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Actualizing the affordance of mobile technology for classroom orchestration: A main path analysis of mobile learning

Bai-Li Hwang
National Taiwan University of Science and Technology, D10309201@mail.ntust.edu.tw

Tzu-Chuan Chou
National Taiwan University of Sciences and Technology, tcchou@mail.ntust.edu.tw

Chen-Hao Huang
National Taiwan University of Science and Technology, chhuang@mail.ntust.edu.tw

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Bai-Li Hwang
Department of information management
National Taiwan University of Science and Technology
Taipei, Taiwan
Email: D10309201@mail.ntust.edu.tw

Tzu-Chuan Chou
Department of information management
National Taiwan University of Science and Technology
Taipei, Taiwan
Email: tcchou@mail.ntust.edu.tw

Chen-Hao Huang
Department of information management
National Taiwan University of Science and Technology
Taipei, Taiwan
Email: chhuang@mail.ntust.edu.tw

Abstract

Ubiquitous and increasingly accessible, mobile technology enhanced learning in the learning process, referred to as "classroom orchestration," is inspiring an increasing number of studies that examines mobile learning from various perspectives. Nonetheless, educators find themselves confronted by the ever-evolving features of mobile technology and challenges in implementation context. This study, therefore, surveys the research literature on mobile learning using main path analysis, and cites "affordance actualization" by Strong (Strong et al. 2014) as a theoretical lens to identify the research themes from results found in main paths, to develop a “mobile learning actualization” framework. This particular framework integrates several research themes, ranging from system features, educator and learner, the goal of mobile technology adoption, contextual implementation, to the outcome of mobile learning. These insights have proven constructive for educators to adapt mobile technology to a learning environment, thus successfully achieving classroom orchestration.

Keywords (Mobile Learning, M-Learning, Affordance actualization, Main path analysis)

1 Introduction

Mobile devices and the convenience they offer to users have redefined learning experiences with its innovative learning approach; they have also been recognized as the future of modern education. In this paper, we aim to focus on the challenges of the use of technology in the classroom, with its variable and complex nature, and how digital technologies play a supportive role in the learning process (Ozdamli and Cavus, 2011), which is referred to as "classroom orchestration." Even though the feature of mobile technologies has been identified as a game-changer in promoting learning efficiency, its potential deserving more in-depth, scientifically-based exploration, the existing research merely focuses on system features and system objectives still. What is noteworthy about mobile technology is its ubiquity, making it different from other traditional learning implements; it allows educators to receive learner feedback more efficiently and enrich the curriculum with mobile-supported activities.

Moreover, several factors in a learning environment, such as the usability of digital technology (Sung et al., 2016), the ease of use of the learning system (Mac Callum and Jeffrey 2014; Park 2011), and internet stability and connection (Cavus & Al-Momani, 2011) have to be taken into account in the way they challenge both educators and learners. These factors zone in on the materiality aspect of technology to highlight the objective and the nature of technology, referred to as "technology affordance" (Faraj & Azad, 2012). Thus, the approach to actualizing these technology affordances to promote their learning efficiency becomes the most critical factor in today's education development. Considering that the mobile technologies and implementation approach could pose a significant for educators in classroom management, this study aims to address the following research question:

How to actualize the affordance of mobile technology in a learning environment?

In answering this research question, this study adopts the main path analysis, plus systematic literature analysis approach to track the development trajectory of mobile learning.

We identified several observation focuses in this field while exploring the various studies of mobile learning: system features, educator and learner, the goal of mobile technology adoption, contextual implementation, and the outcome of mobile learning. This research, for better integration, adopts Strong's affordance actualization (2014) to construct research topics in current use, so as to better conceptualize the deployment process of mobile learning. This study aims to develop an integrated model to further our understanding of actualizing mobile learning for classroom orchestration.

2 Contextual background

The advent of digital technology has enabled digital learning without boundary, and revolutionized learning environments and learner experience worldwide. While technology adoption is generally perceived as positive, there is a growing awareness of the drawbacks in digital learning (i.e. environmental and geographic limitations) that must be addressed. The good news is, mobile learning enabled by mobile device is the solution to dissolving these limitations. Nonetheless, the solution has increased instructors' workload in class (Dillenbourg et al., 2013).

These in-classroom tasks are administered either in-person or online. Yet whether in-person or online, classroom activities will invariably involve individual assignments, group activities, or a combination of both. In other words, teachers are confronted with more classroom tasks, while having to supervise various learning activities under multiple constraints.

Classroom orchestration is defined as a teacher's approach to managing multi-level activities in real-time under multi-constraint conditions. This topic has attracted growing attention in recent years, and become the shared goal of educators, especially in technology-dependent classrooms, to achieve enhanced collaborative learning (Dillenbourg et al., 2013).

How does mobile learning play into classroom orchestration? Several mobile learning articles point out that mobile learning could be recognized as a purpose, which relies on the ubiquitous features of mobile technology to construct an environment with high learning efficiency. We therefore hope to bring the nature of learning into focus, and put to use mobile learning as an approach to achieving classroom orchestration.

Numerous studies have explored mobile learning from various perspectives, including conceptual framework (Chang et al., 2003; Chen et al. 2003; Lai et al. 2007; Peng et al. 2009); adoption factors

analysis (Hamidi and Chavoshi, 2018; Karimi, 2016; Looi et al., 2014; Martin and Ertzberger, 2013); the technology acceptance model (Al-Emran et al., 2018; Almaiah et al., 2019a; Almaiah et al., 2019b; Chavoshi and Hamidi, 2019; Hoi, 2020); and mobile learning goals (Cheon et al., 2012; Gikas and Grant, 2013; Hao et al., 2017; Schwabe and Göth, 2005; Sharples et al., 2002). Although several literature pieces identify mobile learning as a means to improving learner's knowledge and skill, a thorough examination of such has yet to be established. Therefore, we hope to revisit previous articles to better-understand the value of mobile learning. Following this contextual background, we will move into Literature Review, Research Methods, Analysis, and Conclusion for a comprehensive perspective of mobile learning currently in-use.

3 Literature Review

3.1 Mobile Learning (M-Learning)

An earlier definition of mobile learning is based primarily on the use of mobile technology, which could be acquired through mobile computing devices (Quinn, 2000). A study by Lehner and Nosekabel (2002) summarizes its definition as "providing digital information and teaching materials required by learners through services or devices that are not limited by time and place, with a view to assisting learners to acquire knowledge." Hoppe et al, (2003) makes plain that m-learning is a method featuring mobile vehicles and wireless transmission.(Trifonova and Ronchetti, 2003) believe mobile learning to be the combination of action technology and digital learning, that mobile learning devices have three abilities: interaction, content access, and service access. (Seppälä and Alamäki, 2003) assert that mobile learning is more than just the digital aspect of the education experience: it also embodies the characteristics of mobile. M-learning, therefore, is superior to digital learning in that it can be done anytime and anywhere. (Chu et al. 2010) believe that besides improving individual learners' experience, mobile devices and wireless communication tools are excellent collaborative learning activities.

However, erroneous instructional designs may have an adverse impact on learner's experiences, due to possible excessive cognitive load (Chu, 2014). Studies have revealed that learners' attitudes and learning behaviors are noteworthily correlated with the success of school mobile learning (Cheon et al., 2012). For educators, choosing appropriate learning aids and making thorough preparation before implementing mobile learning is imperative for improving learner's knowledge and skill.

Most importantly, m-learning as an approach may not always achieve the desired results. The efficient learning environment is not solitarily dependent on digital technologies, but must rely on the efforts of educators and learners to achieve classroom orchestration.

4 Research Methodology

4.1 Main path Analysis

Main path analysis (MPA) was first proposed by (Hummon and Doreian, 1990), suggesting that one can trace the major development trajectory of a scientific discipline through citation links. This method reduces massive amounts of information embedded in a citation network into a few crucial paths (Ho 2020). These crucial paths not only hint at the most significant articles but also the main knowledge flow paths of a target field. This method was implemented in the beginning in the social network analysis field (Batagelj and Mrvar, 1998), and now it has been widely adopted in a wide variety of disciplines (Liang et al., 2016; Park and Magee, 2017; Xiao et al., 2014).

MPA consists of two steps: in step one, the traversal counts of each citation link are calculated in a citation network (Batagelj 2003; Batagelj and Mrvar, 1998) and as a result, it differentiates the significance of each citation link. Among the various traversal count algorithms, this study adopts the search path link count (SPLC) algorithm per the suggestion referenced in (Liu et al., 2019). Step 2 involves a search for the crucial paths according to traversal counts of the links.

Traditionally, the main path is a single path. As evidenced by analyses on the single path -- one by Hummon & Doreian (1990), and the other by Liu & Lu (2012), main path in current studies does more than just search for multiples paths; it also ensures that all the top significant links are chained in the final results (Hung et al., 2014; Liu and Lu, 2012).

These advantages allow one to examine multiple subfields while at the same time recognize important contributors. Therefore, this research applies key-route MPA to visualize the key knowledge

development trajectory of mobile learning. Key-route MPA is always associated with a key-route number which indicates the number of top links to include in the resulting main paths.

Database	Web of Science
Search Strategy	TS = ("e-learning" OR "mobile learning" OR "m-learning" OR "digital learning") AND AB = ("classroom" AND " education")
Timespan	From January 1, 2003 to May 26, 2020

Table 1. Search strategy and key words used

4.2 Literature Search

The authors collect academic articles and associated citation information from the Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCIE) databases of the Web of Science (WOS) service. Table 1 presents the query strategy. The search yields a total of 934 papers, published between January 1, 2003 and May 26, 2020. 2003 was selected because it was the year that m-learning educational strategy was first developed. Next we collect the citation information on each of these papers from the WOS database. The citation information is used to construct the citation network, which becomes the base for MPA.

5 Analysis

5.1 The Sub Research Themes

To examine main paths in better detail, this study applies the global main path approach (Liu et al., 2013) to trace the top most significant paths, thus bringing recent and earlier clusters of papers into better focus. By increasing the number of paths selected, the details of the citation network surface by fits and starts. Four branches of literature are illustrated in Figure 1, as per our analysis. Each branch presents a sub-research theme. Darker dots indicate end nodes. Link weights are indicated with different line thickness. Thicker lines indicate heavier weights.

After examining the title, abstract, and keywords of these papers, the four sub-research themes are accordingly determined: System features, teaching and learning motivation, outcome projection, and contextual implementation.

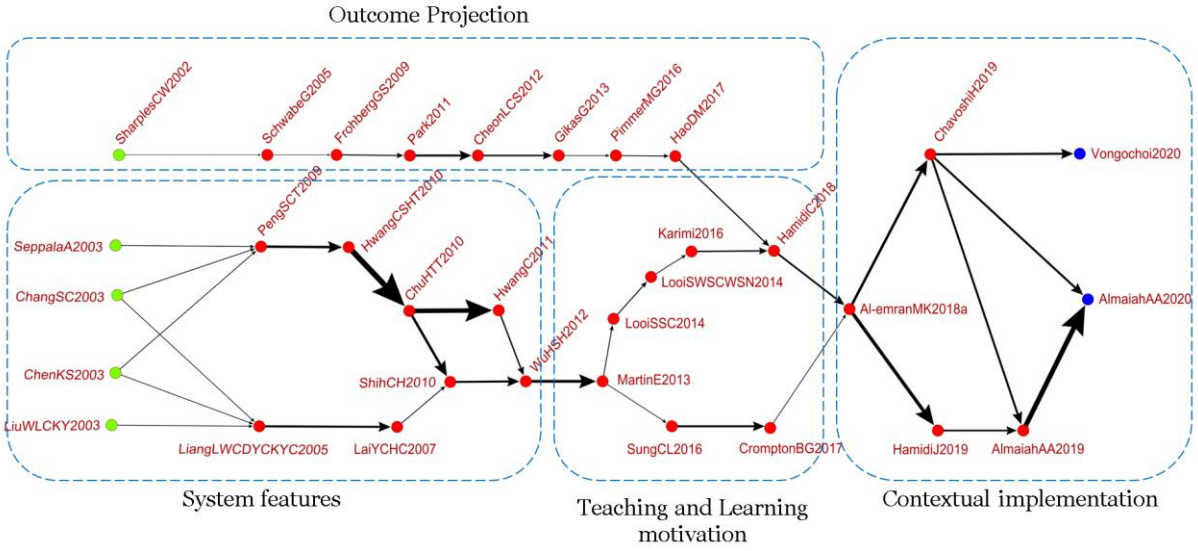

Figure 1. Multiple global main paths of Mobile Learning.

5.1.1 System features

Research interests on system features and application versatility of instructional systems of electronic devices began to heighten since Wi-Fi and mobile devices surged in availability. These research efforts discuss users' understanding and perceived functions of Wi-Fi and handheld devices. Seppälä and Alamäki (2003) demonstrate how mobile devices are used in the training of teachers as well as sharing pertinent experience through SMS-messaging and digital pictures. On the other hand, Chen, Kao, and Sheu (2003) develop a mobile learning system, which utilizes Wi-Fi technology and PDA (Personal Digital Assistant) devices, aiming to explore possible roles that the mobile learning system could play in the classroom setting. Liu et al. (2003) explore how Wi-Fi technology intensifies the application of mobile learning systems to better learner experience. Later, Liang et al. (2005) expand the use of wireless communication technology inside classrooms and provided an in-depth study of "digital classroom environment" characteristics. Peng et al (2009) inspect how mobile devices enable educational technology to transform instructional environments and learning materials, to improve teaching and knowledge ubiquity. Alternatively, Chu et al. (2010) take advantage of RFID (Radio Frequency Identification) in the classroom to reinforce the connection between innovative teaching methods and learners' experience. This particular study reveals that combined and applied clinical skills, along with in-class knowledge, which traditionally were taught separately, have reflected an uptick in learning synergy when conducted via mobile learning systems and transmission sensing devices (Wu et al., 2012). Research efforts of this stage primarily focus on system features depiction, and the versatility of Wi-Fi and mobile systems application.

5.1.2 Outcome Projection

Mobile technology has made progress in leaps and bounds in the past decade, furthering the online learning environment to greater ubiquity. Starting in 2002, scholars began to trial-implement the mobile learning system to better understand its advantages and strengths. In 2002, Sharples et al. referenced the theory of m-learning to initiate the design and implementation of a long-distance education system, while exploring user feedback and experience. In 2005, Schwabe and Göth designed Mobile Game to promote m-learning alternatives. The project also called to mind the need to evaluate the overall learning benefits of mobile-assisted learning. In taking the m-learning research into new perspectives, Park in 2011 systemized the mobile learning environment to shed light on its scientific concepts, which helped instructional designers to integrate mobile technologies for greater teaching effectiveness. A short while later, a new research angle began calling attention to learners' cognitive state as they participate in mobile learning, to monitor their acceptance level, experience and willingness to adopt mobile learning (Cheon et al., 2012). Besides exploring positive outcomes, Gikas and Grant (2013) started to observe the setbacks that the mobile platforms bring to students. In 2016, Pimmer et al. began to reflect on mobile learning, and this study launched a new research direction toward mobile-assisted education initiatives. In general, m-learning and ubiquitous learning in the higher education community is found to be more commonplace given that learners have greater access to mobile platforms.

Resultantly, scholars began to attain goals enabled by portable technologies that make m-learning unique, and push to promote the effectiveness of mobile learning so as to improve learner's knowledge and skill. As stated earlier, this discussion remains, in reality, in a state of expectation; the results are still in projection. It was not until Al-Emran et al. published an article in 2018, proposing the TAM model (Technology Acceptance Model) to observe learners' acceptance of mobile learning, and track educators and learners' willingness to use mobile learning, that solid reference for the design of subsequent systems began to surface, in turn becoming valuable reference to the future of m-learning.

5.1.3 Teaching and Learning Motivation

With m-learning growing in importance in the education community, scholars are placing equal focus on the function and application, or the design and implementation of the mobile learning system, while also beginning to consider other factors. As illustrated in Figure 1, the focus of research began shifting to educators and learner experience in 2013. While reviewing articles produced during this time, we found that the role of mobile technology became more auxiliary in the classroom setting. The focus of the research has also veered to the interaction between learners and educators to support more positive learning outcomes.

The new research era also inspired a new slew of studies. Martin and Ertzberger (2013) set about acknowledging other factors: "Does mobile technology allow learners to receive information from educators?" or "How to deploy mobile technology during courses so as to stimulate learning interests?" They also studied extensively the influence of mobile learning on the grades and attitudes of learners.

On the other hand, Looi et al. (2014) directed their research attention to teachers who implemented mobile learning, to investigate how different teaching orientations affect course results, in particular the means of integrating mobile technology and the way of interacting with students, which understandably influence educators' teaching approach. When mobile learning became an integral component of the conventional education practice over time, scholars began to examine educators' teaching methods reforms, and their impact on teaching effectiveness. (Looi et al., 2014)

Besides discussing the impact of mobile learning on educators' teaching performance, a new study surfaced to attempt to identify features that motivated learners to use mobile learning systems (Karimi, 2016); Sung et al, on the other hand, surveyed the overall influence of integrated application of learners' diverse mobile learning tools (ex: NB, PDA, Smart Phone) on mobile learning in the same year. To follow up, the research further studied factors that impacted the willingness of higher education learners to adopt mobile learning methods (Hamidi and Chavoshi, 2018), since differences in perspectives between educators and learners pose a series of challenges for mobile learning approaches.

In short, researchers of this specific stage refrain from focusing solely on information systems, learners, educators, or education objectives. Instead, they started to take every factor into account, even considering environmental determinants in hope of providing a contextually-robust introduction. To that end, we are, at this stage, more concerned about contextual implementation.

5.1.4 Contextual implementation

Contextual implementation is defined as a circumstantially-aware problem-solving approach to realizing the goal as part of the iterative process (Leonardi, 2011; Leonardi, 2013; Strong et al., 2014). Research at this stage primarily focuses on how to enable students to adapt to a mobile learning environment through the actual m-learning process. Several existing studies analyze m-learning in developing countries, and discover that social factors have significantly boosted learner's acceptance of mobile learning (Chavoshi et al., 2019). This article asserts that support from the government and mobile teaching methods have a definitive effect on the society. In addition, Hamidi et al. (2019) observed that higher-education institutions regard mobile learning as a method to improve students' university experience. Also, different from traditional e-learning literature, the disquisitions on mobile learning put more weight on the interactive dynamic between teachers and students. These writings affirm that mobile technology plays a significant role in classes and helps provide necessary information in time to educators and learners separately (Almaiah et al., 2020). To sum up, the real objective of mobile learning is to enable classroom orchestration, which takes place in many forms: to help students effectively process information, allow teachers to monitor students' learning progress, and to create new opportunities for traditional educational institutions. In other words, the boundaries in traditional learning practice are dissolved by mobile-assisted teaching methods, making the learning experience more efficient and possibly, more fulfilling.

5.2 The Transformation of Research Focus: From Mobile Technology Affordance to Classroom Orchestration Actualized

While researching for MPA-centric themes, we noticed that previous literature reviews lean heavily on "Affordance" but later, scholastic attention begins to shift to bringing the "Affordance" of mobile technology into the learning environment. We therefore suggest using "Affordance Actualization," proposed by Strong et al. (2014), to better integrate the marrow of previous literature reviews.

According to an essay published by Strong et al., "affordance" can be reviewed from two perspectives: "IT artefact" and "Actors and their goals." Per literature reviews, we believe these system feature-inspired theses are in fact a probe into IT artefact to explore the essence of the system. The following "Actors and their goals" are divided into two portions in our analysis. One part discusses the motivation of learning and teaching; the other focuses on the projection outcome of mobile learning introduction. While analyzing the research topic, we discover that the core of m-learning is connected to the impact of mobile technologies on classroom education. That being said, we agree with Stoffregen's (2003) corte point that sees affordance as an opportunity to help mobile technology users to realize their goals: enhancing user's understanding of mobile technology will achieve affordance.

The actualization of classroom orchestration is given much spotlight after we thoroughly analyze the research cluster of writings on contextual implementation. As mentioned previously, other than helping students process information more effectively, modern mobile tools also provide teachers greater flexibility to assist students with information-processing, thus improving their learning performance. These new m-learning devices are far more superior to toolkits of the earlier days: their

relatively rudimentary designs required more operational training; also, these older mobile-assisted models contain numerous operating systems, and aren't always serviceable. That being said, the studies in this cluster discuss ways to build a closer interactive mode and preferable study environment through mobile technology for educators and learners alike. Therefore, by adopting the theoretical framework of "Affordance Actualization" and analyzing previous literature on mobile learning, we have identified a mobile technology introduction model suitable for education. Further discussion will be introduced in the following chapter.

6 Discussion and Conclusion

Arrows in figure 2 indicate the knowledge flow direction, connecting from the cited papers to the citing papers. Each paper is assigned a label that begins with the last name of the first author, continues with the first initials of the co-authors (in capital letters), and ends with the publishing year. The thickness of the links is proportional to their SPLC values.

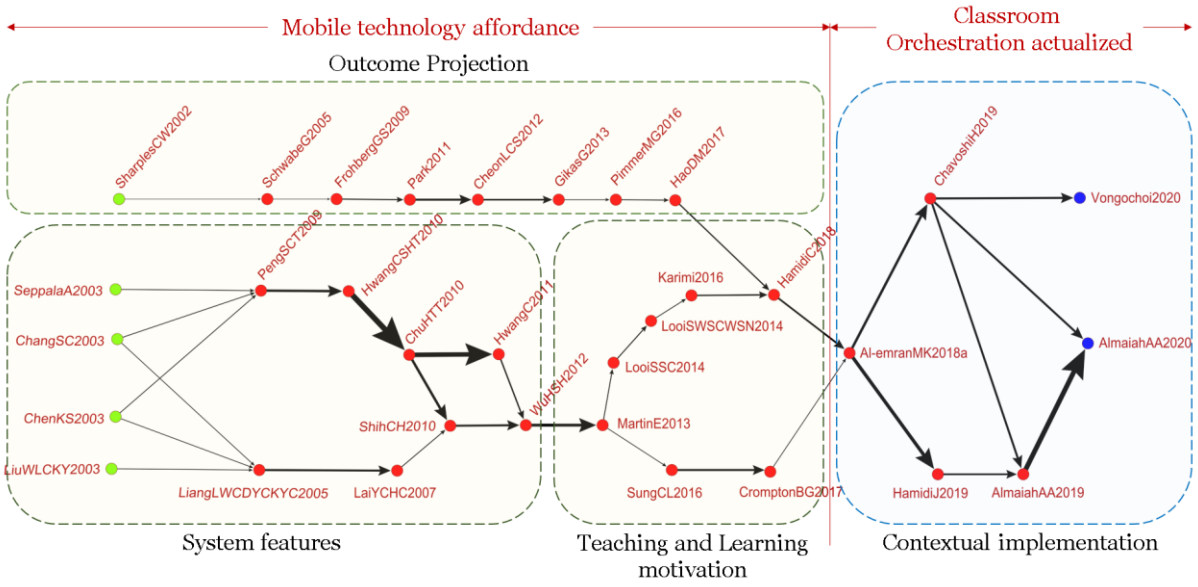

Figure 2. Key-route main paths and transformation of research focus

Key-route MPs provide an indicator for us to track the driving method in the initial stage of mobile learning technology, and several key factors are at play here. We can also note how to apply the value of science and technology to an education initiative, and three elements should be examined here: system functionality, educator & learner, and finally, goal-orientation. These three elements will influence our course directions so at this stage, our cognitive processing is constantly dictated by the external environment; but improvement is possible since we have control over what goes on in these environments.

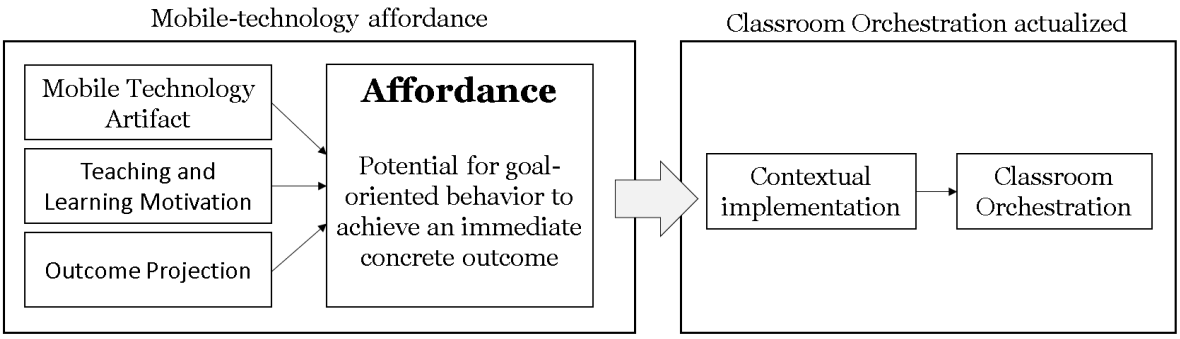

Figure 3. Model of Mobile Learning affordance actualization

Affordance actualization of the past is used to achieve organizational goals; the theory of affordances is now widely believed to be applicable to the educational contexts. Now, inspired by literature precedents studied, we recreate the "mobile learning affordance actualization model" in Figure 3 to identify the potential for achieving education affordance. IT as an artifact is seen here with actors and goals, replaced by educators and learners. This model will support the development of more environmentally-adaptable teaching methods and system features, thus improving educational effectiveness and classroom orchestration in any m-learning programs.

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