Revisiting the Blended Learning Literature: Using a Complex Adaptive Systems Framework

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ABSTRACT

This research has two aims: (1) to bridge a gap in blended learning research — the lack of a systems approach to the understanding of blended learning research and practice, and (2) to promote a more comprehensive understanding of what has been achieved and what needs to be achieved in blended learning research and practice. To achieve these aims, we first assess the strengths and limitations in existing models of blended learning, then propose a framework for blended learning that is grounded in the complex adaptive systems theory. The proposed framework sees blended learning as a system consisting of six essential subsystems, and all the subsystems relate to and interact upon one another. The proposed framework is then applied to the review of 87 empirical studies from the current blended learning literature. The review identifies several gaps in current blended learning research and practice, and advances our understanding of some untapped potential of this new system of learning. We hope that this research will shed light on critical issues in understanding blended learning and in scaling up its implementation in tertiary education.

Keywords

Blended learning, Complex adaptive system, Blended learning model, Framework, Flipped classroom

Introduction

Because the term "blended learning" has been commonly used in tertiary education for well over a decade, it is perhaps not an exaggeration to say that it has become part of the vernacular. Blended learning has been gaining in importance, especially during the last five years, with the development of online learning and the recent rise of MOOCs and flipped teaching. Our literature review indicates that its effectiveness and validity as a new form of learning has been established in practice. At the same time, our review also reveals that the great majority of the empirical studies into blended learning are research interventions of short duration conducted at either the course or task level, focusing on just one or a few aspects of blended learning. As a result, investigations into blended learning continue to be fragmented and many important issues remain unexplored. This is highlighted by Owston (2013, p. 1), who stated: "There is a need for research investigating why blended learning, despite its many inherent advantages, has not been scaled up successfully in very many institutions."

The term "blended learning" has been used interchangeably with "mixed mode learning," "hybrid instruction," and "technology-mediated/enhanced learning." It has been defined and redefined by various studies, but none has provided us with a complete view of what constitutes blended learning and how different components of blended learning work together over time to achieve an integrated whole. Perhaps the most widely held understanding of blended learning is that it is a combination of "face-to-face instruction and computer-mediated instruction" (Graham, 2006, p. 5). This current study aims to promote a deeper understanding of blended learning research and practice, first using a different perspective—the complex adaptive systems perspective—and secondly, through a review of the recent literature on blended learning.

To achieve this aim, this article first assesses the strengths and limitations of existing blended learning models then discusses the theories of complex adaptive systems in an effort to develop a framework that effectively captures the nature and dynamics of blended learning. This discussion then leads to the proposal of a framework for complex adaptive blended learning systems, called the CABLS framework. We then apply this framework to a review of the recent blended learning literature to identify gaps in current blended learning research and practice. We hope that this

research will promote a more comprehensive understanding of what has been achieved and what needs to be achieved in blended learning, in terms of both research and practice.

A review of blended learning models

During the last 15 years, a great number of blended learning frameworks and models have emerged, and these have advanced our understanding in many important ways. The following review discusses a few of the most influential models, and this discussion provides diverse lenses through which to view the differences between these models and the one proposed in this research.

Shea's grounded model promotes a pyramid framework starting with "our assumptions and beliefs about the nature of knowledge" (2007, p. 31). This is followed by the identification of "the theories of learning that reflect these philosophical underpinnings," the articulation of "complementary pedagogical approaches," "instructional strategies and, ultimately, specific learning activities." As we can see, this model focuses on one aspect in blended learning, the instructional design of a blended curriculum.

McSporran and King's (2005) generic framework for blended learning advocates the selection of delivery methods in line with learning needs and available resources. Again, this model caters only to one element of blended learning, content delivery, which is useful in guiding the delivery of blended learning at a course level rather than guiding the implementation at an institutional level.

A more comprehensive framework is found in the Octagonal Model proposed by Khan (2001). This model contains eight elements: pedagogical, technological, interfacial, valuational, managerial, resource supportive, ethical, and institutional. According to Singh (2003), this model has provided guidelines for many blended learning and e-learning programs. The identification of these elements in blended learning contributes to our understanding of the magnitude of such learning. However, it does not underline the intricate and dynamic relationship between these elements and how they evolve together to sustain implementation beyond the course level.

One model that recognizes the dynamic relationship between elements in online learning is the well-known Community of Inquiry (CoI) Framework developed by Garrison, Anderson, and Archer, (2000, p. 87). However, this framework is not for blended learning, per se, although the three elements — cognitive presence, social presence, and teaching presence — are very relevant to blended learning. The CoI Framework has been widely operationalized in examining interaction in computer-mediated communication (CMC), in both synchronous and asynchronous modes (also see Ling, 2007), as a part of online learning.

As shown in the above discussion, each of these models has its own concerns and focuses and examines blended learning from different perspectives. Although they have all contributed to our understanding of blended learning in one way or another, none has been able to provide a complete picture of blended learning as none has explored blended learning using a complex adaptive systems approach. Consequently, blended learning still seems to be a giant puzzle, consisting of intertwined disjointed parts, all trying to connect. It has been difficult to see the whole picture of blended learning because each element, in isolation, only offers part of its landscape without interconnection. This current research recognizes this gap and attempts to explore what constitutes blended learning and how its constituting elements work individually and together, and attempts to examine the impetus that drives blended learning forward. We therefore turn to complex adaptive systems theory for guidance.

Complex adaptive systems: A theory for re-conceptualizing blended learning

The integration of technology-mediated learning with campus-based learning has made learning more complex than ever before. The complexity lies not only in the emergence of new elements in teaching and learning, but also in the changes brought about by the interaction between these new elements. The technology as a new element and its impact on learning can serve as a prime example. Lim (2002, p. 412) points out that technology "may trigger changes in the activities, curriculum, and interpersonal relationships in the learning environment, and is reciprocally affected by the very changes it causes." Clearly a complex systems approach is needed to effectively address such

complexity and the reciprocal changes. To better understand such an approach, this section presents an overview of some basic tenets of complex adaptive systems.

Originating in physics, chemistry, and mathematics, complex adaptive systems theory has been widely used to gain an understanding into the complexity of dynamic and non-linear systems such as neural systems, ecologies, galaxies, and social systems (see Bertalanffy, 1968; Waddington, 1977; Waldrop, 1992). Complex adaptive systems are described as being living, open systems that "exchange matter, energy, or information across its boundaries and use that exchange of energy to maintain its structure" (Cleveland, 1994). At the crux of the complex adaptive systems theory is the concept of the edge of chaos, which was best defined by Waldrop (1992) as follows:

> All the complex systems have all somehow acquired the ability to bring order and chaos into a special kind of balance. This balance point — often called *the edge of chaos* is [where] the components of a system never quite lock into place, and yet never quite dissolve into turbulence, either. The edge of chaos is where life has enough stability to sustain itself and enough creativity to deserve the name of life. The edge of chaos is where new ideas and innovative genotypes are forever nibbling away at the edges of the status quo, and where even the most entrenched old guard will eventually be overthrown (p. 12).

This concept of the edge of chaos holds the key to an accurate understanding of complex adaptive systems. The essential ability of such systems is to always maintain a balance between stability and turbulence, which, in turn, keeps the systems dynamically stable, healthy, and innovative. Complexity scholars have identified several key features of complex adaptive systems. In this article, we will focus on the following five fundamental attributes: complexity, self-organization, adaptability, dynamism, and the ability to co-evolve.

Complexity describes the nature of a system consisting of multiple subsystems interacting with one another in a non-linear fashion. Each of the subsystems also contains its own subsystems, as neatly put by Cleveland (1994):

> Complex systems tend to arrange themselves in "layers" of integration, such that each system is part of a larger whole, which in turn is part of an even larger system, which is part of larger systems and so on. At each level, each system is simultaneously autonomous and integrated with the systems at its level, above it, and below it.

Self-organization embraces two meanings: (1) the subsystems within a system interact with one another through feedback and iteration to give birth to new orders or patterns of relationship between their inner elements, and (2) such spontaneous emergence of new order is not imposed by external forces (Cleveland, 1994).

Adaptability illustrates a process that is often triggered by the systems' ability to "form new rules from combinations of old rules and new information from the environment" (Cleveland, 1994). This is the systems' natural selection process of evolution in which the fittest survive.

Dynamism portrays the ability of complex adaptive systems to be "poised on the edge of chaos — stable enough to maintain their structure, but sensitive enough to external changes that they can undergo rapid and unpredictable periods of change" (Cleveland, 1994). Being dynamic is regarded as the ideal state that a living system should maintain, stable but not static, transformative but not chaotic.

The ability to co-evolve refers to subsystems acting upon each other to form a "fitness landscape that is constantly changing as they change" (Cleveland, 1994). A key notion underlining the concept of co-evolution is the mutual and multiple impacts between a subsystem and the systems around it, resulting in adaption to one another (also see Kaufman, 1993, 1995).

To sum up, complex adaptive systems are dynamic and open, and have the innate ability to self-organize, adapt to, and evolve with their environment. Such a systems view provides a different lens through which to examine the nature of blended learning.

The proposal of a complex adaptive systems framework for blended learning

Learning itself has been seen as a complex and dynamic system (You, 1993; Branch, 1999). Branch identified eight subsystems in the system of learning: students, content, media, teachers, peers, time, goal, and context. This systems

view of learning and our literature review and practice in blended learning inform the current research. We therefore propose a six dimensional framework named the Complex Adaptive Blended Learning System (CABLS). Figure 1 illustrates the six subsystems and their relationships: the learner, the teacher, the technology, the content, the learning support, and the institution. Similarly to any complex system, the six subsystems act within themselves and upon one another in a dynamic and non-linear fashion. At the same time, each of these subsystems has its own characteristics and internal driving forces, depending on surrounding subsystems, to maintain its vitality. Furthermore, each subsystem also has its own subsystems, and all interact with one another to form a system of blended learning.

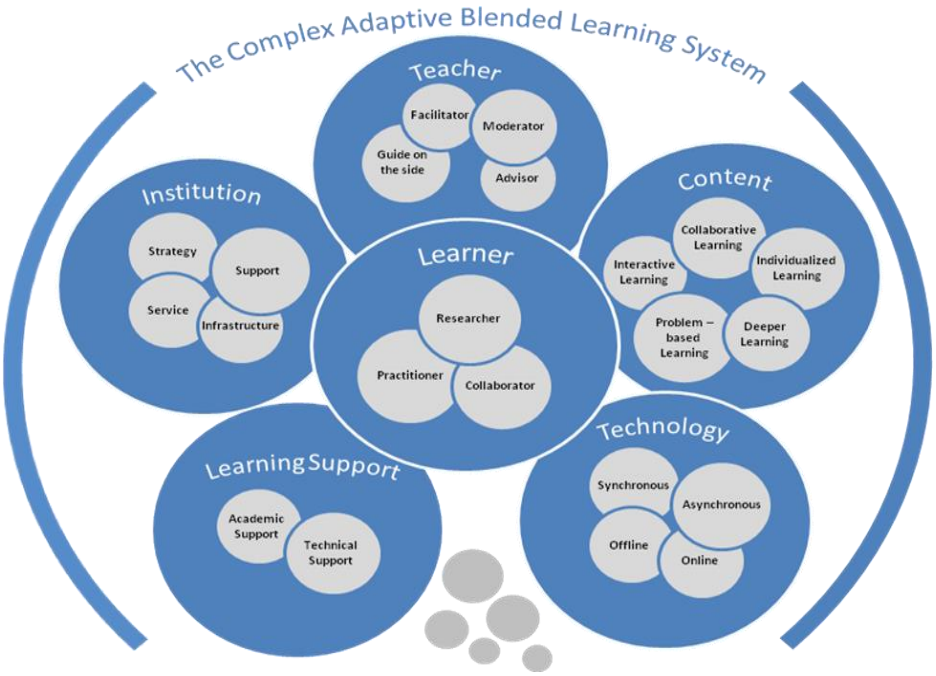


Figure 1. The Framework of Complex Adaptive Blended Learning Systems (CABLS)

The learner in CABLS

As a complex subsystem, the learner co-evolves with other subsystems, constantly acquiring new identities. Blended learning studies have confirmed the transformation of learners from being passive to becoming active participants in learning. This is a result of undergoing a dynamic, adaptive process of change as they interact with other subsystems in the multimodal learning environment.

The teacher in CABLS

In blended learning environments teachers co-evolve with other subsystems, particularly with learners, to become a generation of teachers with new identities and multi-disciplined professional skills. There are many new labels that describe this generation of teachers, for example, e-moderators (Salmon, 2004), facilitators, guides on the side, and advisors, among others.

The content in CABLS

The content that learners are engaged with in blended learning has never been as rich and engaging as it is today as a result of constantly interacting with, and often determined by, the learner, the teacher, the technology, the learning support, and the institution. This is clearly demonstrated in Singh's (2003, p. 52) categorization of blended learning, which largely captures the kinds of learning content taking place in blended learning. These categories include blending offline and online learning; blending self-paced and live, collaborative learning; blending structured and

unstructured learning; blending custom content with off-the-shelf content; and blending learning, practice, and performance support. Empirical studies have pointed toward the emergence of deeper learning (see Moor & Gilmartin, 2010) as one of the changes caused by the new content in blended learning.

The technology in CABLS

The complex nature of technology has been recognized by scholars such as Ni and Branch (2008). They identified multiple interactions within technology and between technology and the environment, and pointed out that such complexity has been insufficiently addressed in research, "thereby rendering the results of many research studies about educational technology lacking in generalizability or application" (p. 30). In addition, the unceasing advances in technology often "kick" blended learning to rejuvenate it, while at the same time, keeping it balanced on "the edge of chaos," stable enough to maintain its internal structure but sensitive enough to the changing needs of the learner and the new challenges and potential brought about by new technologies. Empirical studies have shown that new technologies usually undergo a dynamic, adaptive process of emergence, adoption, and establishment or obsolescence. The self-organizing process of the systems eventually retains those technologies that best facilitate blended learning.

Learning support in CABLS

The CABLS framework distinguishes itself from existing blended learning models by pushing learning support from the background to the foreground. The rationale for this push lies in a learner's control over their own learning, a central tenet in the learner-centred approach. In this study, learning support is considered to contain two kinds of support: academic support focusing on helping learners to develop effective learning strategies, such as time management and collaborative skills, and technical support aiming to help students improve their knowledge of the technological tools and the fluency with which they use the tools to complete specific learning tasks. Both kinds of support are provided for specific purposes at the course or task level. Again, the development of learning support mechanisms should be informed by the needs of the learner, effectuated by the expertise of the teacher, necessitated by the constant advances in technology, and ensured by institutional support.

The institution in CABLS

Including the institution as a subsystem in the framework elevates blended learning from the course level to the institutional level. In order to sustain blended learning, support mechanisms should be provided at an institutional level and can include strategies, policies, support and service (See Graham, Woodfield, and Harrison, 2013). These mechanisms are interrelated and informed by, the learner, the teacher, the technology, the content and the learning support. In turn, the institution becomes a major driving force behind the development of the subsystems around it.

In summary, the emphasis on the interdependency and dynamic interaction between the subsystems clearly marks the difference between the CABLS framework and the existing blended learning models. We would like to point out that the subsystems in the CABLS framework are not exclusive and exhaustive, but due to the constraints and focus of this article, we are only able to discuss the essential components of blended learning.

Using the CABLS framework to analyse the gaps in blended learning research and practice

This section reviews recent empirical studies in blended learning using the CABLS framework. The purpose of this review was to further explore the essence of blended learning and identify gaps in blended learning research and practice.

Data collection

Our review of the blended learning literature covers the period between January 1, 2013, and August 21, 2014. Eighty-seven journal articles on empirical studies (excluding theoretical articles) were found through a title search in SCI, SSCI, CPCI-S citation indexes via Web of Science, an online citation indexing service. Key words used in the search were "blended learning," "blending learning," "b-learning," "blended instruction," "blended course," "blended program," "blended environment," "blended class," "blended e-learning" "flipped classroom," "flipped classrooms," "flipped class," "reversed teaching," "reversed instruction," "flipped teaching," and "flipped learning." The inclusion of flipped classrooms in blended learning is justified by the fact that this model encapsulates all the subsystems of blended learning, but few articles use the two terms in their studies at the same time.

Data analysis

We applied the proposed framework to coding and analysing the data collected. To be more specific, the articles reviewed were first categorized in accordance with their focuses, which were coded into the six subsystems in CABLS, namely, the learner, the teacher, the technology, the content, the learning support, and the institution. This does not mean that each of the studies reviewed below covers all the six subsystems in the CABLS framework. On the contrary, none is comprehensive enough to cover all of them and each at most only examines a few subsystems.

Findings from the review of blended learning literature

This section comprises two parts. Following the CABLS framework, Part 1 identifies the subsystems and the relationships that were covered in the literature. Part 2 goes a step further to examine what has been achieved in relation to each subsystem and its relationship to others and further explores the gaps in blended learning research and practice.

Part 1: Identification of subsystems and their relationships

In order to provide a bird's-eye view of the research achievements in blended learning during the last 20 months, we first calculated the total number of times each subsystem was covered in the 87 articles (see Figure 2). We can see from Figure 2 that the total coverage for all subsystems exceeds the total number of reviewed articles, because most articles cover more than one subsystem. The great majority (95%) of the reviewed articles focus on the learner, followed by content (79%), and technology (54%). The percentage drops dramatically when it comes to focus on the teacher (32%), on the institution (17%), and on the learning support (15%).

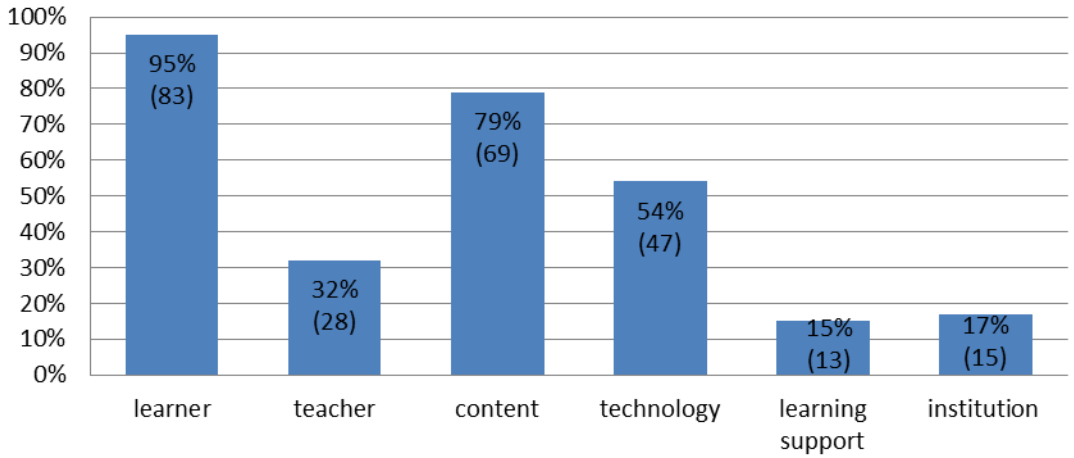
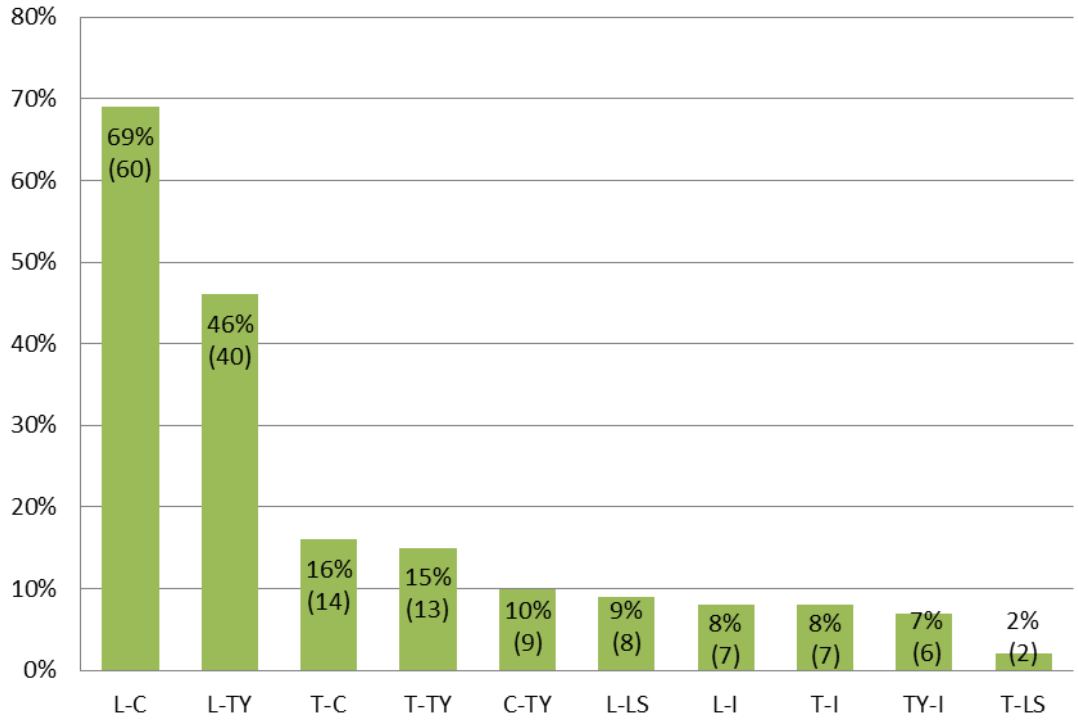


Figure 2. Number and percentage of each entity identified in the 87 articles

To futher interrogate the above findings, we adopted a systems approach to recode the data according to the relationships between the different subsystems in CABLS. Statistically, there should be 15 one-to-one relationships among the 6 subsystems. However, only 10 relationships have been identified in the 87 articles, as shown in Figure 3. Clearly, learner-content is the most investigated relationship because 69% (60) of the 87 articles discussed it. The learner-technology (46%, 40) relationship came second. All other relationships appear to be insufficently investigated, with the relationship between the teacher and the learning support (2%) receiving the least attention.

Both Figures 2 and 3 confirm that learning support has not been subjected to much research. Furthermore, our review has failed to find any research focusing on the relationships between the learner and the teacher, the content and learning support, the content and the institution, the technology and learning support, and learning support and the institution, all of which are important relationships that could determine the success of blended learing. For example, an in-depth study into the relationship between learning support and other entities could shed light on the potential support the teacher and the institution have on effective autonomous learning. We also acknowledge that, apart from these one-to-one relationships, there are also one-to-many and many-to-many relationships in CABLS, which have not been acknowledged in the reviewed studies. They are nevertheless crucial issues that are beyond the focus and scope of the current research, but that are in need of investigation by well-designed research.
In summary, the findings contained in Figure 3 corroborate those displayed in Figure 2. Together, they depict a comparatively complete picture of the current blended learning landscape. The indentification of these relationships and the gaps in research also attest to the effectiveness of the proposed framework in promoting a deeper understanding of blended learning.



Note. L = Learner; T =Teacher; TY = Technology; C = Content; LS = Learning Support; I = Institution
Figure 3. Number and percentage of relationships between entities identified in the 87 articles

Part 2: Findings relating to each subsystem and their relationships

In this section, we will use findings from specific studies as exemplars to uncover how each subsystem in the CABLS framework has changed over time, and how each subsystem interacts with others within the systems. Due to the length limitation of this article, we will focus only on key issues relating to each subsystem.

The learner in blended learning

As shown in Figure 3, previous studies focusing on learners cover the learner-content, learner-technology, learner-learning support, and learner-institution relationship. The discussion about these relationships centres largely on two issues: learning performance and students' satisfaction.

The overall findings point to improved learning outcomes and behaviours, and learners' overall positive reception of blended learning. For example, when discussing the use of the flipped classroom approach, Forsey, Low, and Glance (2013, p. 481) reported that "students feel more accountable regarding the ideas and theories explored in class." The development of "metacognitive ability in comprehension, argumentation, reasoning and various forms of higher order thinking" was observed by Hsu and Hsieh (2014, p. 233). McLaughlin, Griffin, Esserman, Davidson, Glatt, and Roth (2013, p. 196) concluded that "The flipped classroom promoted student empowerment, development and engagement." In terms of students' perception of blended learning, although some studies identified that positive perceptions relate to higher grades (e.g., Owston, York, & Murtha, 2013), the majority of studies have confirmed learners' positive responses to blended learning (see Perez, Lopez, & Ariza, 2013; Kiviniemi, 2014).

The teacher in blended learning

We can see from Figure 2 that only 11% of the reviewed research focuses on teachers, which covers teacher-content, teacher-technology, teacher-learning support and the teacher-institution relationship. Among these relationships, the one between the teacher and the institution has emerged as being a key relationship as it relates to institutional support for professional development (see Moskal, Dziuban, & Hartman, 2013; Matzat, 2013; Owens, 2012). The study by Carbonell, Dailey-Hebert, and Gijselaers (2013) best illustrates this relationship. On one hand, they advocated a bottom-up approach promoting the initiation of blended learning by the faculty; on the other, they stressed the importance of institutional culture which "values experimentation and supports such initiatives and a collaborative project climate" (p. 37). Despite the lack of research into teachers as a subsystem, the change in the role of the teacher has been reported. Xu (2013, p. 538) pointed out that teachers have been transformed from a "knowledge initiator, class controller" to facilitator, advisor, and promoter of learning.

The content in blended learning

As demonstrated in Figure 2, the content, including curriculum design and delivery, has been much researched, coming second only to studies into the learner. Improvements in learning content have been reported. In terms of innovative curriculum design in blended learning, Elia, Secundo, Assaf, and Fayyoumi (2014, p. 543) summarized the following new principles:

> (a) the involvement of heterogeneous stakeholders in the course's design phase; (b) the focus on competence development rather than on knowledge transfer; (c) the choice of team work as an additional component to evaluate individual students' performances; (d) presence of remote and F2F interactions among peers and between teachers and students; (e) the usage of web 2.0 tools as enablers of collaborative learning processes and social networking; (f) continuous tutoring both for content and technological issues.

The recent increase in the adoption of the flipped classroom model represents innovation in content delivery in blended learning. Almost all the studies into the flipped class have confirmed that short and concise pre-recorded video lectures allow students to learn the content in greater depth and at their own pace outside the classroom. In turn, such a thorough understanding of the content facilitates more effective classroom learning as students can more easily apply in class what they have learned from the video lectures outside class. As a result, they are "getting more out of their contact hours" (Forsey, Low, & Glance, 2013, p. 479). The class has also become a venue for further consolidation of content comprehension through tasks and in-class quizzes (Tune, Sturek, & Basile, 2013). According to Ferreri and O'Connor (2013, p. 1), "This change in delivery format allowed students to spend the majority of class time conducting small-group learning activities, such as case studies to promote communication, problem solving, and interpersonal skills." Improved learning and better performance were also reported (see Ferreri & O'Connor, 2013; Missildine, Fountain, Summers, & Gosselin, 2013).

By the use of the systems approach, we can see that the content, including content delivery in blended learning, has been transformed as it interacts with the teacher, the learner, and the technology. A lack of any of these subsystems would result in content not being as rich or engaging and the delivery not being as effective or as powerful. In turn, the improved content and content delivery have transformed both the learner and the teacher.

The technology in blended learning

The studies reviewed have confirmed the crucial role of technology in the success of blended learning implementation. A reliable and robust IT infrastructure for the whole institution and diversified learning management systems have been recognized as prerequisites for successful blended learning (see Alsabawy, Cater-Steel, & Soar, 2013; Chen, Wang, Kinshuk, & Chen, 2014). Another theme that is characterized in the blended learning literature is the necessity for the constant replacement of older technology with newer technology.

Among the 19% of the reviewed studies that do discuss technology, few are concerned primarily with technology, although they have covered the relationship between technology and the learner, the teacher, the content, and the institution.

As shown in Figure 3, the relationship between the learner and technology was the second most discussed relationship. Among these studies, some investigated the learners' attitudes towards the use of technology and their ICT competence (e.g., Dias & Diniz, 2014; Padilla-Melendez, Aguila-Obra, & Garrido-Moreno, 2013), while others reported the effect of technology on learning (e.g., Elia et al., 2014; Lopez-Perez, Perez-Lopez, Rodriguez-Ariza, & Argente-Linares, 2013).

The learning support in blended learning

Learning support was hardly mentioned in the reviewed articles, as indicated in Figure 2. This is why Figure 3 only shows its relationship with the learner and the teacher. Moskal Dziuban, and Hartman (2013, p. 17) talked about the need for support for "deeper subjects such as course content or an assignment" and suggested that support should occur through multiple methods such as instant messaging, email, telephone, or web-based tutorials and materials. These cursory remarks suggest that learning support has not emerged as an individual subsystem in existing blended learning research and has not received due attention. We hope that this current research will bring attention to the necessity for the provision of such support, because it is an important factor affecting the learner, the teacher, the effective and efficient use of technology, and the institutional support. To some extent, such support can determine the degree of success of blended learning.

The institution in blended learning

Both Figures 2 and 3 confirm the previously inadequate number of studies into the institution as a subsystem in blended learning, which supports the comment from Porter, Graham, Spring, and Welch (2014, p. 185) that "while a number of scholars have conducted course-level investigations of BL's effectiveness, very few have provided guidance for BL adoption at the institutional level."

The study by Graham, Woodfield, and Harrison (2013) is one exception, proposing a three-stage framework for the adoption of blended learning, following their examination of six cases of institutional implementation. The three stages include awareness/exploration, adoption/early implementation and mature implementation/growth. For each stage, they also suggested key strategies, structures, and support to address issues relating to the overall design, development and implementation of blended learning. Porter et al. (2014) conducted a follow-up study, applying the framework to assess the degree of implementation of blended learning by 11 institutions in the US. Another notable study discussing institutional implementation of blended learning was reported by Taylor and Newton (2013). Compared to other studies into blended learning, this is the most comprehensive research, and it covers curriculum design, students' experiences, staff experiences, educational technologies, and institutional factors. Although it does not specify the use of a systems approach, it does recognize the importance of the alignment of university systems and processes with the expectations of the learner and the faculty. It concludes that "strategic institutional change

will only happen if there is a shared vision and energy that touches all parts of an organisation" (p. 59). A similar contention is reflected in the call by Garrison and Vaughan (2013, p. 28) for "committed collaborative leadership that engages all levels of the institution."

The relationship of the institution with the learner, the teacher, and the technology makes fewer appearances, as revealed in Figure 3. The learner-institution relationship examines how institutions should take into account learners' needs and expectations when implementing blended learning, and how learners should be supported at an institutional level. The need for alignment of "institutional, faculty, and student goals" is a case in point, as advocated by Moskal, Dziuban, and Hartman (2013, p. 15).

Through the CABLS framework, the above review has identified several gaps in current blended learning research and practice. First of all, none of the reviewed studies covers all the six components, and none examines the interaction between the subsystems in blended learning in line with a systems perspective. Secondly, through the lens of the CABLS framework, we were able to reveal relationships between subsystems that are in need of more substantial research, such as the relationship between learning support and other subsystems. Thirdly, the CABLS framework also enables us to direct future research to relationships that have not yet been investigated in blended learning studies, such as one-to-many and many-to-many relationships between the subsystems.

Establishing a deeper understanding of blended learning

In the section above, we closely examined each subsystem in blended learning to capture its changes and its relationship with other subsystems. However, as none of the reviewed studies adopted a systems approach, the system attributes of blended learning, such as its ability to adapt, its dynamics, and its complex, self-organizing and evolving nature, were not explored explicitly. In this section, we will further explore these attributes in order to establish a deeper understanding of blended learning as a whole.

Blended learning is complex.

Although none of the above reviewed studies covers all the subsystems specified in the CABLS framework, when taken as a whole they confirmed that blended learning encapsulates all of the six subsystems and that they relate to each other in one way or another. Without a systems approach, these studies could only explore some basic linear relationships between these subsystems, leaving more complex and non-linear relationships untapped. The CABLS framework reveals the complexity of blended learning and directs us to the pressing need to investigate the more intricate interaction and inter-dependence among the subsystems, because this determines how well the subsystems blend into one larger system. Thus, the complexity of the systems compels us not to see blended learning as a simple combination or mishmash of face-to-face learning and technology-mediated instruction. Instead, it should be viewed as a complex system that seamlessly fuses face-to-face learning with technology-mediated learning. As a result, blended learning has evolved into a new system of learning with a new generation of learners and teachers. The complexity of this evolution deserves a more in-depth examination than we were able to achieve in this article.

Blended learning is adaptive.

As a complex system, blended learning embraces the ability to learn and change its behaviour in response to changes within and around it. The blended learning literature has confirmed the changing needs of learners and teachers, providing fertile ground for adaptation for each of the subsystems. Learners and teachers learn to adapt to the new learning environment in order to benefit; content design and delivery are constantly being adapted to the new multimodal environment as manifest in the emergence of various blended learning models, including the flipped classroom model; technology is being developed and adapted to better realize learning goals; learning support responds to the needs of new learners and the development of newer technology to better support learning; and institutions constantly adjust their strategies, policies and support measures, informed by what is taking place in blended learning practices. Various studies have touched upon the adaptive nature of blended learning, but no explicit, in-depth studies into this adaptive nature have been found.

Blended learning is dynamic.

All the studies reviewed for this research explicitly or implicitly confirmed that blended learning is dynamic. Similar to any complex system, on one hand, blended learning has the ability to maintain its inner structure and stability, and on the other hand, it has never been static. Instead, it progresses in reaction to changes within and around it. In more concrete terms, all the subsystems are transforming through their interaction with one another. Together, they maintain the inner stability of blended learning, but at the same time this stability is continually threatened by new changes and innovation in the system. It is in this ceaseless process that blended learning keeps advancing.

Blended learning is self-organizing.

As a living system, blended learning has proved its ability to organize itself through the spontaneous emergence of new relationships and communications between its subsystems, and within each subsystem. This self-organizing process is a natural product of the interaction between the different subsystems. The flipped teaching model is a classic example, demonstrating that new relationships between the teacher, the content, and the learner have been formed through interaction with the new delivery mode and the technology.

Blended learning is co-evolving.

The co-evolving nature of blended learning has been clearly demonstrated through our discussions of the empirical studies of blended learning. Through constant and dynamic self-organization and adaptation, blended learning evolves with its multimodal environment to produce learners with new learning behaviours, teachers with fresh skills and identities, and enhanced learning outcomes.

Concluding statements

This article proposes a framework for blended learning grounded in the complex adaptive systems theory. The adoption of such a perspective has enormous implications, not only for our understanding of the nature, quality, and magnitude of current blended learning achievements, but also for our exposition of gaps that need to be bridged in future blended learning research and practice.

Firstly, the application of the CABLS framework to the review of the blended learning literature suggests that this framework is able to promote a systematic and holistic view of blended learning, providing us with a more complete picture of such learning. Differing from existing models that see only parts of blended learning in isolation and ignore its dynamic qualities, this framework allows us to view all the subsystems in relation to each other as an integral whole so that the big picture will not be lost from view.

Secondly, through the review of the empirical studies, the proposed framework illustrates the ways in which the subsystems within blended learning interact with, and impact upon, each other to grow as a healthy system. This may have practical implications for blended learning practice because it will compel researchers to investigate the feedback loop of the systems (Cleveland, 1994) and the interaction between the subsystems to avoid one-way interpretation of causality.

Thirdly, we hope that this framework will facilitate a deeper, more accurate understanding of the dynamic and adaptive nature of blended learning. With an understanding of why and how temporal stability is constantly disturbed, and new balance is reached from the interaction and collaboration of the subsystems in blended learning, we could have a better grasp of its developmental stages and be better able to see where it will lead us. As a result, we could be well prepared to meet the challenges ahead in our effort to scale up and eventually normalize blended learning in tertiary education.

Finally and more importantly, although this research represents our initial application of the proposed framework, the systems approach enabled us to reveal untapped potential and crucial issues to be further investigated in future research, such as the provision of learning support, the promotion of institutional involvement, and the non-linear relationships of the subsystems in blended learning. The next step should be the implementation of interventionist

projects to examine the effect of applying this framework for blended learning in selected higher education institutions.

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