TOWARDS SCALABLE DIGITAL SKILLS TRAINING IN RESOURCE-CONSTRAINED ENVIRONMENTS: AYITIC GOES GLOBAL IN HAITI

Research paper

Abstract

In a context of high unemployment and marked gender inequality, online education for women becomes a niche with great potential in Haiti. Returns to education are particularly high in ICT-intensive jobs and IT outsourcing offers concrete opportunities for remote employment, providing alternatives for economic diversification and job creation that are particularly relevant for youth and women. The problem faced in many developing countries, such as Haiti, is that traditional models, architectures and platforms for online learning do not lend themselves well to their context as typical assumptions about the availability of adequate civil and digital infrastructure, and the evolution of social and cultural habits towards normative behaviors in the digital economy are rigorously challenged. Therefore, it becomes important to develop platforms suited to their context. This has motivated the research question that this paper seeks to address, namely "What is the appropriate Architecture that supports learning strategies for delivering scalable digital skills training in a resource constrained environment?"

This research paper proposes an architecture that was developed specifically for blended learning in resource constrained environments and describes how a prototype for this was designed, built and deployed in Haiti.

Keywords: Digital Literacy, Transactional Distance, Scalable eLearning Architecture, Resource Constrained Environments

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1 Introduction

The developing country, Haiti, is often characterized as one of the poorest countries in the Western Hemisphere (UNDP, 2016), and is still recovering today from the devastating effects of the 2010 earthquake that severely damaged infrastructure, cost thousands of lives and adversely affected economic activities. With over 5,000 schools damaged or destroyed by the earthquake, Haiti faces serious challenges in its educational infrastructure (Sider, 2014). The education deficit situation is exacerbated for women due to persistent social beliefs and a historical pattern of discrimination and violence against women as a structural feature in Haitian society and culture[1].

In a context of high unemployment and marked gender inequality, online education for women becomes a niche with great potential in Haiti. Returns to education are particularly high in ICT-intensive jobs and IT outsourcing offers concrete opportunities for remote employment, providing alternatives for economic diversification and job creation that are particularly relevant for youth and women. The project "*Ayitic Goes Global: Empowering Women through Digital Markets*"[2] was conceptualized to determine how best to build digital skills among young Haitian women in urban and rural contexts to create employment opportunities through online services. Although seen as a feasible response to the pervasive deficits in Haiti's educational infrastructure, achieving the sustainable delivery of online/distance education and digital skills training still has to contend with a broad range of issues, including: *the availability of local trainers, facilitators & mentors; the development of current, context-relevant, language-specific training content; and training delivery mechanisms that enable on-line / off-line access modes to allow for limited bandwidth infrastructure with intermittent availability*.

Rapid advances in digitization, web technologies and available bandwidth have enabled the emergence of new models of education, teaching and learning (broadly categorized as eLearning). Massive Open Online Courses (MOOCs) have emerged as a significant capability and competitive issue for established higher education institutions and traditional education models. MOOCS typically share a number of common attributes: *Online mode of delivery; Short videos; Online quizzes and assessments; Peer and self–assessment; Online forums*. These characteristics are based on certain pedagogical assumptions including: Availability of high bandwidth; Target learners whose learning styles have been shaped as digital natives; Pervasive mobility and learning consumption on-demand (Glance, Forsey, & Riley, 2013).

However, as is often the case, context matters greatly. The typical assumptions about the availability of adequate civil and digital infrastructure, and the evolution of social and cultural habits towards normative behaviors in the digital economy are rigorously challenged in many developing countries such as Haiti. Therefore the traditional models, architectures and platforms for online learning do not lend themselves well to these contexts.

The nature of such learning architecture design projects in developing contexts such as Haiti, brings with it some limiting constraints of resources such as electricity and Internet access. Implementations are typically remote and not connected to the Internet. In other cases the connectivity may be available, but is intermittent. In such environments, we need a distributed architecture to handle service needs at the core and the edge of the network (Verma & Ryan, 2016).

Architecture or architectural design provides a blueprint for converting the strategic goals of any IT project into a plan. This plan provides for flow and processing of information, including the infrastructural components of hardware, software, data and networking. These components are assembled into a platform forming a system that best supports the architectural plan, which in turn enables and fulfills the overarching strategic goals.

[1] Report of the Inter-American Commission on Human Rights (IACHR)
[2] http://ayitic.net; https://www.youtube.com/watch?v=X-zu8ZOEl7Y

Therefore, it becomes important to develop platforms suited to their context which has motivated this research and the overarching research question that anchors this study is framed as follows:

> *What is the appropriate Architecture that supports learning strategies for delivering scalable digital skills training in a resource constrained environment?*

In this research paper, we describe a specific architecture that fulfills the goals of blended learning in resource constrained environments. The platform is an implementation of the architectural plan into the software (mobile apps), hardware (tablets), data (analytics), and networking (cloud backend) (Hay & Muñoz, 1997). We designed, built and deployed a prototype for the project implementation in Haiti.

The remainder of the paper is structured as follows. Section 2 examines the relevant literature on aspects of Digital and Data Literacy. We examine the applicability of Moore's vintage Transactional Distance Theory to modern eLearning design and pedagogy. Section 3 applies Transactional Distance Theory as a lens through which the eLearning pedagogical design is framed. Section 4 describes initial results and preliminary insights from the "Ayitic Goes Global" project in Haiti. Section 5 discusses the findings and contemplates strategies and challenges of scaling digital literacy in the Caribbean, which could provide an architecture design template for other developing contexts.

2 Literature Review

2.1 ICT Innovation in Developing Countries

Although it has been accepted that ICTs can play a pivotal role for developing countries the issue of how to ensure their relevance in the context of these countries still requires further understanding (Nielsen, 2017). Nielsen points to the lack of research on digital technologies and the significance of digital innovation for developing countries. They point to the literature that speaks to the need to consider the context in which ICTs are to be implemented and used. Foster and Heeks (2013) call for inclusive innovation which they define as the means to make innovation relevant to low income groups (Foster & Heeks, 2013). This could mean addressing problems relevant for the poor, enabling the poor to adopt the innovations or creating innovations to improve the livelihoods of the poor. Based on this definition the research described in this paper would therefore be categorized as an inclusive innovation. Nielsen (2017) stress that the context of developing countries pose unique challenges to ICTs and, because of this, require different technologies and implementation approaches. They provide some examples of these unique challenges including resource constraints such as weak ICT infrastructure and electricity outages which result in issues with Internet connections. These challenges call for solutions that require little bandwidth and support offline capabilities which have been an important consideration in addressing the research question that has been posed in this paper.

2.2 Digital Literacy in the Caribbean Context

Digital is rapidly becoming the dominant mode of interaction for commercial, social and economic activity, hence the Digital economy. Data is the oil that fuels the Digital economy and data literacy is the ability to collect, organise, manage, evaluate and apply Data to various business scenarios and activities which is rapidly becoming an essential in-demand employability skill. With the emergence of the Digital economy, Digital literacy / Data skills have become an imperative and a right, no longer a privilege (Murray & Pérez, 2014).

The GSMA Report "Connected Society: Digital inclusion in Latin America and the Caribbean" identifies the lack of "digital literacy and skills" as one of the biggest barriers to digital inclusion in Latin America and the Caribbean (Sharma & Lucini, 2016). For Caribbean societies to overcome the digital divide, and keep pace with the rapidly evolving digital economy, then digital literacy and data skills must become a universal right, rather than a privilege, for Caribbean youth. The UN's Sustainable Development Goal SDG 4 Target 4.4. which seeks to "*increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship*" emphasizes this imperative (Montoya, 2018).

2.3 Defining Digital Literacy

A comprehensive review of the literature highlighted a variety of conceptions of Digital Literacy (Rosado & Bélisle, 2006), which fall into two broad categories of definitions. There are those primarily concerned with technical skills versus those that are focused on cognitive and socio-emotional aspects of working in a digital environment (Eshet-alkalai, 2004). An example of the former comes from the Cornell University Digital Literacy Resource that defined Digital literacy as "the ability to find, evaluate, utilize, share, and create content using information technologies and the Internet". However, in essence, Digital literacy involves more than the mere ability to use digital tools or work with digital media.

Martin (2008) synthesizes the literature and integrates several previously existing "*literacies of the digital*" (e.g. ICT Literacy, Information Literacy, Media Literacy, Visual literacy, Communication literacy) to offer the following comprehensive definition of Digital Literacy :

> "*the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyze and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life situations, in order to enable constructive social action; and to reflect upon this process*"

The definition promotes competence-based learning (Voorhees, 2001), which is important given the job-demand-driven nature of the training requirements suited for many developing countries such as Haiti and those of the wider Caribbean. The merits of a competency-based approach to learning include:

- *Increased Learner Engagement*: The learner engagement model of competency-based education tends to be much higher because learners have ownership over their learning experience through learner-centered approaches and structure that enable greater flexibility and self-paced modes of delivery
- *Skills-based Approach*: One of the key benefits of competency-based education is that learning centers on real-world skills and competency development.
- *Explicit linkages to Bloom's Educational Taxonomy*: Competency-based education makes learning outcomes measurable and increases the probability of more effective assessment and validation.

We subsequently made the following amendment to our adopted definition of "Digital Literacy"

Digital literacy is the ***knowledge***, ***skills*** and ***attitude*** of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyse and synthesise digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life situations, in order to enable constructive social action, and to reflect upon this process.

We use "*knowledge, skills and attitude*" instead of "*awareness, attitude and ability*" with "knowledge, skills" being somewhat more amenable to measurement & assessment than "ability" according to Bloom's Taxonomy, and "*knowledge*" will incorporate "*awareness*".

2.4 Pedagogical Considerations

Pedagogy is the discipline that deals with the theory and practice of teaching or simply, the means by which education achieves its objectives. At a conceptual level, pedagogical strategies are informed by the principles of teaching and learning as well theoretical concepts which as Behaviourism, Cognitivism, Constructivism and Connectivism (Ertmer & Newby, 2013). At a programmatic level the concern is with the *what* and so is about identifying target competencies, learning objectives, sequencing and organizing of content, specifying learning activities and deciding how to deliver content. At an individual lesson or module level, instructional design is concerned with the *how* (Wiley & others, 2002) (Gustafson & Branch, 2002). The focus is on which specific instructional, navigational and assessment methods are best suited for the course content, modality and learner.

Traditional theories of Learning describe how knowledge is absorbed, processed, and retained during learning: Behaviorism, Cognitivism, Constructivism and Connectivism (Siemens, 2004). Connectivism is an attempt to construct a new learning paradigm for the Digital age, that takes into account the effects and possibilities of technology-enabled learning in a networked context (Goldie, 2016). This requires the engagement of learners in an overtly social and networked learning experience and emphasizes the connections that develop among the participants, materials, and learning. This approach amplifies learning, knowledge and understanding through self-education structured as a distributed network, and aggregated together using technology.

2.5 Moore's Transactional Distance

Moore's transactional distance theory (Moore, 1973, 1993) is based on the assumption that the most profound impact on distance education is pedagogy and not the physical or the temporal distance that separates the instructor and learner. It is a relative measure of the physical, psychological and communications separation between the learner, the content, and the instructor/facilitator. The extent of transactional distance is a function of three key variables, namely structure, dialogue, and learner autonomy. Dialogue speaks to the degree of interaction / communication between teachers and learners, increasing the dialogue reduces the transactional distance. The second dimension, structure, is about the rigidity or flexibility of the course's educational objectives, teaching strategies, and evaluation methods. A high degree of structure increases transactional distance. Autonomy is the extent to which learners are able to decide on when to learn, what to learn, how to learn and how much to learn. A greater degree of Autonomy is associated with increased transactional distance. These dimensions and their effects on Transactional Distance are reflected in ***Figure 1***.

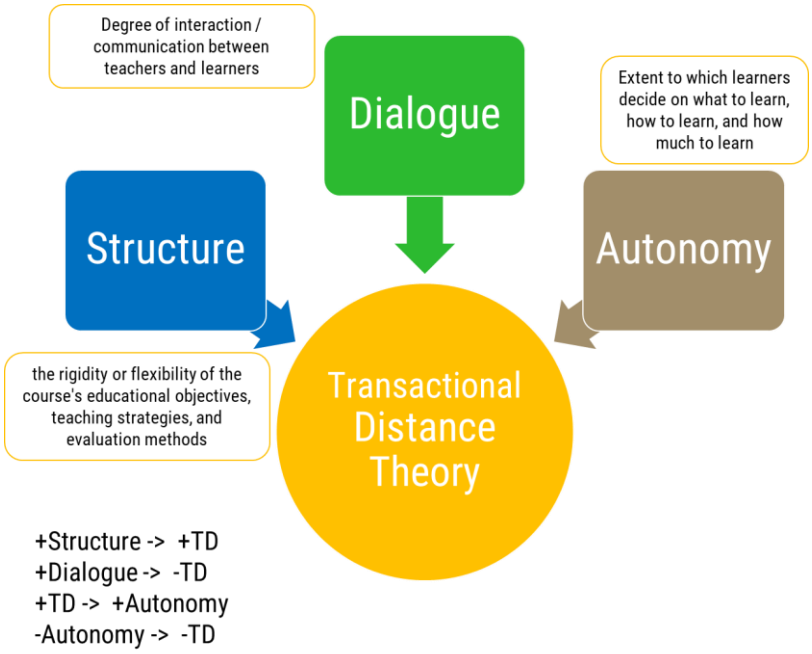

Figure 1. Transactional Distance

These are all considerations that must be accounted for in the design of any online learning environment. The Transactional Distance theory is somewhat vintage in its origins (Moore, 1973, 1993) and certainly predates the onset of the Internet and today's high-bandwidth, Internet-enabled digital models of education, teaching and learning. While some critics have accused the theory of being tautological (Gorsky & Caspi, 2005), Transactional Distance has continued to be a useful framework for design

or interrogation of distance education pedagogy in its various manifestations (see Benson & Samarawickrema, 2009 for several cases).

In general, according to Moore, the effectiveness of distance teaching (on-line learning) is significantly influenced by the extent to which the institution and the individual instructor are able to provide the appropriate opportunity for, and quality of, *dialogue* between teacher and learner, as well as appropriately *structured* learning materials. Furthermore, learner characteristics, and in particular, the optimum degree of *autonomy* are important determinants of this balance, and considerable time and effort has to be devoted to understanding the needs of target learner populations, and individual learners.

Huang's (2002) consideration of transactional distance and other elements of Adult learning theory (eg. Brookfield, 1995) in the design of constructivist online learning for adult learners is particularly relevant to the empirical context in Haiti. These considerations include:

i. **Importance of a structured curriculum**: learner's need to know "how learning will be conducted, what learning will occur, and why learning is important"
ii. **Interactive learning**: Interactivity motivates and stimulates learners. Active learning through interactions with instructors, other learners and content is a crucial function in distance learning.
iii. **Self-directed learning**: the ability of taking control of the techniques and of the purposes of learning.
iv. **Experiential learning**: prior experience of the learner creates individual differences, and could be a valuable resource in a collaborative and socially constructed learning environment.
v. **Critical reflection and problem solving orientation**: a form and process of learning whereby adults think contextually and critically. In particular, they can learn best when knowledge is presented in real-life context
vi. **Motivation to learn**: Adults have high motivation to learn when the learner can gain the new knowledge to help them to solve important problems in their life.
vii. **Instructor's role as facilitator**: the instructor's role becomes more of a consultant, guide, and resource provider with a responsibility to monitor and warrant the quality of learning and peer discussions.

3 Architectural Design - Scalable ELearning

The design parameters are further conditioned by the resource-constrained environment in which the teaching and learning is delivered. Resource-constrained environments in developing contexts can provide unique infrastructure, technical and social / cultural constraints (Anderson, Anderson, Borriello, & Kolko, 2012).

In the case of Haiti and this specific project, a combination of factors exacerbate the constraints:

- Capacity and quality deficits in civil infrastructure such as schools, roads and transportation services limit opportunities for traditional approaches to education. The recurrent disruptions of civil unrest and the attendant security concerns, increase the value opportunity for remote / distance teaching.
- The Caribbean region, which lies at the geographical axis of continental giants North & South America, is a heavily multilingual region with a colonial legacy of English, Spanish, French, Dutch and a variety of local dialects. Therefore eLearning design that is scalable at a regional level will need to incorporate multi-linguality as an essential design attribute.
- Internet infrastructure in Haiti is severely limited and/or expensive for the target participants, and access will likely be constrained (low-bandwidth and/or intermittent) for the foreseeable future (in

2017, only 12% of the population in Haiti has Internet access penetration[3]). eLearning design has to contemplate and make provisions for delivery modes that allows for remote, disconnected access and that is not dependent on continuous Internet access.

- However, while Haiti has one of the lowest Internet penetration rates in the Caribbean, access to mobile phones has increased rapidly, and smartphone access is also growing (Sider, 2014). Mobile devices will therefore be an important learning device for access and consumption of learning content.

Given these resource constraints together with aforementioned pedagogical considerations, Transactional Distance theory provides a useful conceptual framework for integrating the various elements in order to inform the following eLearning architectural design process.

Structure

Of necessity, the job-demand-driven nature of the training requirements dictated a competency-based approach to the curriculum and course content design, with structured learning outcomes that can be measured and evaluated. The target learners (young adult women) needed to be presented with a clear structure of "*how learning will be conducted, what learning will occur, and why learning is important*" in order to relate the program to their specific social context and generate high motivation to learn and gain new knowledge.

Course content was organized in alignment with explicit learning objectives, and the materials were lock-sequenced with a progressive, directed learning path that enabled students to achieve incremental mastery of a concept before moving on to the next. This approach was in keeping with Risdale et al. (2016, 2015) who recommend a module-based learning approach to digital literacy which allows students to achieve learning outcomes in stages and to build upon previously learned skills. It also allows the learners to build confidence in their abilities in a gradual way.

Autonomy

Notwithstanding the highly structured curriculum and course content and organization, it was necessary to allow for a fair degree of flexibility in terms of how learners engage with the program. A blended learning approach, combining synchronous & asynchronous modes of delivery provides learners (particularly women) with the time flexibility to pursue training opportunities while maintaining their essential livelihoods, and helps to mitigate the risk of high attrition rates that are typically associated with eLearning delivery. A key element of the blended learning delivery approach was the explicit incorporation of the instructor's role as a Facilitator which became more of a mentor, guide, resource provider and problem solver.

A deliberate decision was made to provision mobile tablet devices to learners as part of the program. This provided an important instrument for designing and deploying the program as self-paced mobile-enabled courses employing the flipped classroom concept. This provided learners with the flexibility to access learning content on demand and outside the constraints of physical classroom sessions and limited Internet access.

Dialogue

In keeping with the transactional distance framework, increasing degrees of structure and autonomy will tend to increase transactional distance. Hence it was necessary for the program delivery architecture to enable a significant degree of dialogue (interactivity) in the instructional design.

The Courseware was designed as modular eLearning objects with a variety of interactive elements and embedded quizzes that worked well on the mobile tablets and allowed for active learner interaction, versus the traditional passive learner experience that comes from just reading (e.g. pdf documents).

[3] ITU Statistics (2013)

Each course module incorporated built-in reflections that invite the learner to reflect on the learned concepts and cognitively apply them to familiar contexts.

Interactive face-to-face sessions scheduled on a weekly basis, between learners and facilitators, are an important component of the blended learning model. In addition, an online virtual learner community provides for facilitator-student and student peer-to-peer interactions in the online domain.

3.1 A Blended Learning Model

The Blended Learning Model is illustrated in ***Figure 2*** below, and enables the seamless integration of online (face-to-face) and offline (distance) learning methods.

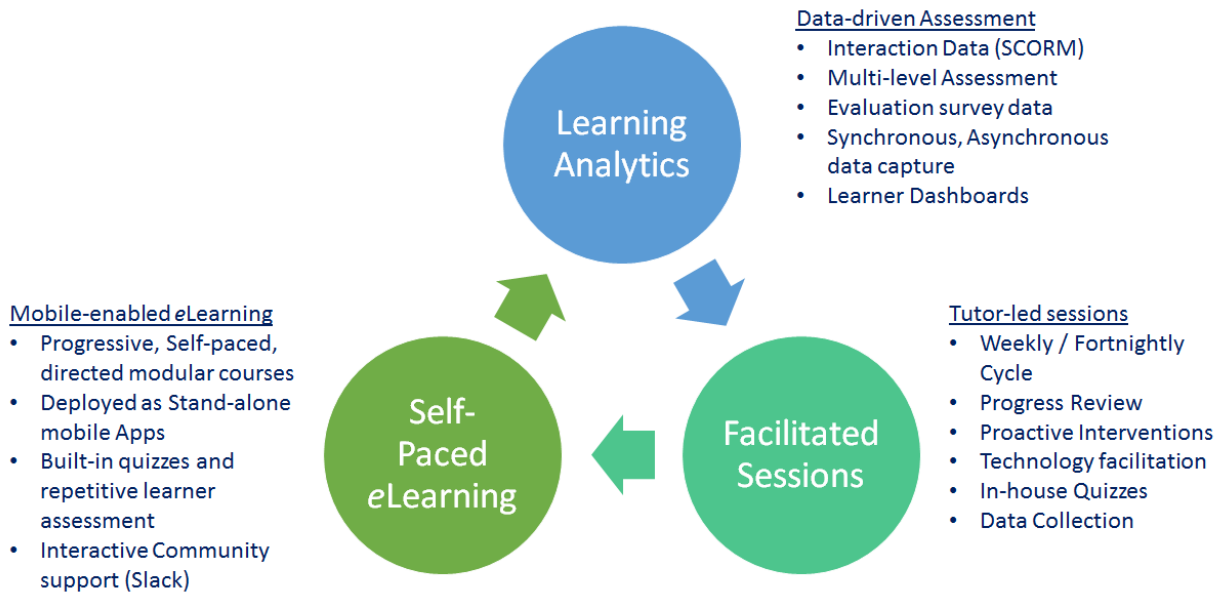

Figure 2. Blended Learning Model

An important feature of this blended learning model is the Learning Analytics component. We have already reflected on the importance of Active learning through learner interactions with instructors, other learners and content. The ability to *measure*, *collect*, *report* and *analyze* learner interactions becomes a key component of the eLearning architectural design (Chatti, Dyckhoff, Schroeder, & Thüs, 2013).

3.2 Architecture Implementation

In this section, we discuss the various technology components used to instantiate the architectural design. In order to manage deployment costs and allow for scalability, we integrate open source tools, cloud-based software-as-a-service platforms and custom software-developed components. The use of distributed components enables the architecture to scale through replication (see ***Figure 3***).

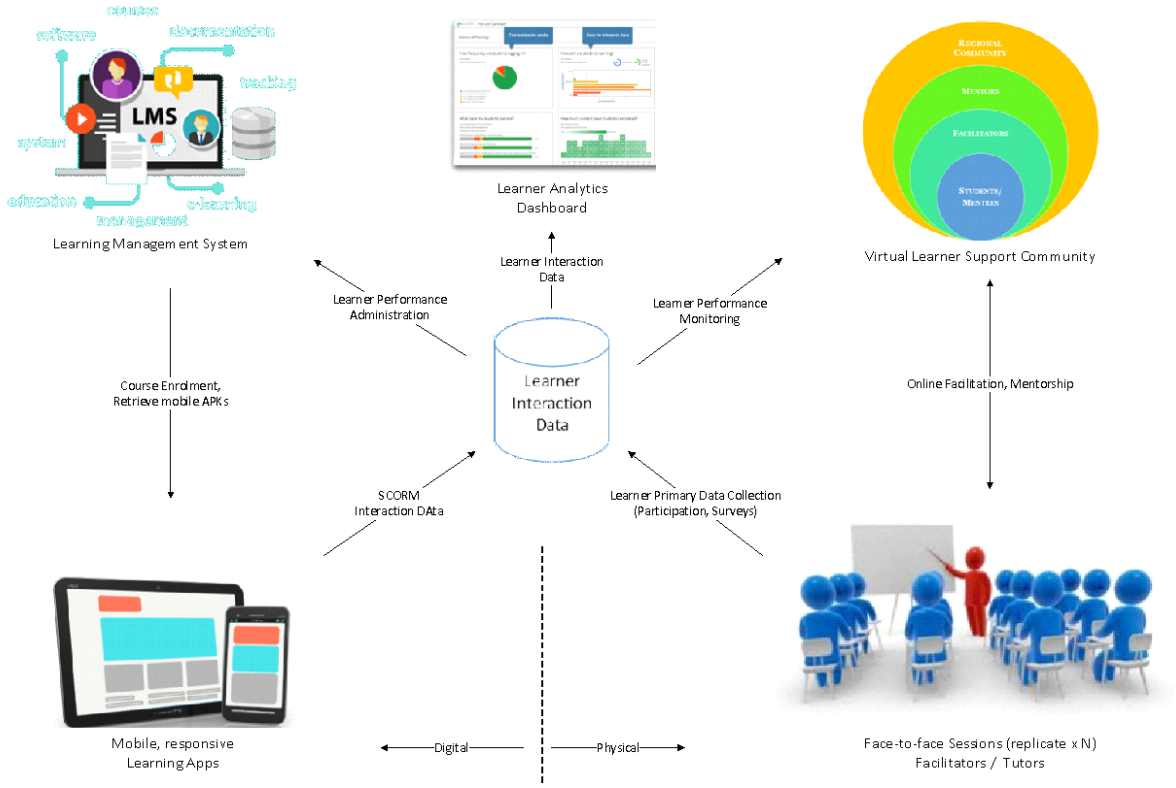

Figure 3. Blended Learning Architecture

Responsive, Mobile-enabled, Learning Apps

The use of the ADAPT[4] open source framework and authoring tool enabled the design of highly modular eLearning objects that combine text and graphic components on a scrolling page to create a rich, interactive and responsive learner experience. The responsive design enabled the courses to be deployed on any device: *mobile phones, tablets and desktops*. The stand-alone mobile editions of the courses were generated as mobile apps (apk objects on android devices) that provided learners with the flexibility of stand-alone disconnect operation that does not require continuous Internet connectivity.

Tablets

Tablet devices were an important component of the learning architecture and provided the primary basis by which courses were accessed and consumed by learners. This was particularly important for deploying the program as self-paced courses using the flipped classroom concept, especially in an environment where reliable Internet access was constrained for most course participants. The interactive design of the courses, with built-in quizzes and reflections also worked well on the Tablets and allowed for active learner interaction and engagement, even while disconnected. All user interaction with the course materials were recorded as standard SCORM[5] activity which was intermittently uploaded for subsequent analysis.

[4] https://www.adaptlearning.org/
[5] Sharable Content Object Reference Model (SCORM) - https://scorm.com/

Learning Management System

Google Classroom was deployed as the Learning Management System (LMS). Beyond providing an electronic repository for the courseware and related content, Google Classroom provided more of a "social media" learner experience as compared with more conventional LMS's such as Moodle. This social character, together with features that mimicked a real-world classroom metaphor, enabled managed student-to-student and student-to-facilitator interactions that encouraged a "community spirit" within cohorts, and promoted "peer to peer learning".

Learning Analytics

The learner interaction data is the "glue" that integrates the various components in this distributed learning architecture. All courseware (web/mobile) were designed to capture and record learner interaction data as standard SCORM objects. While SCORM was designed primarily as a standard for sharing course content among different e-learning systems, in this case, we use SCORM as the means of collecting, packaging and transporting interaction data from the distributed eLearning objects to the Learning Analytics system. Learner interaction data was subsequently stored on a custom-developed online data portal which enabled facilitators and course administrators to track student progress as well as record in-course assessment performance.

Virtual Learner Support Community

Online learning (distance teaching) can be an isolating experience that leads to high attrition rates. Engagement of learners in an overtly social and networked learning experience that emphasizes the connections that develop among the participants, materials, and learning, is an important design consideration. The use of Google Classroom provided a structured social context within the "virtual classroom" and encouraged interactions and collaborative learning within student cohorts. We further experimented with wider online support communities using platforms such as Slack, that put learners in communication with actors such as other cohorts and mentors.

4 RESULTS: LESSONS LEARNED

The project "Ayitic Goes Global in Haiti", provided a unique socio-cultural context for evaluating the architectural design of digital skills training within a resource-constrained environment.

The empirical domain consisted of a digital / data literacy skills training program for 300 young women learners between the ages of 17 – 29, conducted over 3 cohorts during a 15 month period, and was characterized by significant infrastructure, technical and social / cultural constraints. Infrastructure constraints included: *Limited Internet connectivity, unreliable electricity supply, cost of transport, access to a device at home*. Socio-cultural constraints included: *Time availability and domestic responsibilities that limited opportunities to pursue education opportunities; Financial constraints; baseline digital skills and language; gender bias and cultural stigma about women in technology.*

The architectural design components employed (***Figure 3***) demonstrated the potential to meet the pedagogical requirements of the target adult learner constituency, even within these constraints; specifically:

- The adverse impact of capacity and quality deficits in civil infrastructure, Internet access, and transportation services was diminished by the deployment of stand-alone mobile editions of the courseware that provided learners with the flexibility of disconnect operation that did not require frequent travel to a physical teaching space, or continuous Internet connectivity. This benefit was especially evident, when protracted civil unrest and the attendant security concerns disrupted the program, but did not prevent learners from continuing to engage with, and progress through the course materials.

- Active, self-directed, experiential learning, all important attributes of distance learning for adult learners, were facilitated through the social, collaborative components of the architecture (eg. Google Classroom) that enabled the creation of cohort sub-communities and encouraged continuous interactions between learners and instructors, other learners and the content.
- The Learning Analytics component mitigated the "transactional distance" challenge of online learning by generating a constant stream of learner interaction data that enabled facilitators and course administrators to track student progress as well as record in-course assessment performance.

How effective was this learning architecture in delivering digital skills training for the target learners? The results of the training intervention are summarized as follows:

- The online blended learning model was successful, yielding high graduation, and low attrition rates
    - Graduation rate (average): 85%
    - Attrition rate (average): 3%
- Infrastructure deficits (power+connectivity+transport) were effectively mitigated and did not correlate negatively with grades/graduation.
- The role of the "Instructor as a Facilitator" was identified as one of the most critical success factors to the high retention rates, and students valued their facilitators as tutors, mentors, guides and role models.

Beyond the visible program results, as measured by successful completion and formal assessment mechanisms, qualitative surveys of the participants post-graduation highlighted a number of intangible impacts, as perceived by program beneficiaries:

- experienced an increased confidence in the ability to navigate the online world and access resources to increase their knowledge
- the different tools they learned helped them to better manage time, bring discipline and planning into their lives, and manage tasks and workload
- increased ask for technical support from friends and family indicated a change in how graduates are perceived
- ability to mentor younger siblings, friends, and youth in similar programs, sharing knowledge and taking leadership roles
- graduates experienced a greater acceptance of work role and less expectations to do household work at home

5 DISCUSSION AND CONCLUSIONS

The deficit of "*digital literacy and data skills*" is considered one of the biggest barriers to digital inclusion in Latin America and the Caribbean. Digital literacy and data skills have rapidly become in-demand employability requirements, and can now be considered an essential competency for Caribbean youth.

New emerging models of education, teaching and learning that leverage current advances in digitization, web technologies and available bandwidth hold the promise for scalable digital literacy training delivery to address these deficits. The popular emerging platforms for scalable digital training, such as the MOOCs make assumptions about the availability of high bandwidth infrastructure and the characteristics of target learners, that are not consistently valid for many developing contexts.

The primary objective of this paper was to describe a specific architectural design process for developing a learning platform that fulfills the goals of blended learning in a resource-constrained environment. The design choices were informed by considerations from Transactional distance theory, as well as other considerations from Adult learning theory. Two key components of this architecture were:

Tablet devices: the decision to provision Tablet devices for each of the course participants was an important enabler for overcoming many of the infrastructure deficits (e.g. Internet access, travel costs,

etc.), as the mobile device provided learners with the flexibility to access learning content on demand and outside the constraints of physical classroom sessions and limited Internet access. In addition, it enabled the design of a high degree of interactivity and dialogue in the modular elearning courseware.

Learning Analytics: Although not an explicit element of the transactional distance framework, learning analytics is considered to be an important aspect of the *Dialogue* dimension. The ability to *measure*, *collect*, *report* and *analyze* learner interactions is a key capability, and the "glue" that integrates the various components of the distributed eLearning architecture. In addition to facilitating tracking of student progress as well as recording in-course assessment performance, learning analytics opens up further opportunities for analyzing and understanding student interaction patterns and learning behaviours.

Scalability is, perhaps, the most important design goal of the learning architecture developed through this study. The integration of open source tools (ADAPT eLearning framework), cloud-based software-as-a-service platforms (eg. Google Classroom) and custom software-developed components (Analytics Portal), has provided a distributed learning architecture with the potential to scale through replication. This is a very different scale-up model when compared to the popular Massive Open Online Courses (MOOCs) that rely on a heavy, centralized server infrastructure. The Caribbean School of Data[6] is a current funded initiative that will seek to deploy this distributed learning architecture across seven (7) countries in the Caribbean to deliver accessible digital literacy and data skills training in order to increase employability and economic opportunities for marginalized youth.

[6] http://coi-csod.org

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