CONTEXTUAL ANALYSIS OF TECHNOLOGY USE IN RESOURCE-CHALLENGED SCHOOLS

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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The tropical rainforest is one of the most important biomes on the planet. Bradshaw, Sodhi and Brook (2009), experts in global ecology, have shown that rainforests support more than two-thirds of the world's species, despite covering only 7% of the Earth's land surface (p. 79). Unfortunately, the qualities that make these lush ecosystems great also make them incredibly fragile and vulnerable to human exploitation; extinction rates from habitat loss are acute in the tropics, given the high species richness of these habitats. Global biodiversity experts Lovejoy and Nobre (2018) found that 17% of this species-rich biome has already been destroyed as of 2018, and suggested that if deforestation climbs higher than 25% an ecological tipping point may be reached, shifting southern and central Amazonia from a tropical rainforest into a non-forest ecosystem called a degraded savannah (p. 1). Even more concerning is the series of anti-environmentalist policies enacted by Brazilian politicians in recent years. Former Brazilian President Michel Temer eliminated multiple construction licenses previously required for companies to clear parts of the rainforest, while enacting policies which reduced public oversight and transparency requirements concerning such projects. Additionally, his administration cut the Brazilian Ministry of Environment's budget in half before freezing it for a twenty-year period set to begin in 2018. Temer's successor, Jair Bolsonaro, has promised to continue increasing access to Amazonian resources (E. Pereira, Ferreira, Ribeiro, Carvalho, & H. Pereira, 2019, p. 8).

Unsurprisingly, Bradshaw, Sodhi, and Brook (2009) concluded that the greatest long-term improvements regarding tropical conservation can be realized via good governance of tropical biodiversity resources. Soares-Filho (2006) corroborated this mentality by showing that the establishment of good governance and environmental legislation by 2050 could entirely eliminate deforestation in protected regions of the Amazon, while reducing it by up to 35% in

unprotected areas (p. 85). It is therefore of great importance to instill conservationist values in the next generation of potential policy-makers, world leaders and engineers. The technical project responds to this deforestation crisis and represents a viable long-term solution as it aims to generate interest in and concern for the Amazon Rainforest among middle school students via an educational, gamified web application. This learning module is being hosted by the Amazon Aid Foundation, a Charlottesville nonprofit which aims to distribute this educational game across North American middle schools. But because tropical rainforests exist primarily in developing countries where governments are rife with corruption, the greatest potential for a long-term shift to good-governance, and ultimately the preservation of Earth's biodiversity, resides in the youth native to these developing, tropical countries.

A sociotechnical analysis will therefore be conducted in the following analytical research paper to determine how online materials like the technical project can be more effectively integrated into the schools of developing countries like Brazil where they can have the biggest long-term impact. More specifically, this paper will first employ a Technology and Social Relations model to examine existing problems that have hindered the integration of technology across different resource-challenged communities (RCC), and the sociotechnical contingencies that govern their successful, or unsuccessful, integration. The concept of blended learning will then be introduced and used in conjunction with the Pacey's Triangle (1983) model to determine how the unique cultural, organizational, and technical contexts of different RCC can be leveraged to guide research and design of effective learning environments that blend face-to-face instruction with online learning.

CLOSING THE DIGITAL DIVIDE

Classrooms at all levels of education throughout the United States are becoming more and more tethered to technology. Public schools now provide at least one computer for every five students, and spend $3 billion dollars every year on digital content (Herold, 2016). But technological innovation in the classroom also demands innovation in the way teachers educate, apply and integrate the technology in order to be truly effective. This is especially true among developing countries that believe leveraging technology in the classroom can drastically improve the learning process, and possibly reduce cost by substituting for teachers and staff who are not affordable.

Barriers to Effective Technology Use in Resource-Challenged Classrooms

Integrating an Information Communication Technology (ICT) within the curriculum is often the first step taken by disadvantaged schools to facilitate teaching and learning. ICTs include computers, telephones, calculators, projectors, and interactive white boards, among other tools. Many studies conducted in developing countries or developing school systems, however, have revealed a trend of ineffective implementation of ICTs in classrooms which can both lead to, and be the result of undesirable relationships in the classroom environment and in wider organizational contexts. These relationships are best modeled by a Technology and Social Relations STS model seen in Figure 1 on page 4. Teachers adopting such technologies must first build working relationships with their school staff and administrators, who are represented by the bottom-left circle of Figure 1. Francis, Ngugi and Kinzi (2017) conducted a study of ICT integration in Kenyan secondary schools and found that a main factor hindering this implementation is bad "school vision on ICT and administrative support" (p. 74). These authors also suggested that schools' management need to allocate more funds for the repair and

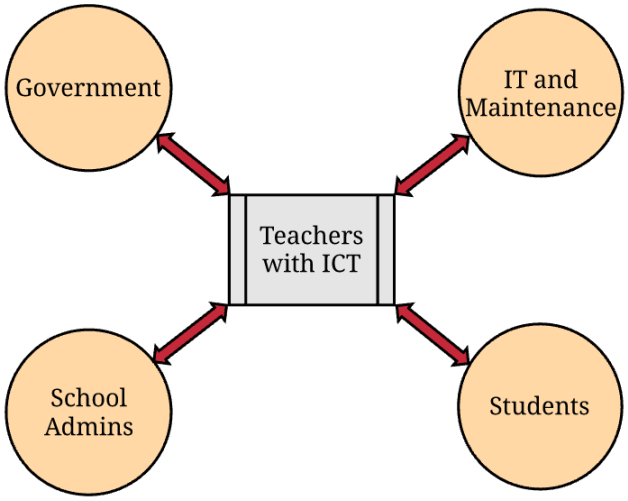

Figure 1: Technology and Social Relationships Model for ICT: Teachers must build and maintain social relations with various groups to implement ICTs effectively (Adapted by Dylan Peters (2019) from W. B. Carlson, 2009).

maintenance of the already available ICT, concluding that "the schools should plan for the installation of ICT infrastructure as well as envisioning the need for regular training of teachers in ICT as a staff development program" (p. 82).

A stronger relationship must also be established between teachers using ICT and maintenance personnel, the latter group being illustrated by the top-right circle in Figure 1. A recent study of the effectiveness of ICT integration in Ghana concluded that "training teachers to possess the requisite knowledge and skills to effectively support their students' ICT usage in classrooms is necessary", and that "training and competence are determinants of successful ICT integration in schools and classrooms" (Buabeng-Andoh, 2019, p. 283). These results reveal the need for teachers to establish ongoing relationships with knowledgeable IT staff members and proper training personnel; a relationship between these three actors could improve teachers' confidence and competence surrounding the use of information communication technologies, ultimately leading to a more effective integration of available technology with existing teaching practices.

A third social complication also arises from the new dynamic between teachers and students, represented by the bottom-left portion of Figure 1, that arises when novel technology is introduced in a classroom setting. A case study of ICT implementation in Cameroonian schools (Ngoungouo, 2017) found that students sometimes became less obedient after computers were

introduced, describing how “there are situations where some of them would refuse to allow others use of the available tools, while some of them would use the tools for their personal reasons” (p. 157). The role of the teacher appears to be jeopardized when certain technologies are introduced in a classroom, potentially due to a shift of power to the students themselves. One behavioral study on how the introduction of interactive whiteboards into Turkish secondary schools affects teacher authority found that “use of the Smartboard in class is also reported to have several negative effects on the teacher’s role by making class management difficult and making it difficult for the teacher to be adopted by students” (Kutluca, Yalman & Tum, 2019, p. 117). A shift in teaching pedagogy is therefore needed to ensure teachers maintain control and order in the classroom after integrating novel technologies.

Finally, a more general, yet arguably more important relationship between the government of an underdeveloped country and its school system is critical to ensure ICTs are implemented and used effectively. However, many such countries do not uphold or maintain certain policies regarding the implementation of technology and infrastructure, resulting in a homeostasis of ICT use among schools. For example, the government of Kenya has been keen on using information and communication technologies to increase access to education for Kenyan students. In 2004, a national ICT policy was developed by Kenya’s Ministry of Education (MoE), which, using government funding, aimed to provide common ICT framework and direction throughout Kenyan public schools and integrate ICT in education management, teaching, and learning (MoE, 2006). However, recent findings by Buabeng-Andoh (2019) reveal that in spite of these policies and strategies laid down, the MoE failed to anticipate certain challenges that would hinder effective integration. It has been reported that half of all the schools in Naivasha, Kenya have technology such as televisions and computers, but a large number of

teachers and students fail to use them regularly (Ngugi, 2012). In other counties, it has been found that the MoE has put in little effort to sustain ICT implementation projects for secondary schools (Nyaga, 2014).

So far, and as apparent in Figure 1, the discussion concerning educational technology integration has centered around the actual teachers who integrate ICT tools in their practice, and the roadblocks they encounter when implementing technology in the classroom. The discussion will now shift to analyze the potential of blended learning, which is a flexible approach to integrating technology in the classroom "in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path, and/or pace and at least in part at a supervised brick-and-mortar location away from home." (Staker & Horn, 2012, p. 3). Blended learning, as will be discussed in the next section, is conducive to the holistic principles of Science, Technology, and Society (STS) studies because it is concerned with designing classroom pedagogy around unique resources and social contexts. For instance, it is not enough to say that the governments and policymakers of RCC must build and maintain a relationship with their school systems, because this still begs the question of how these schools will actually implement the resources provided. Policymakers often overemphasize the mere presence or provision of technology and equipment without giving attention to the more complex, long-term processes that underlie social development and inclusion (Warschauer, 2003, p. 303).

The Promises and Challenges of the Blended Learning Approach in RCC

Blended learning (BL) is an approach that seeks the optimal mix of two learning modes: face-to-face instruction and technology-mediated instruction. Rather than merely splitting content between these two delivery mediums, however, BL aims for a more harmonic balance (Osguthorpe & Graham, 2003). Many empirical studies have shown the positive impacts of this learning approach, including the meta-analysis by Means et al. (2010), which showed that blended learning was more effective than exclusively online or face-to-face learning modes. One challenge when it comes to designing blending learning environments, however, is the myriad alternatives by which a BL environment can be designed. Those who design such environments must make a multitude of informed decisions based on the available resources and the improvements in learning they seek to achieve (Ismail, Mahmood & Abdelmaboud, 2018). On the other hand, the flexibility of these learning environments, which are highly adaptive for different students, settings and content (Staker & Horn, 2012), makes the approach promising for use in developing countries which have varying levels of infrastructure and resources. A holistic STS model could guide the BL designer's decision making process by contextualizing the available technologies and resources that exist in a given school system; It has been shown that the mere provision of technology is not enough because the unique cultural contexts, beliefs and resources of different RCC must be considered to design an effective BL approach. In addition, very little research has been conducted on BL implementations in research-challenged primary and secondary schools; existing research primarily address blended learning in higher education (Lazem, 2019, p. 185). This discussion of the challenges and benefits of blended learning raises the question: Can holistic STS principles such as Pacey's Triangle be used to inform the design

of more effective blended learning environments across different resource challenged communities?

HOW PACEY'S TRIANGLE CAN GUIDE BLENDED LEARNING DESIGN

While the social relations model in Figure 1 (p. 4) helps to identify some of the current problems that teachers and instructional designers face when implementing education technologies in RCC, it fails to address the broader network in which the social relations are embedded. Thus it can be useful to contextualize the various actors involved in the ICT diffusion process using the organizational, cultural, and technical aspects framed by Pacey's Triangle in Figure 2 below. This model can also be used to identify sociotechnical roadblocks to ICT integration that could be overlooked otherwise, and to compare existing case studies on blended learning environments in both developed and developing countries.

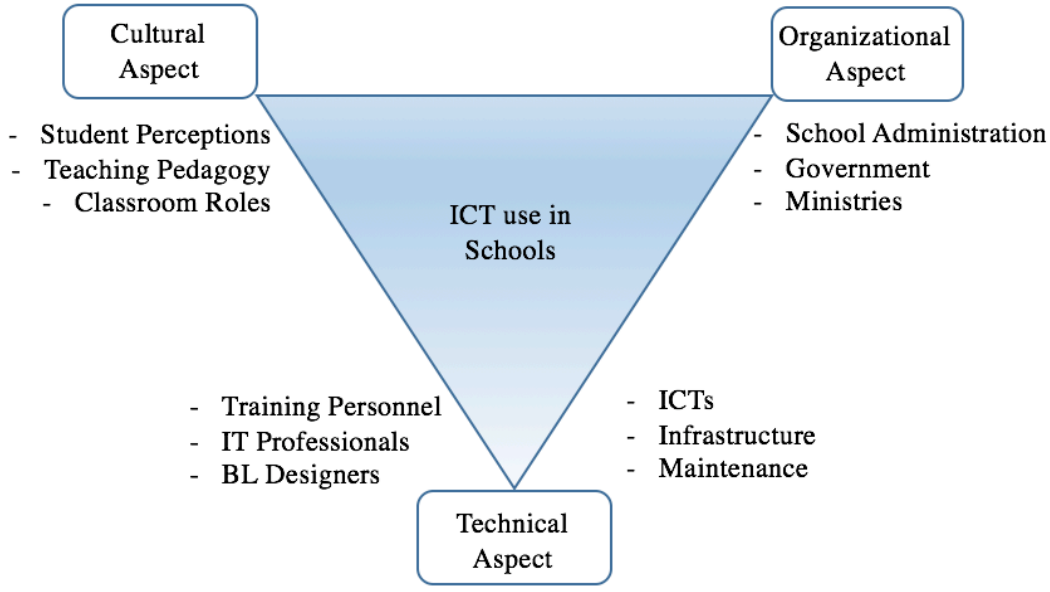

Figure 2: Paceys Triangle: Contextualizing the actors involved with integrating ICT in developing school systems (Adapted by Dylan Peters (2019) from Arnold Pacey, 1983).

Using Contextual Analysis to Identify Sociotechnical Roadblocks

The actors involved in the technical aspects of ICT use also have influential sociotechnical roles within both cultural and organizational contexts, as highlighted by Figure 2. For example, IT professionals and those experienced with ICTs are situated on the bottom-left side of the triangle, which means they have influence within both cultural and technical contexts. In his doctoral thesis, Peter Ngugi (2012) studied the use of ICT in education management within Kenyan secondary schools and found that teacher training programs primarily focus on the development of technical ICT skills, but fail to address how to actually apply these skills within current teaching practices. These integration programs involve technical personnel who are unfamiliar with the pedagogical aspects of a classroom environment, and who are therefore unequipped to work within this cultural context. The interpretive flexibility of information and communication technologies could be a main reason why this cultural-technical barrier has been surmounted by school systems of developed countries, but still impedes progress in undeveloped countries; ICTs are versatile by nature, but without training that considers the cultural aspects of a school, teachers end up using these novel technologies at face value.

A second sociotechnical roadblock to effective ICT integration is made apparent by examining the actors at the bottom-right of the triangle in Figure 2. Specifically, the availability and accessibility of ICT infrastructure, maintenance and other related resources are key elements for facilitating ICT adoption; obviously a teacher cannot use educational or communication software without access to computer-related hardware and proper network infrastructure. Many studies have found, however, that when a government, or its educational ministry, does fund integration programs, the provision of ICT resources in schools does not guarantee that it will be used by teachers (Gulbahar, 2008; Ertmer, 2005). Since the turn of the century, many

governments have been heavily investing in integration plans by funding educational infrastructure and professional teacher training. The Kenyan government is one such example as for years they have been laying fiber optic cables across the country, provisioning computers, multimedia laboratories, and connecting schools to Local Area Networks (LANs) (Francis, Ngugi & Kinzi, 2017). As explained, however, the Kenyan Ministry of Education failed to anticipate certain cultural and technical challenges, such as the need for proper ICT training and maintenance programs, and deeply engrained perceptions of value and expectancies surrounding the success of ICT in the classroom (Buabeng-Andoh, 2019, p. 283).

Using Contextual Analysis to Guide the Blended Learning Approach

In her short paper on designing blended learning environments for RCC, Dr. Lazem (2019) introduces design heuristics that she hopes will guide future instructional designers. Lazem obtained a PhD in computer science in America before returning to Egypt where she holds a research position at the City of Scientific Research and Technology Applications. Her research concentrates on the field of Human-Computer Interaction, and has contributed to the design of novel technologies for, with and by marginalized communities (Lazem, n.d.). Although she does not explicitly perform any sociotechnical analyses herself, Lazem's recent analysis of the success of hole-in-the-wall (HITW) experiments in India and the success of one-laptop-per-child (OLPC) policies in developed countries led to the synthesis of her first design heuristic, localization. This heuristic purports that "BL Designs that are grounded in the understanding of the local reality are more likely to succeed" (Lazem, 2019, p. 188). For example, the HITW experiment in India, in which an unattended computer was affixed to a public slum wall, was so successful because, according to Lazem, the experiment reflected a collective view of ownership

and knowledge sharing that is commonplace in India, whereas HITW experiments in Western countries and the UK, where ownership is more individualized, were less successful. Conversely, Lazem purports that OLPC policies have been more successful in developed countries where individualism and independent ownership are core cultural values (2019, p. 188).

Lazem's analysis demonstrates that by embracing the complex realities of different RCC, novel solutions can be found to address the contextual challenges unique to different communities. She hopes that future work will "investigate the operationalization of [her] introduced heuristics in the presence of practical barriers such as the lack of a supporting fund" and will "identify fine-grained design guidelines for BL in RCC" (p. 189). Pacey's Triangle, as shown in Figure 2 (p. 8), represents a viable way to identify these fine-grained design guidelines because it can be used by instructional designers to understand how the cultural values of a specific community relate to the communities' unique technical and organizational aspects. Dr. Lazem, however, shows only at the surface level how different educational contexts necessitate different design decisions, and she asserts several areas, such as children's use of ICT at home, where there is a research void (2019, p. 187). This need for future research reinforces the potential of using holistic STS models such as Pacey's Triangle to identify practical and cultural obstacles to educational technology integration, and to develop novel solutions that spin these obstacles into opportunities.

CONCLUDING REMARKS

In summary, the Technology and Social Relations model was first used to identify the various obstacles that can prevent teachers from effectively integrating information communication technology in a classroom setting. Because this discussion was centered around how teachers use ICT, the wider social and organizational contexts of the examined case studies was ignored. Blended learning was then introduced as a more promising approach for ICT integration in resource challenged communities because of its high flexibility and ability to adapt to different students, settings and content. The question of whether using Pacey's Triangle would be an effective tool to guide blended learning design in RCC was borne from the observation that STS principles and models had not explicitly been applied to any contemporary blended learning research. Although Lazem (2019) drew conclusions by considering the cultural contexts of HITW and OLPC case studies, she failed to discuss at depth the organizational and technological aspects that Pacey's Triangle would have elicited. The goal of this thesis is not to define the fine-grained design guidelines for a learning environment for any specific resource-challenged community. Rather, the goal was to demonstrate the efficacy of using Pacey's Triangle to design learning environments that dynamically integrate technology in light of available, or unavailable resources. Hopefully, if future blended learning research using Pacey's Triangle is successful, then the door will be opened for novel technical solutions, such as the application presented in the technical project, to enter developing school systems and inspire change.

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