular, females are typically excluded from reaping the benefits of ICTs. Many of these factors have been discussed in previous sections.

Putting a laptop into the hands of every student is an idea that has been attempted before. The One Laptop Per Child project is probably the best example of such an initiative; after years of implementation and millions of dollars spent, OLPC is

notable particularly for its failures (see: 3.4). Of course, there's nothing wrong with a student having their own laptop, and this can even be seen as an eventual goal of the PP. By introducing students to useful tech they gain an appreciation of its utility, later graduating to more advanced devices, much in the same way that children growing up in the global North are acclimated from an early age to the use of ICTs by video-chatting with grandma on a parent's smartphone. However, what is common in fat countries (early acclimatization to ICT) can still be quite rare in the lean, where poor families often struggle just to have enough food and clean drinking water. Technology finds itself rather far up Maslow's hierarchy of needs in such circumstances, and it is with recognition of this fact that the PP has been designed.

Of course, those students that already have access to ICTs can quite easily partake in the benefits of video lectures on the PP platform as well, by simply logging on to the website at lecture time. Ultimately, the physical device known as the "Portal Portal" is just an optimized interface for accessing a website. The website and its embedded videoconferencing system is itself accessible by virtually any device, operating system, and web browser that can navigate the internet.

By creating a solution that is tailor-made for its environment, in collaboration with the users themselves, and making every attempt to study both the short-term effects and the long-term implications of such a solution, we propose that the PP fills a particular void in the educational problem space for disadvantaged girls and young women in rural Bangladesh, and even possibly beyond.

5.4 Typical Interaction

Refer to Appendix D for written student and instructor workflows. Figures 5 and 6 show workflows in flow-chart form.

All distance teaching sessions are initiated and managed on the instructor's end via a dashboard on the PP System website, accessed via the instructor's own computer. Sessions take place in the website, using embedded videoconferencing

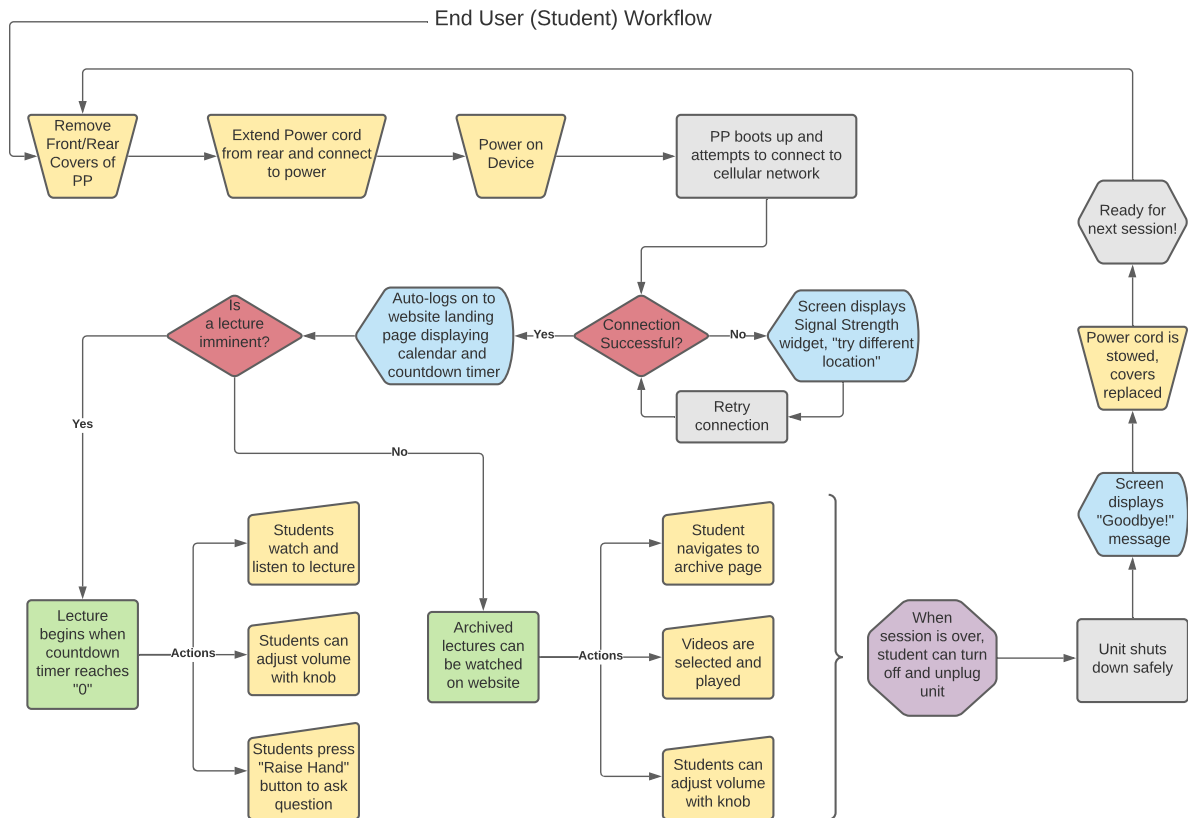


Figure 5: Student Workflow

tools based on the open-source WebRTC standard. Because sessions are initiated from “central command”, all the student (end users) have to do is plug in the PP and power the device on. When switched on, the device boots up, connects to the 3g/4g network via its cellular modem, and automatically searches for and logs on to the website. If a lecture session is imminent or underway, the PP unit navigates to the Videoconference page. If no session is imminent, the Landing (calendar) page will display.

Many PPs can be connected to a teaching session in the same manner as a web conference. The lecturer will be able to see each unit that is logged on and control the microphone for each. Students will see the Instructor only.

Because good teaching often relies on two-way communication between teacher and student, the PP is equipped with a webcam and microphones so that the

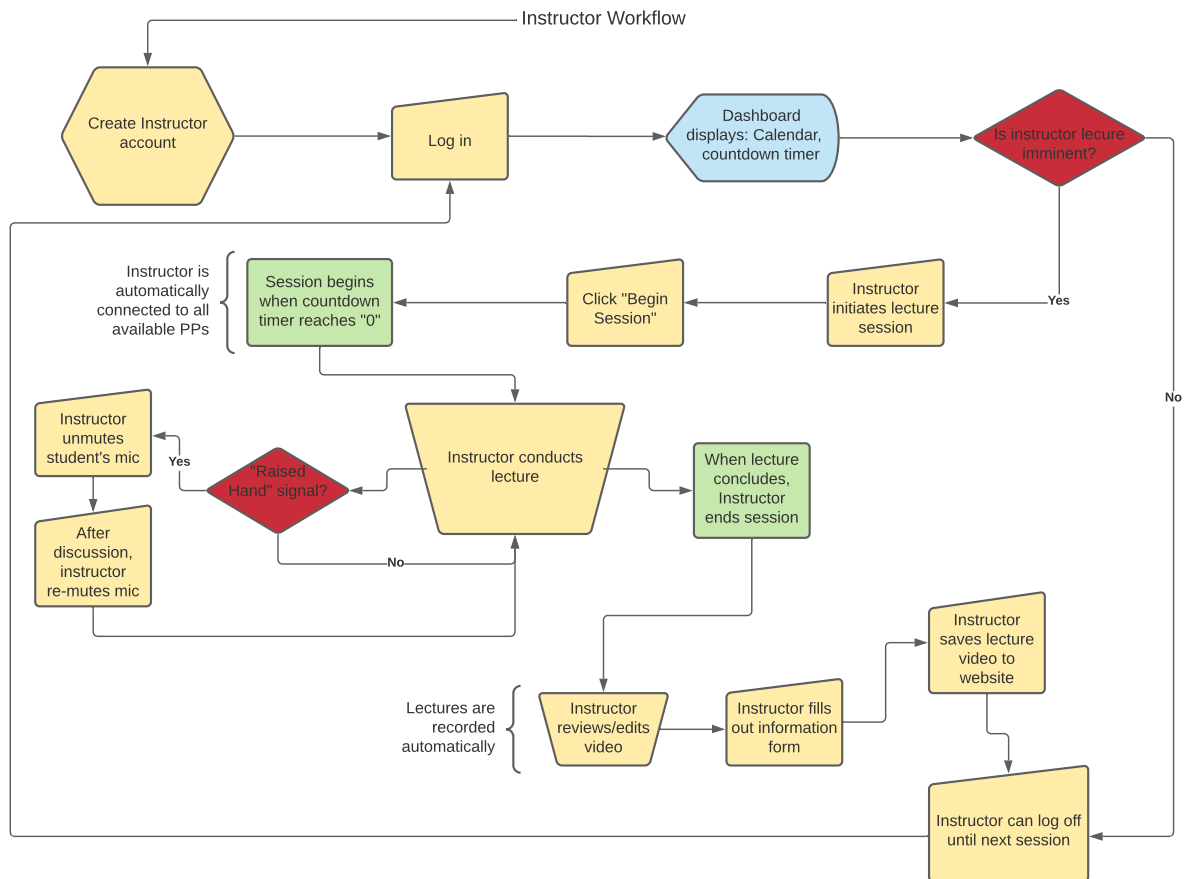


Figure 6: Instructor Workflow

instructor can see and hear students on the other end. On the other hand, this situation can easily get quite chaotic if many PPs are connected and all microphones are turned on, so the default position is that all PP microphones are muted during lecture. Therefore a signaling system has to be implemented to allow students to “raise their hand” before their mic can be switched on by the instructor. Since the PP has no keyboard or mouse as an interface, there is no way to do this by the usual means, i.e. clicking an on-screen “raise hand” icon with a mouse or other interface. A touch-sensitive screen is a possible solution, but adds cost, especially at larger screen sizes. Also, since interchangeability and easy availability of parts is a cornerstone of the PP design, it is preferred to keep the screen as low-tech and inexpensive as possible.

Because of this, the straightforward solution is to employ a pushbutton switch on the front panel of the PP, clearly marked with a “raised hand” icon (see figure 2). A student who has a question has to simply press the button and wait for the lecturer

to enable her microphone so that the question can be asked. Once the question has been answered, the instructor can re-mute the student's mic, and continue the lecture.

A few additional buttons on the front panel of the PP allow the user to navigate to other pages on the website (see figure 2, "navigation buttons"). For example, students that missed a lecture, or that want to revisit a particular past lecture can use the buttons to go to the archive page of the website, choose a past lecture, and play the video. These buttons are arranged in a simple "up, down, left, right, OK" configuration. Many users that have previous exposure to a common TV remote control will already have an intuitive sense of what these buttons do, but instructions in English and Bangla attached to the inside of the front cover will clarify the methodology for the un-initiated.

5.5 Maintenance, repair, and end-of-life disposal

5.5.1 End-of-life impact

Because of the seriousness of the problem of e-waste in Bangladesh (and indeed, worldwide), thought has been given toward making the Portable Portal as environmentally low-impact as possible. While no electronic device could ever be completely carbon-footprint free, there are many ways in which we can improve the durability, flexibility, and repairability of the device. In this way we can keep it and its components in use for as long as possible, and out of the e-waste dump. Figure 7 illustrates the life cycle of the PP from resource extraction through end-of-life, highlighting the direct and indirect areas we can influence through design.

By creating a blueprint for the assembly of the PP, the intent is for the parts to be procured and the device to be assembled in Bangladesh. By keeping production local, the procurement chain is much shorter than, for example, assembling the device in Norway and then shipping to Bangladesh. This would be extremely

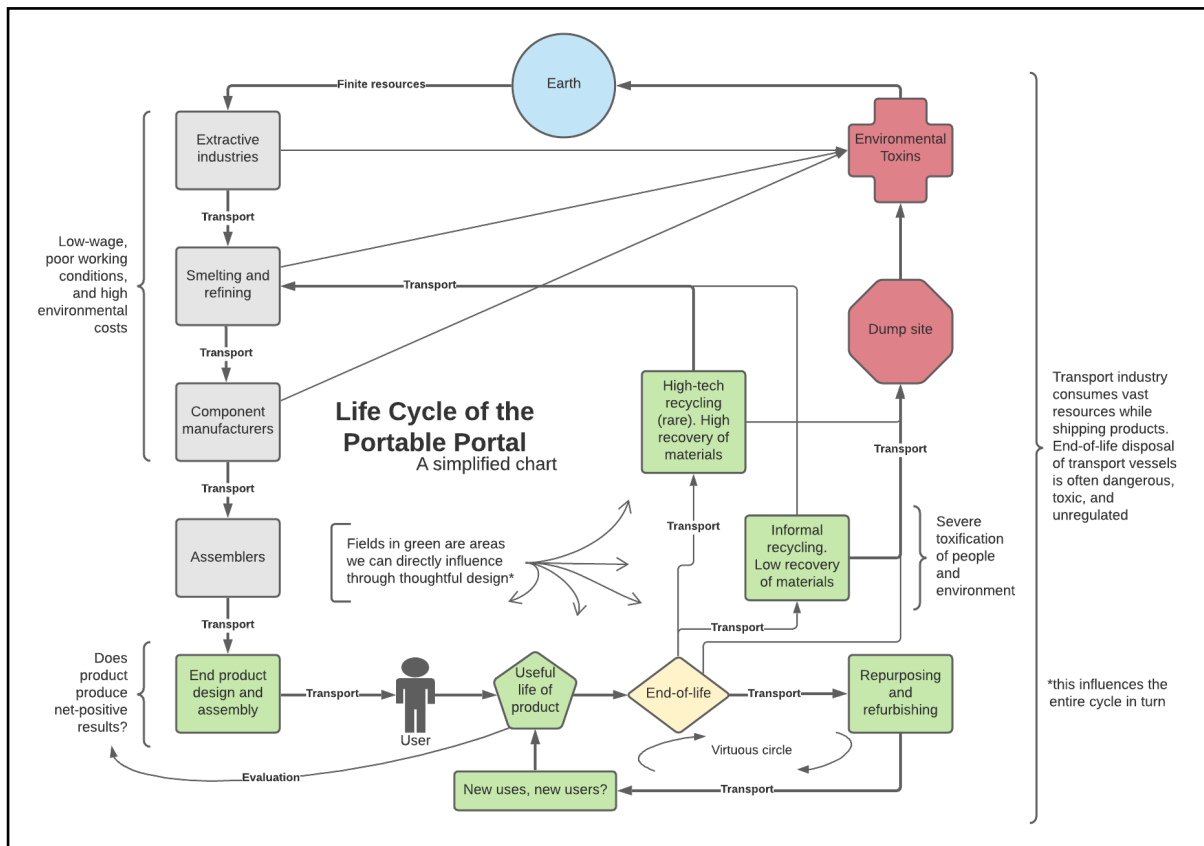


Figure 7: Life Cycle

inefficient, considering that many, if not all, of the parts are manufactured in Asia already, some in Bangladesh itself and others in China or other close neighbor countries. By reducing the distance that parts have to travel in order to get to their destination, we are already starting with a lower carbon impact.

Procuring parts and assembling the device in Bangladesh with an emphasis on parts that are made in Bangladesh has the additional benefit of supporting the economy, both national and local. Growing Bangla companies such as Walton Electronics make a wide variety of products, including computer monitors and power supplies, that are on-par with products made elsewhere. Supporting these companies supports the workers that make the products. Sourcing other products from local shopkeepers and employing local technological know-how to assemble the device supports and provides valuable jobs, supporting the local economy by keeping the Takas circulating locally.

5.5.2 Sustainability

A computer uses a significant amount of energy and resources over its lifetime. As much as 70 percent of this consumption occurs in the production phase. Exact figures are difficult to assess due to lack of transparency on the part of manufacturers and suppliers, but one study concluded that annual greenhouse gas emissions in 2008 from laptop manufacture, use, and disposal activities in the United States alone was equivalent to that of 700,000 midsize vehicles (Hoang et al. 2009).

Laptops and desktop computers have an average lifespan of three to four years, similar to other tech such as smartphones, printers, and monitors. Once the device is non-operational or obsolete, it most likely will wind up either landfilled or falling into the informal recycling sector in a developing country like Bangladesh, as described above. Reported recycling rates vary depending on study, but can be assumed to be from eight percent to no more than 20 percent (Hoang et al. 2009; WEF 2019).

Extending the lifespan of a computer by only two years can reap significant savings in GHG emissions and energy consumption. A report from a pilot project at the University of Edinburgh, designed to reduce the university's carbon footprint, calculated that by extending the life of a single computer and monitor from four years to six resulted in carbon-emission savings of approx. 190 kgCO₂e. The report further states that if fully implemented at the university, the program would reduce GHG emissions by at least 380,000 kgCO₂e, equivalent to that of 150 automobiles (Hart 2016).

One of the sustainability-oriented goals of the PP is to therefore make it as long-lasting as possible, by making it durable and repairable with easily-replaced parts. Then, when no longer serviceable, re-purposable, and when no longer re-purposable, recyclable.

5.5.3 Replaceability of parts

All parts of the PP are replaceable by a reasonably competent technician at relatively low cost. This is not a comprehensive list, but covers the main components (for an estimated price breakdown see Appendix B):

1. The central processor is a commonly-available Raspberry Pi 4, a low cost and versatile development board with a wide range of uses. These boards are easy to get and easy to configure, and are widely available in Bangladesh.
2. The microphone, camera, and cellular modem are all widely-available Raspberry Pi accessories, and are high-quality, user-configurable components that can be swapped out at low cost in the event of failure.
3. Audio amplifier and speaker system: the design uses an inexpensive class-D amplifier board that costs around USD \$3. These are small, bare-bones audio amplifiers that are easy to source. The design of the PP case allows for many different configurations to fit, so many solutions are possible if the original board fails and cannot be repaired. The speakers fit a 3" cutout, a very typical speaker size that offers good sound reproduction and low cost. A broken speaker could be replaced by a new one for around \$2, or a salvaged speaker could be procured.
4. The monitor screen is a Bangladesh-produced Walton Electronics screen. The case design is flexible, however, and would allow other manufacturer's screens in the same nominal size to fit, if replacement were required and the original screen was not available.
5. UPS (uninterruptible power supply) also available from Walton Electronics or various Chinese suppliers.
6. Case: the case is a rugged road case of the type used to carry sensitive equipment on flights or other demanding applications. We've opted for aluminum and steel parts for durability, but also for the end-of-life recyclability advantage over plastics. The case can be build by any competent carpenter using readily-sourced parts and plywood.

No special tools or knowledge are required to replace a part on the PP, only basic hand tools and a reasonable degree of mechanical insight. Once the design has been “finalized” through physical prototyping (with recognition of the need for continued evaluation and re-design), assembly/disassembly documents can be completed, and will be available to any user on the internet. This differs considerably from most ICT, which are not designed to be user-serviceable. Indeed, many modern ICT don’t appear to be designed for servicing at all, as companies maximize profitability through a deliberate program of planned obsolescence for their products. Designing for easy servicing and disassembly facilitates product maintenance, upgrading, reuse, and materials recovery, all key points in the creation of a circular economy, rather than a one-way street from mine to landfill (Mendoza et al 2017).

5.5.4 Durability

To make the device long-lasting, its parts are selected to be high-quality, relatively inexpensive and easily replaceable. They are mounted inside a sturdy road case lined with shock-absorbing foam to protect them from damage in rough conditions. This contrasts to the average laptop, monitor, or other common ICT component, which will not tolerate much abuse before it must be consigned to the scrap heap.

5.5.5 Re-purposability

Raspberry Pi (raspberrypi.org) is a durable and very popular open-source platform for all kinds of uses, from education to robotics to IoT (Internet of Things) applications and many others. Once the PP has served its purpose, the R-Pi parts (microprocessor, modem, camera and microphone) can easily be removed and reused, resold, or donated to a school for teaching basic computing and programming. The monitor screen is a standard model and can be reused for any purpose a screen can be imagined for. The power supply, audio amp, and speakers can all be separated from the other parts and reused. Lastly, the case itself is a

sturdy box for the transport and protection of its contents. It's not difficult to imagine such a box living a long and useful life long after its original purpose has passed.

This re-purposability is very different from the average laptop, whose parts are quite difficult if not impossible to separate and reuse independent of their corollary components. The miniaturized and tightly fitted components of all-in-one devices like laptops and cellphones make them wonders of technology while new, but this advantage contributes to their relatively short life cycles and problematic end-of-life disposal (Fan et al 2013).

5.5.6 Recyclability

No matter how durable, eventually the useful life of a ICT will come to an end, at which point it becomes potentially toxic e-waste. How to safely and efficiently dispose of the device, extracting its useful components and dealing with the remainder is a very complex issue. The current state of affairs is clearly neither sustainable nor conscionable, in which a growing mountain of harmful waste is broken down by the world's poor, using primitive methods that cause untold harm to themselves, their children, and the environment (Olowu 2012; Perkins et al. 2014; Mihai and Gnoni 2016).

The final phase of an ICT's life cycle is breaking down its components and extracting for reuse the raw materials from the collection of circuit boards, wires, screens, glass, plastic, and metal parts. This is a worthwhile (and potentially lucrative) project. A used ICT contains, in relatively high concentrations, many precious metals that are in limited supply worldwide. For example, the World Economic Forum states that "there is 100 times more gold in a tonne of mobile phones than in a tonne of gold ore". (WEF 2019). Up to 60 metals are commonly used in ICTs, including gold, silver, copper, and platinum, in addition to the so-called "high-tech" minerals like lithium, cobalt, tungsten, etc (He et al 2018; Holgersson et al 2018). Extracting these finite resources from used electronics will become more and more important as global supplies dwindle, and remaining resources become increasingly difficult and

destructive to extract. Unfortunately, state-of-the-art recycling plants for e-waste are far from ubiquitous, and the technology for recovering certain metals is very much still in its infancy (Kaya 2016; Marra et al 2019). The vision of a circular economy for technologies will take time and the coordinated will of a multitude of stakeholders, including designers, manufacturers, governments, and end users.

The PP has the advantage of being durable, modular, repairable, upgradeable and repurposable. However, recyclability suffers from the same problems inherent in recycling any piece of technology, which is the low availability of state-of-the-art systems for full materials recovery from e-waste, particularly in developing countries like Bangladesh. However, one way we can lower the danger level of e-waste is to reduce the proportion of plastic in its make-up, as one of the biggest sources of toxic contamination from the improper recycling of e-waste is the burning of plastics, which releases a host of toxic chemicals into the environment (Olowu 2012; Premalatha et al. 2014; Rifat et al 2019). Much of the plastic in electronic products is in the enclosure. For the PP and for many ICTs, the enclosure itself makes up a large proportion of the mass of the product. By using aluminum instead of plastic for the case of the PP, we exchange a difficult-to-recycle and potentially toxic material with a higher value and much easier to recycle metal. In this way, at least, we can improve the recyclability of our product.

6. Evaluation

Although the Portable Portal System has not yet been implemented in the field (which was not within the scope of this thesis; see 7), making an ethical-technological assessment of the system is essential in this design phase. By reflecting on the choices made in the design process documented in Part 2 of this thesis and informed by the knowledge gained by studying the ecological setting of our proposed technology documented in Part 1, we can come to a better understanding of the push and pull of diverse factors that affect our proposal. Through creative analysis, insights can be gained about the impact of our technologies, which in turn can inform the iterative process of testing, redevelopment, and re-testing throughout the lifetime of the project.

In the conceptualizing phase of the Portable Portal, several features were identified in conversations with Speak Up as a jumping-off point for development. They were:

- Rugged, durable, and portable construction to be used in rural villages
- Flexible power options to deal with power grid unreliability
- Ability to operate satisfactorily on a 3g/4g cellular network
- Simple to operate for those with low technological competence

These features continued to be important in subsequent discussions. Other considerations were addressed as the project unfolded, such as environmental and economic impact, undesirable misappropriation of the tech, misinformation, etc. These will be discussed further in this section.

For this evaluation we rely on tools and concepts developed in the field of STS, in particular Kiran, Oudshoorn, and Verbeek's framework for ethical-constructive technology assessment, or eCTA (Kiran et al 2015), Verbeek's three levels of technological mediation (Verbeek 2011), and Akrich's heterogenous networks and the concept of "scripting" (Akrich 1992). In addition, Amartya Sen's capabilities approach provides a moral foundation, with the precept of living a life "one has reason to value" as its mantra (Sen 1999).

Taking to task the concept that our technologies are moralizing objects, imbued with their creator's beliefs on what is "correct" behavior (Verbeek 2011), a first question we can ask about the Portable Portal is whether the beliefs of its creators are compatible with the beliefs of its users. It is difficult to imagine a greater cultural and experiential chasm than that which exists between the two. On the one hand, the users are young women from a very marginalized segment of a traditionally agricultural society, rural and very poor even by the standards of a still-developing country. On the other, the creators are uniformly white, male, educated and privileged members of the global North. The development of the technology has taken place in Norway, one of the wealthiest countries in the world. The author has been acutely aware of this weakness, and has attempted to compensate through a

rigorous background study of Bangladesh, its people and history. Many conversations with the founder of Speak Up have helped to clarify, to an extent, the environment into which the PP is to be placed. Despite this, the principle of “no innovation without representation” has been breached, as the PP has been pre-scripted with its creator’s moral vision almost exclusively. It is certain that collaborative engagement is needed with the proposed users of the PP in order to make a more definitive assessment of what “correct” behavior truly looks like.

Going further into the eCTA framework, we can divide the implications of the Portable Portal technology into “hard” and “soft” impacts (figure 8). Hard impacts are those that can be quantified to a degree, such as the technology’s effects on the environment, on the health and safety of its users, or on the local economy. Soft impacts are those which affect societal norms/values and the relationships and

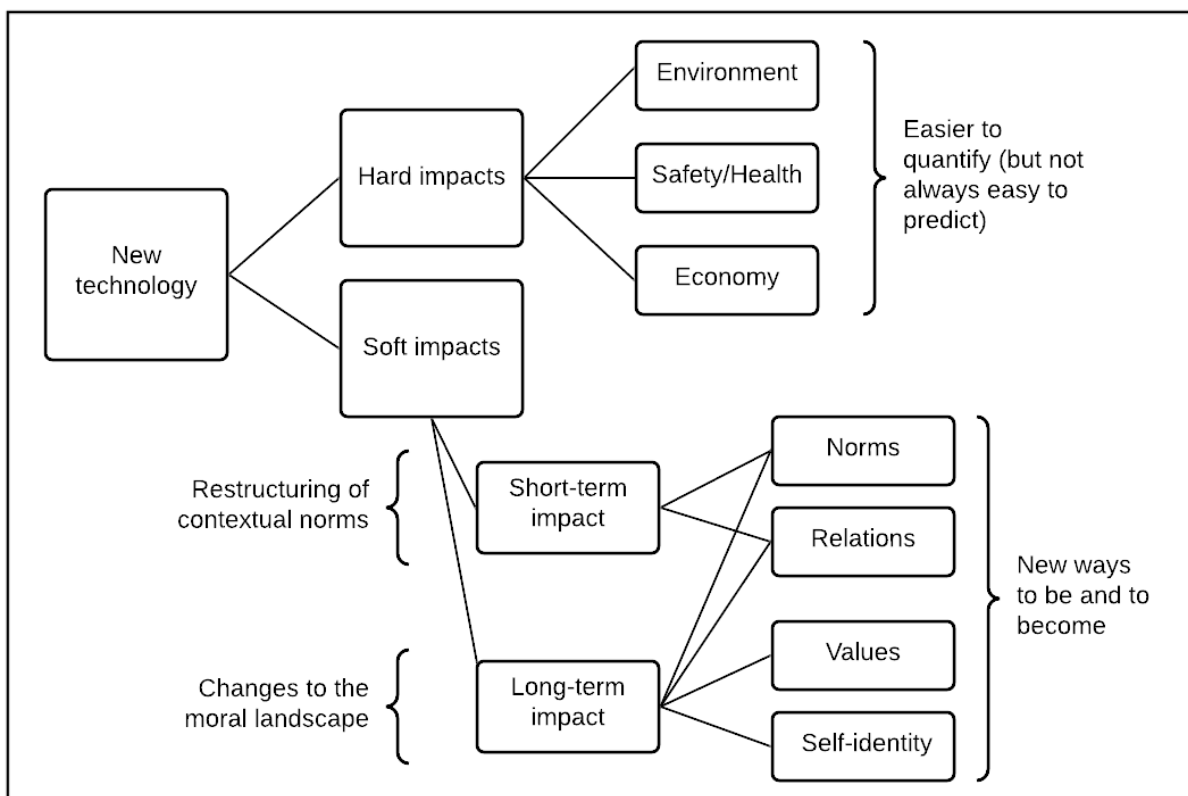


Figure 8: Hard and soft impacts

identities of its users, which can be further divided into short-term and long-term effects. We will first consider the hard impacts before moving on to the soft.

6.1 Hard Impacts

6.1.1 Environmental

The environmental impact of the PP has been carefully considered, as the impact of e-waste on Bangladesh is already a huge problem. Still, there is a negative environmental impact to any development. The only way to avoid this is to not build the system at all, or even research it, as the computer used for this research has consumed many resources in its wake. Even the lowest-tech imaginable approach to research consumes both renewable and non-renewable resources, from the mining of graphite for pencil lead, to the cutting of trees to make pencils and paper, to the various extracted resources used to build, stock, heat, cool, and maintain the university library. While this seems to present an unresolvable conundrum to the environmentalist, the way out is through reconciliation of humanity's drive to create with our moral duty to preserve the planet for all its inhabitants. By creating technologies that "do good", we attempt to balance the impact of extractive industries and waste with the effects of greater openness and understanding that our educational technology brings. Of course, monitoring of our creations is necessary, with careful attention paid to their life-cycle impacts, taking every action possible to reduce waste and damage along the way.

6.1.2 Health and safety

The choices made in the creation of new technologies can have strong effects on the physical well-being of their users. When creating ICT, the potential dangers of the online environment for young women, in particular, are high. An issue raised by the founder of Speak Up in discussions about the PP was the phenomenon of "revenge porn", which had already affected several young women in the Speak Up GEP. In conservative Bangladesh cultures, this can be nothing more than the sharing of a photo of a woman without her head scarf. An act so seemingly harmless to Western observers became quite traumatic for the women targeted, affecting their self-image, social standing, and potentially their physical safety as

well. With the design of the Portable Portal system, there is no potential for general access to the internet or social media, as it only accesses the system's own website, making it hard to imagine how it could be used for such ends. Of course, by essentially side-stepping this issue we merely pass it on to other ICTs such as smart phones, which these young women will undoubtedly also encounter in their lives. The answer to this, echoing Paola Bartoli's comment from section 3.4.4, is "education, education, education" (and perhaps regulation as well). Those of us in the global North have neglected to take proper precautions toward making the online world safer for humans, and we are now passing this neglect to the South. The PP, as an educational tool, could be used to counter this. As a kind of "introductory ICT", it is well-positioned to offer a targeted course on online safety, giving its users a thorough introduction to the darker uses of technology, not only revenge porn but misinformation, hate speech, and other digital dangers.

6.1.3 Economic

Most ICT-oriented aid projects do not take into account the direct economic impact of their interventions. For example, projects like OLPC or PlayPumps (see: 3.4) were merely imposed on their users, being designed and built outside of their respective communities. This is partially true of the PP as well. However, part of the design intention of the PP is that it be built in the country in which it will be used. This is advantageous from an environmental standpoint, reducing the carbon footprint from shipping, but also aids the local economy, by relying on local labor and expertise to build the device. Even better would be if the entire process of creation could be in-country from the beginning, designed in collaboration with its users. Not only can we then ensure the technology embodies the moral script of its users, but we maximize the positive economic benefits of a truly local product.

6.2 Soft impacts

6.2.1 Short term

By introducing a distance-teaching technology into the daily routine of students in Speak Up's GEP, we immediately disrupt their way of relating to the process of learning. While it is designed to enhance their educational experience, we can see that something is potentially lost in the process. It is very difficult, if not impossible, to replicate the experience of an in-person teacher through the screen of the Portable Portal. A good teacher, standing physically before a class or pulling up a chair to help a struggling student, engages with her charges in a visceral way that she cannot hope to match through a screen. The norms of student-teacher interaction, usually invisible, become visible and cumbersome. Even the act of asking a question involves a new way of interacting; walk to the screen, press the "raise hand" button, wait for the teacher to unmute the mic.

This loss of directness and warmth can be a difficult adjustment. It could be said that in exchange, the students receive tutoring they might otherwise not receive at all. Whether the Portable Portal can facilitate other forms of warmth remains to be seen.

Another immediate effect of the Portal Portal is the digital exclusion of those who, for various reasons, cannot access its technology. The design of the PP automatically shuts out many handicapped students, as it assumes ability to see, hear, and navigate the controls on the front panel with the hands. Empowering a diversity of handicapped students, each with their own unique abilities, might require a new approach and a completely different design. Nevertheless, there are adjustments and additions to the Portable Portal system that could be made to enhance inclusion. Braille letters could be added to the front panel so that blind students could find the "raise hand" button. Instructions in English and Bangla, printed on the inside of the front cover, could be augmented with Braille renderings of each. For deaf students, certain lectures could be conducted in Bangla Sign Language. Recorded lectures could be translated into sign language and posted

alongside, or integrated into the original. For the mobility impaired, a 1/4" plug on the front panel of the PP could connect a disability-adapted switch on a long extension for engaging the "raise hand" signal. These and other small additions could make a big difference in inclusion.

As it is intended for use in learning centers operated by Speak Up, an organization concerned with girls' welfare, the PP also potentially excludes boys and men. This exclusion could lead to problems beyond the immediate effect of "missing out" on a beneficial technology, breeding resentment among others in the village that are shut out. To counter this, the PP should be regarded as a village resource, as described in 5.3. If everyone partakes in the benefit of a technology, everyone has a vested interest in its survival. The perception that the empowerment of females is a zero-sum game is to be avoided. Care must be taken, however, that the technology is not misappropriated by others. Considering the uneven power relationships between the girls of Speak Up and others in the community, this should be a cause for cautious vigilance.

6.2.2 Long term

While it is easy to create imaginaries about the positive long-term benefits of a new technology while it is being developed, these imaginaries tend to occlude potential long-term negative impacts. It is, for example, unlikely that the creators of Facebook, Twitter, etc. intended for their social media innovations, designed to draw people together, to have the paradoxical effect of contributing to the increasing paranoia and polarization of society. The Portable Portal system is designed to aid the education of disadvantaged girls; we can imagine its long term impact as one of ever-increasing empowerment for its beneficiaries, with a glittering multitude of knock-on benefits for their villages and the greater Bangladeshi society. This is the imaginary, but what is the reality? It is very difficult to predict the ways in which new technologies can alter the moral landscape, but we can take the example of social media as a cautionary tale.

If, for example, the Portable Portal contributes to the erosion of traditional relational norms in Bangladeshi villages through its empowerment of the marginalized, leading to greater recognition of the value and contribution of these members, this could be seen as a positive impact. However, if this erosion of norms leads to other social erosions, resulting in resentments and even violence against the newly-empowered, this is not positive. If the result of greater empowerment and improved education is an expansion of horizons and increasing political expectations on the part of users, this can put positive pressure on the government to address corruption and improve services and infrastructure, benefitting all of society. But what if increased expectations lead rural dwellers to flee to the already-overburdened city, seeking a life of value for themselves but resulting in the hollowing-out of vital rural farming populations? Or, taking a cue from neighboring Myanmar, the government responds to pressure from its people with draconian violence and repression?

A technology like the Portable Portal does not exist in a vacuum, but is acted-on by its users who are acted-on by it in turn. It is part of a heterogenous network (Akrich 1992) that includes many actors both human and non-human, from the people that use (and don't use) it to the vast chain of extractive industries that produce and sustain it. This relationship can co-evolve in surprising ways. By creating and imbuing our technologies with moral power, we are obligated to monitor the impacts of these affordances of morality and reinvent, reshape, or retire our creations dependent on their observed divergence from "correct" behavior and intended use.

7. Future work

With this scoping study of the Portable Portal system now complete, the project moves into the next stage. Funding must be arranged. A physical prototype must be built, tested, evaluated, documented, revised, tested, and evaluated again. It is assumed that this initial prototyping will take place in Norway, which is a flaw but most likely unavoidable at this point, but that future prototypes will be built in Bangladesh using the template developed in Oslo.

Once the project moves to its intended environment, a process of co-creation can begin. The system must be deployed in the field. Its impacts must be studied. Does it work as intended? Does it have a positive impact? Above all, does it improve the lives of its presumed beneficiaries? Those who stand to gain or lose the most must have a say in how the technology develops. Guide, correct, co-create.

The advantage of the PP in this process lies in its open-source flexibility and DIY aesthetic. Components can be swapped, holes can be drilled, software can be tweaked. If better solutions come along, the entire structure can be dismantled and its parts repurposed. If it's wildly popular, more can be assembled relatively easily, with components readily available.

While this study has focused on development in Bangladesh, the PP concept could prove useful in other countries and communities that grapple with similar educational challenges. In that case, the technology is movable. Of course and as always, new uses demand new evaluation. The process of co-creation begins again in a new environment with its own unique ecology.

8. Conclusion

In this thesis, we have approached the Portable Portal as a technology whose implications go beyond merely addressing a problem of distance. Employing an interdisciplinary approach and drawing insights from the historical, ecological, and environmental context in which it is centered, we have attempted to look beyond the imaginaries of aid success and get to the wicked heart of the matter.

In the process, several insights have been gained regarding the problem of introducing ICT into the educational-aid ecosystem in Bangladesh. First, educational solutions are highly context-dependent. What works in the fat global North will quite often not work in the lean South. This has become clear from our study of various development projects and their failures, although as we have seen, “failure”, like “success” is a concept that is also highly context-dependent.

This leads to another insight: the way we approach aid and development is ready for a refresh. Why do so many seemingly-simple aid projects miss their mark? The answer lies at the nexus of a wide range of continually-evolving technological, environmental, and human factors that contradict and often confound our best attempts to resolve them. The desire to reduce complexity is understandable, but treating development as merely an engineering task, or worse, a photo-op, without confronting the wicked problems that lurk in the ecological bushes is more than just inviting failure. Doing so only feeds the beast, ensuring our problems remain un-tamed and un-tamable.

The concepts and tools developed in the field of STS, particularly the eCTA framework (Kiran et al 2015) utilized in the Evaluation section (see: 7) have proven invaluable for revealing potential weaknesses in our design. In developing the Portable Portal, we have attempted to turn insight into action, designing around the perceived obstacles to success. The danger with this approach, however, is that in the desire to create a “perfect” solution, we produce an object that is utterly pre-scripted and overly constrained, offering no affordance to the user to break free of the chains that bind them to its creator’s moral vision. Rather than enchanting our users with a world of expansive possibility, we wind up only frustrating them or boring them to tears.

This “one-size-fits-none” non-solution is a real possibility, along with a host of other ills. How then shall we proceed? Our way forward lies in the realization, as explicated by Akrich, Verbeek and others in the STS canon, that we are our technologies and they are us. By investing our creations with moral power, we are obligated to monitor their path, guiding and correcting them like the responsible parents we must become.

Appendix

A: Functional Requirements

Portable Portal System Functional Requirements:

The Portable Portal System (hereinafter referred to as the “System”) consists of the Portable Portal (physical device - hereinafter referred to as “PP”) and a website (hereinafter referred to as “Website”) containing embedded video conferencing tools, archived lecture videos, a calendar for scheduling sessions, and other necessary information.

Hardware requirements:

The PP central processor is a Raspberry Pi 4 micro-computer. It is connected to several peripherals:

- R-Pi camera module V2
- ReSpeaker 4-mic linear array
- Cellular modem (manufacturer to be determined)
- Audio amplifier and speakers
- a HDMI monitor
- a UPS
- Six push-button switch (momentary non-latching) controls for navigation (Raise Hand, up, down, left, right, OK)

PP Software Functional Requirements:

The PP boots up automatically when powered on.

On power-up the cellular modem searches for and logs on to the network, if available.

If network is not available, screen displays “Network Not Available” in English and Bangla.

When connection to a network is made, PP automatically logs on to the Website.

The PP connects to the Website’s landing page, displaying the calendar and countdown timer. The countdown timer shows the time until the next scheduled lecture session.

When a lecture is imminent (within 60 seconds), the PP will automatically navigate to the video lecture page of the website.

System connects to the peripherals (mics, camera, modem, screen, audio outputs) automatically.

Microphone array is optimized for videoconferencing use, with echo cancellation and noise suppression.

During lecture sessions, instructor has control over PP microphone, microphone defaults to “muted” during sessions.

Buttons on the front panel of the PP control various functions as follows:

- “Raise hand” button engages the raise hand alert in the embedded videoconferencing application.
- A cluster of five buttons arranged in an “up, down, left, right, OK” circular pattern (similar to a typical TV remote control) is used for Website navigation. Tabs and controls on each page highlight when they are navigated to, and the OK button can then be used to select that tab or control.

When system is switched off and/or unplugged, computer receives shut down signal from the UPS and immediately begins shut-down sequence.

Screen displays “Goodbye!” in English and Bangla during shut-down.

If device is plugged back in before shut-down completes, device will safely shut down before attempting to restart.

Website Requirements:

There are three levels of users for the Website: Administrators, Instructors, and Students.

Students using the PP to access the Website are logged in automatically when the PP boots up and connects to the network. Administrators and Instructors logging in from their own computer must create a secure account with password.

Administrators must approve new Instructors before they are able to access Instructor functions on the website, such as initiating lecture sessions.

The Website has three main pages:

- Landing page: displays calendar and countdown timer. Other messages and information can be posted here by Administrators.
- Video lecture page: this page contains embedded videoconferencing tools.
- Lecture archive page: this page contains all past lecture videos that have been recorded and archived.

Admin level access:

Administrator-level access enables control of the scheduling calendar, software updates, approval of new Instructors, and other Admin. functions as needed.

Software updates for the PPs are under Administrator control and can be delivered remotely from the Administrator Dashboard.

Instructor Level access:

Instructor must be able to create an account and password to log on using an email address.

Instructor must be able to retrieve lost username/password using email address.

Administrator must approve new instructors before access is granted.

Instructor initiates lecture sessions.

Instructor can click “Begin Session” in advance, but session will delay until countdown clock completes countdown.

Instructor can see all connected students or student groups connected via PPs or other devices as in a regular video lecture or conference.

When the Instructor receives a “raised hand” signal, Instructor can then unmute the mic associated with the student/group that initiated the raised hand.

Lectures are automatically recorded.

When session is ended, instructor can review/edit video before saving to the Website.

To save video to Website, Instructor must fill out a form with the date, time, subject, and textbook chapter/pages associated with the lesson.

This information is used to organize videos on the Website, and is displayed along with the video.

Instructor will be prompted to fill out form and save video to the Website before logging off.

Student Level access:

Students logging on to the Website via the PP do not need to enter a password. The PP logs on automatically.



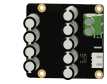










If a lecture is imminent (within 60 seconds) of logging on, PP navigates to the video lecture page of the website and enters full-screen mode. Otherwise, PP navigates to the landing page.

During lecture, students can alert the Instructor using the “Raise Hand” button on the front panel of the PP.

If no lecture is imminent, students can use the front panel controls of the PP to navigate to the Lecture Archive page, and use the controls to select and play past lectures.

B: Price Breakdown

Portable Portal internal components and Price List (in U.S. dollars):

22" Monitor Screen (Walton):	113	
3" Speakers (2):	4	
Raspberry Pi 4B processor, 4GB RAM:	70	
UPS board:	15	
Cellular Modem:	65-126	
ReSpeaker mic array:	30	
Power supply:	10	
Audio amplifier:	3	
R-Pi camera module V2:	30	
Cooling fan:	8	
Large arcade button:	3	
Small arcade button(5):	3	
Toggle switch:	3	

Power socket:

3



Double binding post:

2

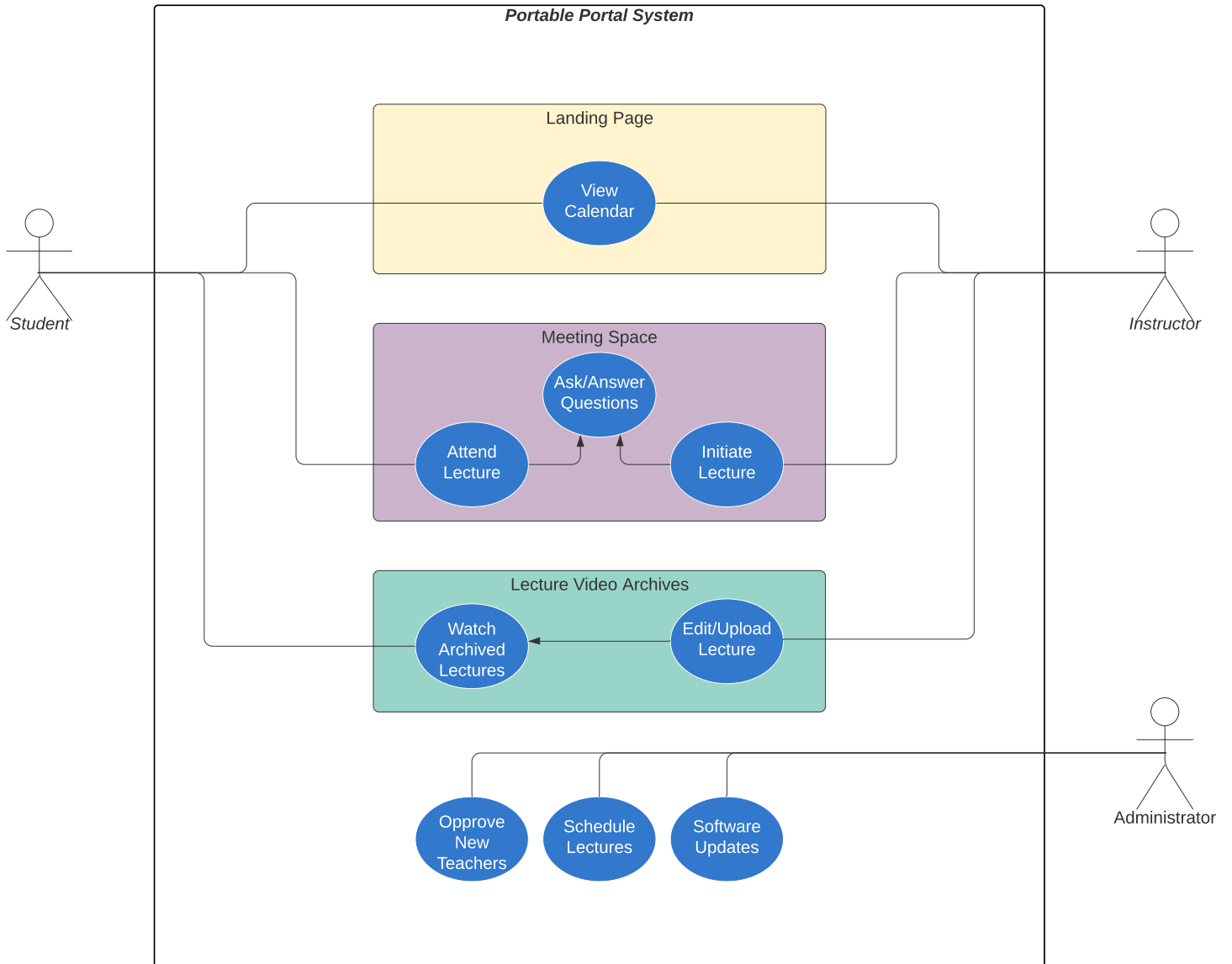


Total: \$362-423

C: Use Case Diagram

Portable Portal Use Case Diagram

Paul Koenig | April 13, 2021



D: Workflows

Student workflow:

Remove front and rear covers of the Portable Portal (PP)

Extend power cord (wall power or battery clamps) and connect to power

- Portal boots up automatically and attempts to connect to cellular network
- If unsuccessful, display signal strength icon and text “try different location”
- if successful, connect to website Landing Page with calendar and countdown timer

If a lecture is imminent:

- PP navigates automatically to Video Lecture page when countdown timer reaches 60 seconds to upcoming lecture
- Lecture begins when countdown timer reaches 0
 - Remote instructor initiates lecture session
- Student(s) watch and listen to lecture
 - Student(s) can adjust audio volume as preferred using volume knob on front panel
 - Student(s) can use the “raise hand” button on front panel to ask question
 - Instructor receives alert. Hand icon appears on screen
 - Instructor manually unmutes user’s mic when ready
 - after question/answer period, Instructor re-mutes the student mic and continues lecture
- When lecture concludes, Instructor ends session. PP navigates back to Landing page

If no lecture is imminent:

- Student(s) can navigate to archived lecture videos page using buttons on front panel (up, down, left, right, OK) to select on-screen tabs and controls
 - Student selects and plays desired lecture using the front-panel buttons

When done with session, user can turn off/unplug unit:

- Unit shuts down safely (UPS provides power buffer)
 - Screen displays “Goodbye!” message during shutdown
- Power cord is stowed, front and back covers replaced

Teacher Workflow:

Create Instructor account on website. Instructor account must be approved by Administrator before Instructor functions are enabled.

Log on to Website

- Landing page shows calendar for upcoming lectures
 - Instructor’s lectures are highlighted
 - countdown timer displays, showing time to next lecture

Instructor initiates lecture session

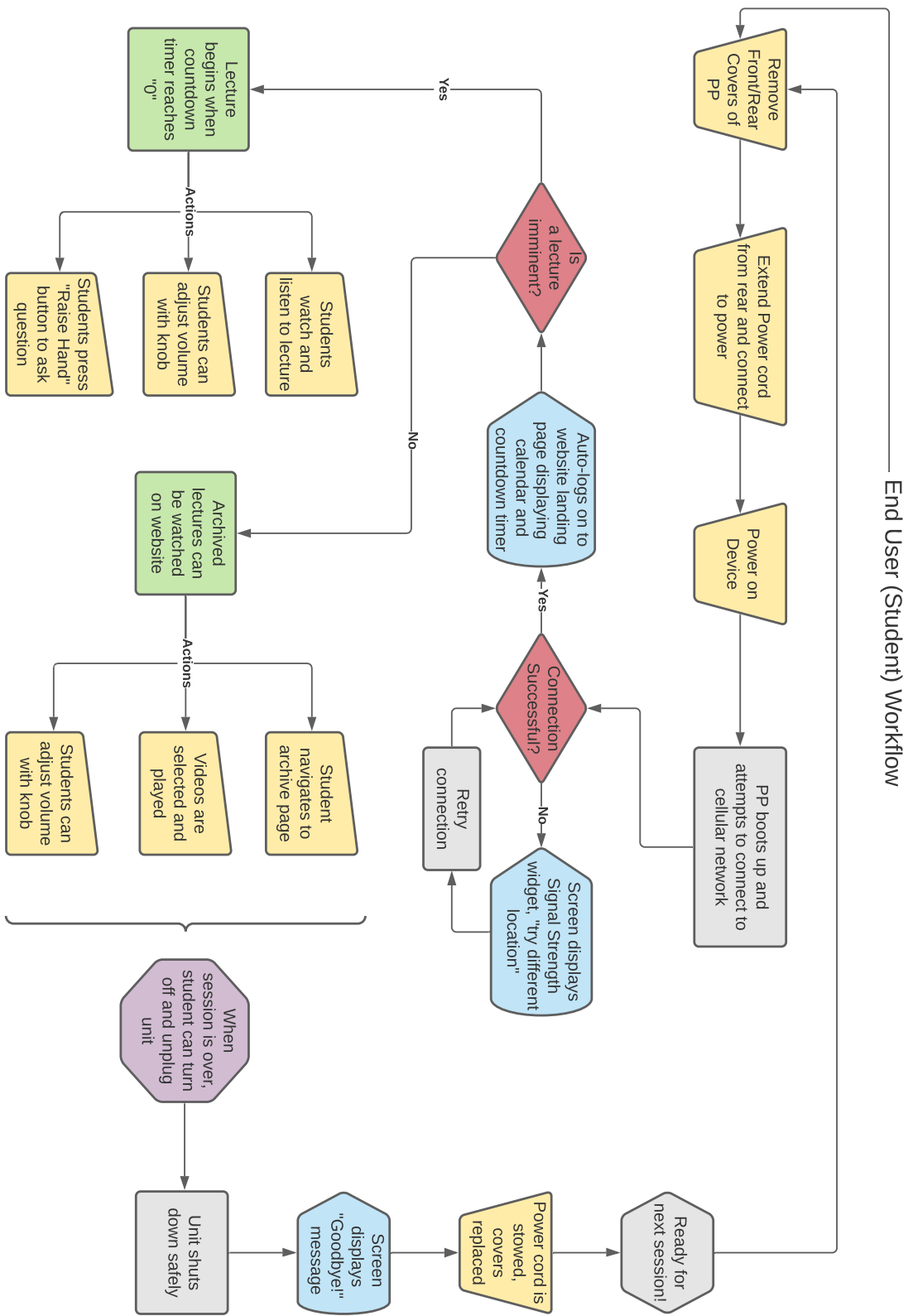
- Session begins when countdown clock reaches 0
- Instructor receives a “raise hand” signal when there is a question from student
 - Instructor must unmute the student’s mic manually when ready
 - Instructor must re-mute the student’s mic manually when done with Q/A

Lectures are automatically recorded

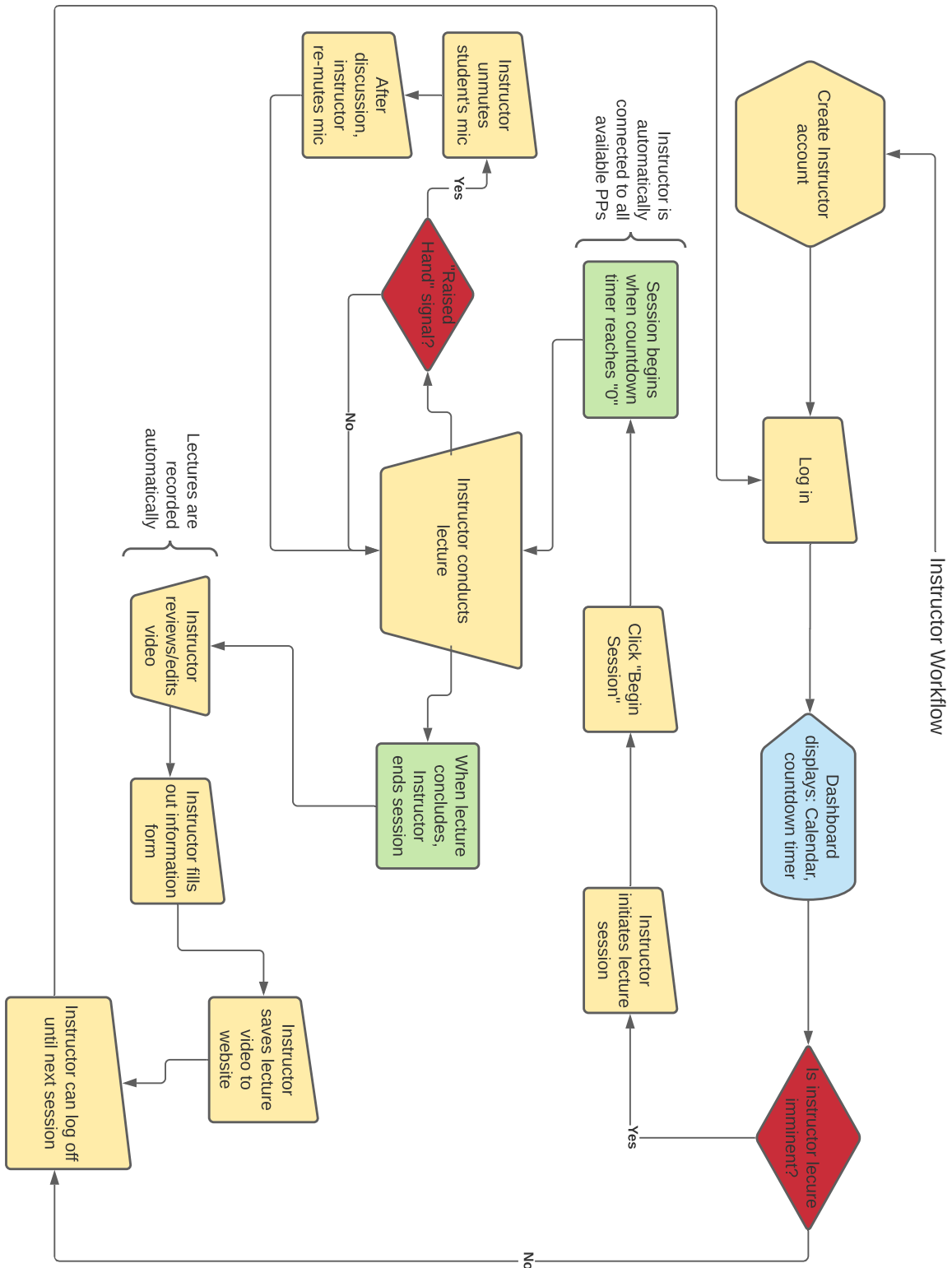
- after session, instructor can review video before filling out information form (date, subject, textbook chapter/pages) and saving lecture video to website
- instructor is prompted to fill out form to properly categorize video before logging off

Instructor logs off

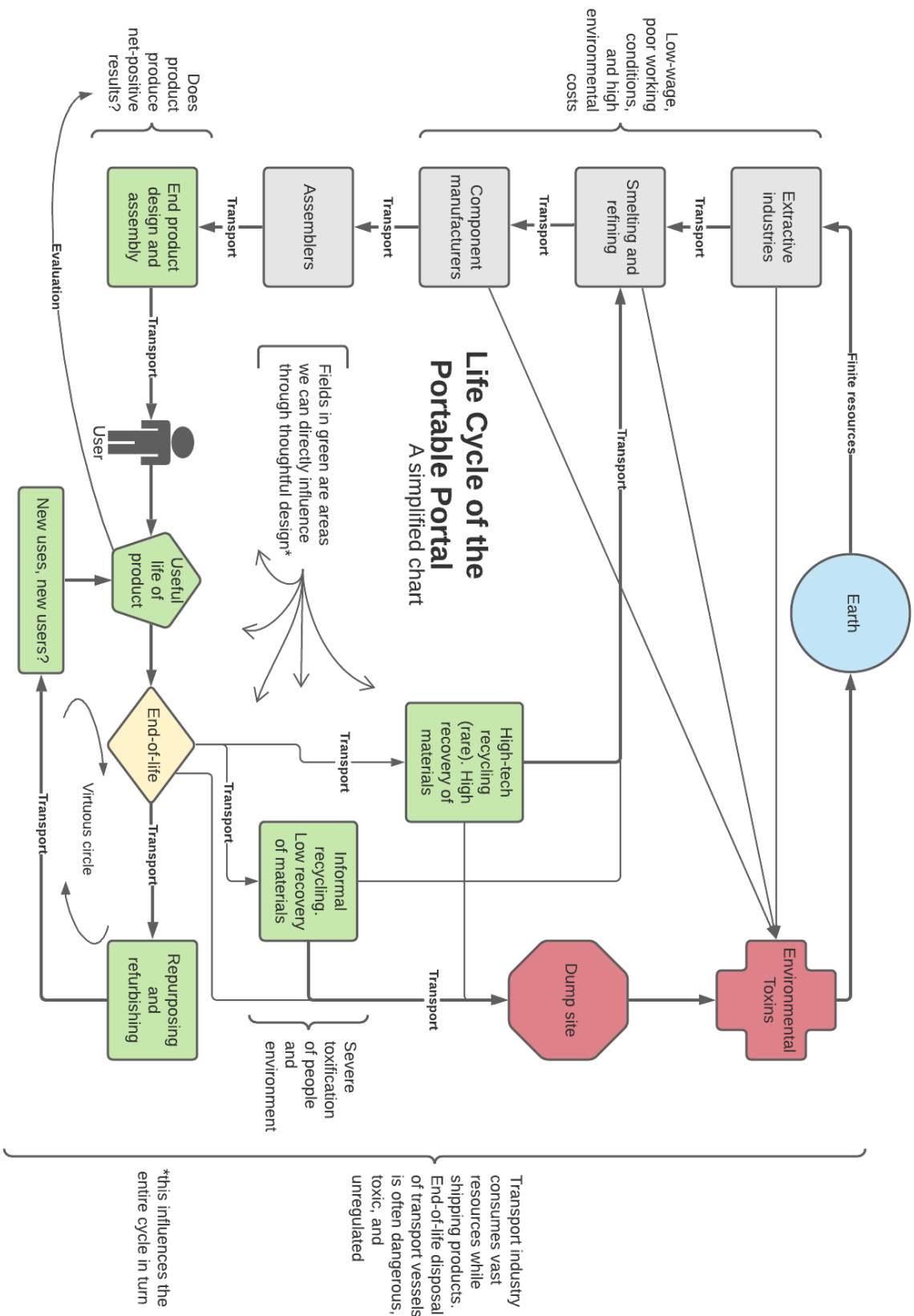
E: Student Workflow Diagram



F: Instructor Workflow Diagram



G: Life-Cycle of the Portable Portal



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