BYOD as One Interdisciplinary Response to Address Gaps between In-school and Out-of-school Learning in the 21st century

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ABSTRACT

BYOD or *bring your own device* generally describes the practice of bringing a personal learning device to the learning or work environment, and BYOD's wide-spread adoption continues to grow across all sectors. This investigation of BYOD research in interdisciplinary settings is designed to help organize key issues and opportunities afforded by BYOD implementation. Digital technology use is opening new learning spaces in K-12 and higher education, but enthusiasm for innovation is balanced with considerations of how these new technology-enabled learning spaces promote safe, well-managed, and enhanced learning. We examine the research on e-learning with a specific lens on BYOD, 1-1, and pervasive technologies across disciplines and sectors of education. Our investigations have led to the design of a framework of possibilities and challenges that have been identified with BYOD. These findings suggest that it would be prudent to maintain an open, investigative stance toward the potential of ubiquitous personalized e-learning and to use the opportunities BYOD presents as a catalyst to shift education toward more personalized, learner-centered approaches.

1. INTRODUCTION

This paper explores the use of BYOD, defined as the use of 1-1 technologies where learners and teachers bring personal computing device(s) to a learning setting. BYOD has reportedly been implemented in more than half of schools surveyed in the US [1]. A pressing issue for education in the 21st century is how to shed traditions that served it well in the past in order to transition to new ways of learning that align with changes in society. Schools today exist within the bricks and mortar legacies of our industrial and agrarian pasts. They are perceived as falling short in preparing students to use technology in critical and productive ways [1]. Meanwhile, the global economy continues to transition to a virtually ubiquitous, 24/7 knowledge-sharing learning ecology where an individual's learning takes place in multiple settings [2]. The continuing transition of economic activity toward a knowledge-based economy has also led to the development of new information and communication technologies (ICT) that enable BYOD. These include: enhanced Internet access, Cloud computing, the growth of web-based productivity tools, better tools to manage safe and secure computing environments at the school or district level, greater inter-operability of devices, always-on access devices, and the growth of cellular technologies and wireless networks. Moreover, the increasing ease of public schooling to build, manage, and upgrade network hardware and software has resulted in a new focus on leveraging student and family devices to support richer technology-enabled learning environments. We argue that Web 2.0 has created the conditions that *necessitate* the shift to BYOD in all educational settings where this has not yet been established, and attention needs to be focused on maintaining quality learning. The next five scenarios illustrate some of the current issues of this transition.

Scenario 1: At the end of the school day, a student carries home her (paper) work on the classification of insects. Her parents pull up images and short YouTube videos of the insects operating in their natural habitats. In this scenario, the modern equivalent of "What did you learn in school today?" receives a *top up* at home: a just-in-time learning opportunity. The challenge here is that while all students have a right to high-quality e-learning in and out of school, not all have equitable access.

Scenario 2: The province of Ontario, Canada administers a literacy test to close to 150,000 students in Grade 10 annually [3]. For the first time, schools could elect to participate in an *online* pilot of this large-scale assessment, as the test administrators acknowledge that most students use e-devices for their everyday writing [4]. The technology supported option was offered previously only to those students with documented disabilities, while most other students used pen and paper. This October, in an attempt to move to the online administration of this assessment, the Education Quality and Accountability Office (EQAO) experienced colossal technical failure, attributed to a Denial of Service (DDoS) cyberattack. This initial attempt by EQAO highlights a shift in

online assessment practices that allows all students the right to use technology without the restrictions that previously placed certain students into more visible categories of difference. Accessible learning through the least restrictive mode should not be reserved for exceptional students or draw attention to their learning needs [5] but the technological infrastructure must be secure, reliable and robust if that goal is to be met.

Scenario 3: A student arrives home from school and begins work on a school-issued laptop computer. She is fortunate to attend a school which provides 1-1 computing assets to all students while also centrally managing the devices. Her laptop seamlessly connects to her home computing network and she begins her homework on the flora in her local community. She creates a presentation using photographs she has taken with her tablet, incorporating an interview with a local botanist and a short video taken while her family was visiting the local farm center. She is fortunate that her family can enroll her in a fee-paying school that supports a technology-enhanced learning environment. While the school is small, it affords an advantage not shared by her friends who attend larger local public schools. The lack of equitable access to technology within a single community becomes clear.

Scenario 4: In a school district that has been dominated traditionally by centrally-designed professional development, a principal asks: when and how BYOD is going to be implemented *by the school board*; if teachers will be withdrawn from class for *centralized training*; and if e-consultants will be assigned to schools. This illuminates some opportunities and barriers of 1-1 technology implementation. If the future of learning is BYOD, what are the expectations for educators' professional learning? Will teacher training be personalized or standardized? Will teachers learn separately from their students, alongside their students, or *from* their students?

Scenario 5: Students in a graduate course discuss an assigned reading outside of class and contact the source authors to discuss it further. They invite the authors to their online, synchronous classroom. Because the grad class follows a flipped classroom model, all of the students have read the article before class. In the presence of the original authors, a rich discussion ensues. Students have their questions answered at the source, and hear about the authors' continuing research initiatives. In this scenario, students use technologies they are familiar with to reach out and collaborate, deepening both their interest in the topic and taking charge of their own learning.

2.0 BYOD AT THE INTERSECTION OF LEARNING IN AND OUT OF SCHOOL

If you focus on the gap that has been identified between the intersection of how people learn outside of school and in school [1], [6], multiple cross-sectorial and inter-disciplinary issues associated with 1-1 computer technologies arise. Some of this gap is attributed to the difference in students' use of technology at home, where they are freely encouraged to use it ubiquitously and at school where that use can be heavily monitored. We explored research and policy on K-12 and tertiary education programs that seek to bridge the gap between in-school and out-of-school learning through technology-permissive approaches such as BYOD. One output of our investigation is the development of a BYOD framework which organizes recent research on 1-1 technology-enhanced learning into categories such as: learning, training, technological infrastructure, and enabling policies for BYOD (and online or network tools for students to access the internet and web-based resources safely). Considerations of closing the gap between how learning happens in and outside of a formal school setting underlies our framework. The critical and reflective arguments in this paper are informed by theories of quality online learning [8], [9] and new pedagogies that promote more enabling environments [10].

The gap between in and out of school learning is not new, but resurfaces in ways that compel us to pay more attention [6], [7], [8]. Thirty years ago, Resnick [7] challenged us to consider the gap between learning in and out of school. She disagreed with the dominant view of the time that school intelligences were unconnected to practical intelligences. She argued that a focus on individual learning and individual success was incongruent with a world where problem-solving necessitated collaboration and sharing information. In her view, students needed more authentic learning, and the direct training (didactic or transmission model) was more suited to eras characterized by relatively little change [6]. Unknowingly, Resnick was raising an issue which would affect learning even more significantly in the digital era. She spoke literally on the cusp of the introduction of the web in education. In the decades since, multiple iterations of polysynchronous and blended learning spaces have emerged. Universities, colleges and K-12 districts initially focused efforts on computer hardware acquisitions, first building labs and then shifting toward 1-1 tele-computing scenarios. Fortuitously, though, Resnick raised attention to the in and out of school learning gap which persists and has changed in the digital era [2], [6]. Despite the efforts of

elementary, secondary and tertiary learning institutions to develop more collaborative and authentic forms of learning, the arrivals of Web 2.0 and 1-1 technologies are now exacerbating the gap between in and out of school learning [1], [2], [6].

Underlying this widening gap are the discrepancies between the way students are taught in school and how they learn on their own time [1], [2]. These discrepancies are paralleled in how teachers expect to be trained in technology rather than seeing it as an adaptive skill for the 21st century. We spend more time outside of school and approximately 18% of waking hours in school [6]. A more significant discrepancy, however, is between how we learn informally outside of school and formal learning in schools. Outside of school, learners can exercise more choice and control in their learning [2], [6]. Within schools, students can be self-directed *if they are given permission to pursue learning that way*. Although digital technologies have opened new ways and spaces for learning, findings indicate that the educational uptake has been slow [1], [6]. The enthusiasm for technology-enhanced learning (TEL) needs to be conservatively tempered with considerations of whether these new learning spaces translate into more enabled student learning environments that align with how we now learn in life. An important aspect of new TEL environments includes consideration of *learner choice* regarding learning materials. Rich computing environments allow learners to access learning materials in addition to print-based resources such as multimedia and interactive learning resources. TEL environments also allow learners to demonstrate learning in diverse ways.

Online learning, in itself, does not necessarily predict that students will more easily meet course outcomes or achieve deeper understandings of key concepts. Nor does e-learning predict the presence of more critical or more transformative types of learning in education. What can be argued, however, is that the emergence of new, innovative e-learning spaces brings with it *the potential to re-examine present pedagogies* in K-12 and higher education and reconsider them in significantly more deliberate ways. We argue that this can be achieved more easily through the use of a BYOD framework that classifies the opportunities and barriers in ubiquitous, personalized technology use in education.

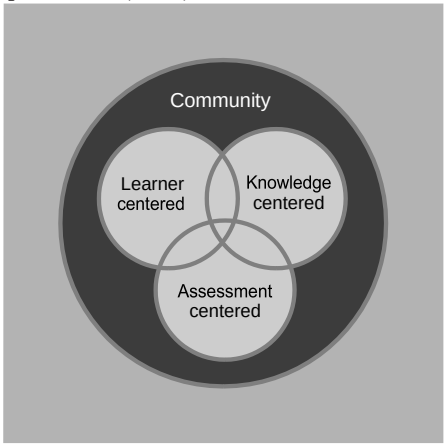
3.0 THE BYOD FRAMEWORK

The BYOD framework which is presented here represents the findings from a review of research on BYOD which included literature reviews, original research on student learning outcomes, and policies. A BYOD filter was applied to the literature search although we included literature on 1-1 computing initiatives. The research did not explore the area of wearable technologies. Analysis of the literature revealed multiple opportunities and barriers in BYOD. Commonly-considered categories were applied to organize the BYOD framework; they include: learning, faculty development, security and management of BYOD, and cost. Each category is discussed next.

3.1 Learning

The literature consistently views that the implementation of 1-1 technologies aligns with more student-centered learning approaches. One large-scale study, *How People Learn* (HPL) [8] was developed from decades of research on learning. It informs considerations of how learning happens in high-quality learning environments in general and in technology-supported learning environments in particular. It employs four descriptive lenses to guide the examination of learning quality: learner-centered, knowledge-centered, community centered, and assessment centered [8]. The HPL framework is presented below:

Diagram 1: Four lenses that together make up the How People Learn (HPL) framework [8].



Anderson [9] applies the HPL quality learning framework to online learning, noting that a learner-centered environment in a Web 2.0 era builds on the individual learner's strengths, interests, and previous understandings in collaboration with peers and the instructor. This requires learning activities which help the student to understand his or her own assumptions and skill level as the learning is approached and as it progresses. Knowledge-centered learning encourages the student to seek out, reorganize and re-use content so that it is personally meaningful and transferable.

Assessment centered learning, according to Anderson includes opportunities to give and receive timely and formative feedback. Learning that is community-centered on the semantic web allows for social augmentation of learning through, for example, tagging and sharing content of value, and building communities of expertise. Anderson sees that e-learning in Web 2.0 opens opportunities for an increasing number of interactions in an increasing number of spaces where students can create and co-create knowledge. Learning online allows students to time-shift, work a-synchronously or synchronously online, and/or engage in global learning in real time [9]. Deeper learning for students encompasses deep understanding of the concepts, and opportunities to apply the concepts in authentic settings while also reflecting on how the learning is happening so that learners can become more adept at learning for life [1]. Education is being challenged to connect what is being taught in schools to real-world challenges at local and global levels [1].

Policy papers on e-learning focus on some of the more practical aspects of e-learning. In realistic terms, cloud computing and mobile applications for learning have already arrived on the educational scene, as has BYOD [1]. Two approaches to implementation emerge [11] in moving forward with BYOD. In the more traditional approach, the educational institution (e.g., school district, tertiary institution) decides on the innovation and provides the budget and training for it to happen. A Bottom Up implementation means that educators become more adept with technology outside-of-school, and encourage their students to use their mobile devices for learning at home and at school. Another Bottom Up approach would be that students, themselves, are the initiators of innovation. In this scenario, less time is spent by students in learning to use devices because they use ones which are familiar to them [11]. It is estimated that students in the US spend 4.5 hours per day using digital technologies out of school [6]. Teaching students at all levels how to access information in a continuous fashion and critically evaluate this information is a significant life skill, and one which also prepares them for higher education [12].

3.2 Teacher Professional Development

If faculty members and school educators and leaders are waiting for the conditions to be perfect in order to implement BYOD, it is possible that they have not yet grasped the concept that working with technology means that you are in a constant condition of *trying things out*. These optimal conditions have been in many cases leapfrogged, not by any formal adoption of BYOD or BYOD policy, but by the continuous adoption of devices by students and faculty in school environments everywhere. This is a new mindset for many, and the implications for teachers need to be carefully considered. When organizational policies have been established for responsible use, as well as privacy and security of sensitive information, educational organizations need to consider mechanisms for policy awareness and compliance [15]. One policy response encourages teachers to accept that technology change is happening consistently in a beta mode [11], meaning that teachers should try out new apps and hardware but also expect that the innovations are going to continuously change and need to be re-learned in future iterations.

3.3 Security and Management of BYOD

The importance of addressing security and management issues related to BYOD cannot be understated [16]. A close relationship must be established between technology support staff and program implementation/curriculum staff such that the two move through the BYOD journey in parallel. An important first step is to create a BYOD policy that will address some key issues upfront. Evidence from US surveys indicate that approximately 12% of students at present report that they are permitted to use their mobile device at all times, indicating that there are wide variations in BYOD policy enactment [19]. Issues that must be addressed as part of the policy are equity, theft, access, safety, cyber risks, responsible/ethical use, monitoring, and the role of the parent. As part of preparing for the management of BYOD, Information Technology (IT) personnel must ensure that the wireless network infrastructure is up to the task. Issues of density, access, and security should be discussed and dealt with in advance of the first BYOD entering the building. Density refers to the number of devices that will typically connect to each access point and the volume of data each will consume. Early indicators would suggest that this number is wildly underestimated. This issue is two-fold in that you must forecast the number of devices each person in the classroom will have while also considering the volume of data they will consume. With next generation technologies such as 3-D video and virtual reality becoming mainstream, it is important that the network infrastructure supports the BYOD implementation, as under provisioning for density can hinder implementation.

As personal devices are employed in the university or school, organizations must find ways to ensure that devices unknown to the organization can be matched up with a user who is allowed to use the resources of

the school, college or university. This is typically accomplished by using a "portal" similar to using Wi-Fi at a hotel. These portals allow a technology system to match the unknown device with a known user allowing the organization a level of accountability for what happens on their network. In addition to device identification, attention needs to be paid to software licensing, evaluation of devices upon the learning environment, policy compliance, and training to understand security and safe Internet use [16]. Finally, firewall and filtering, if in place, should apply the same policies for each user to ensure there is no difference between their access to the internet on a known device than with BYOD.

3.4 Cost

Cost is an important consideration that is more complex than it may seem on the surface, and is often cited as a reason for BYOD implementation (along with flexibility, portability and convenience) [16]. Cost considerations cannot be oversimplified, however, into a simple binary of *stop buying devices* and start investing in infrastructure. A key issue, especially in areas of lower socio-economic status is one of equity. A mix of district school board or institutionally owned, donated, and BYOD may be required to ensure acceptable levels of equitable ICT usage; the need for BYOD support for equity will vary based on student and family need and Internet costs.
Organizations must also look to costs that may be offset when technology is ubiquitous; savings cited include the cost of the device itself [16]. Some experts maintain that the full cost of BYOD can be covered by shifting spending priorities but these calculations rely on an inexpensive end user device and corresponding savings may not be realized immediately [17]. On the industry side, both increases in productivity and revenues have been reported from the implementation of BYOD [16]. What can be said with some certainty, however, is that there is a need for a more fulsome discussion on a blended approach to ensure technology ubiquity; BYOD is not a complete solution. Although more than 71% of US schools are reportedly using BYOD in some format, there are wide variations and considerations [18]. Kolb reports that "although 80 percent of teenagers own a cell phone, the fact is, not all phones are created equally; functionality and phone plans vary widely. Only 37 percent of teenagers own a smartphone, and fewer still have unlimited data plans" [18]. The issues associated with equity, acceptable use, financial implications for parent communities, software licensing, access, and filtering require well-considered policy responses. We continue to seek model policies that respond to these needs.

4.0 BYOD FRAMEWORK: K-12 AND HIGHER EDUCATION

We organized the key concepts associated with BYOD into a framework that would summarize the issues, barriers and opportunities that have been identified in BYOD research. These are summarized below in the BYOD framework.

Learning
Connect in and out of school learning through BYOD [1,2,6,11,12]
An ecology model sees multiple settings as places of learning [2,6]
Modify classroom to maximize student time with the teacher [6, 11]
Investigate the potential of informal learning methods for schools and higher education [1,2,6,11]
Diversify pedagogical approaches [6]
Include more student-centered and inquiry-based models such as PBL [6]
Encourage collaboration and communication to promote deeper learning [6]
Rethink how technologies are offered in schools and higher education in structured ways [6]
Consider how the same technologies can be used across subjects and disciplines [6]
BYOD requires receptive learning environments [14]
Improved academic achievement with BYOD has been reported [14] but is also questioned [17]
Allow student to demonstrate their learning in diverse ways [14]
Use mobile apps to collect evidence of student work [18]
More research is needed into the learning activities, strategies and experiences which improve student technology use at school [17]
Technology
Take an open stance to bottom up adoption [1,11]
Focus the technology on the learning activities not the teaching activities [11]
Seek ubiquitous access and support student ownership [13]
Introduce foundational apps – such as Google drive for sharing [13] apps for presenting, videos, note-taking, etc.
Provide loaner devices and other means to be more equitable [11,14]
Pay significant attention to connectivity and avoid bandwidth congestion [13,14]

Professional Development
Teachers/Instructor efficiency - work and home [15]
Not waiting for adoption because teaching will now exist in a constant state of beta [11]
Develop school leaders' understandings of how to merge formal/informal learning [6]
BYOD has been credited with nudging toward more student-centered learning [17]
Security, Cost and Management
Need for clarity in policies surrounding use of personal devices in schools [17]
Protecting data integrity [13] Pushing apps [13]
Mobile device management systems [15]
BYOD may be more cost effective [13][14] but there is a need for fuller discussion

5. CONCLUSION

Our investigations into the research on BYOD indicate that this curricular implementation model speaks directly to the creation of a rich type of learning environment that holds potential both for learning but also inequality for some student populations. As schools and colleges transition from textbook-based resources and embrace a broader range of learning materials, more multimedia resources will become available to students who have access to devices, allowing them to build their capacity to co-construct and create learning but not everyone can bring or purchase a device. In some cases, finances will determine access to the internet outside of school. This requires not only pedagogical but policy responses. Policy responses need to include: the management of network access and internet filtering to support a BYOD environment; acceptable use of internet resources; and the ability of schools to track specific student use of networks. Technical support in and outside of the classroom is an issue with BYOD and a diversity of devices in use. File compatibility and use of specific software become an issue where costs are downloaded to parents - enhancing inequality in some cases. Internet access is not always cheap for families and geographic issues abound such as access in rural areas which can be expensive through satellite. Finally, the area of teacher training requires much more consideration. In conclusion, questions remain. While the potential of BYOD is clearly emerging, what has emerged also is that BYOD requires an integrated ecology of support that includes organizational leadership, schools, and parent communities.

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