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**ARTICLE**

# CONNECTING, SWIPING, AND INTEGRATING: MOBILE APPS AFFORDANCES AND INNOVATION ADOPTION IN TEACHER EDUCATION AND PRACTICE[I]

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**ABSTRACT:** Despite society's adoption of mobile devices, we have yet to learn whether teachers perceive these artifacts as an innovation and what their potential is for teacher development and practice. This study aims to answer the following questions: what does mobile application affordances teachers perceive for their professional development and practice? What do these affordances reveal concerning Rogers (2003) innovation attributes, namely: relative advantage, compatibility, complexity, trialability, and observability? The analysis of eleven teachers' narratives indicates that teachers do perceive the affordances of their devices for professional development. As for instruction, these teachers report that lack of school equipment and the need for a curriculum that includes the use of emergent technologies may indicate a low degree of compatibility, an attribute concerning a social system's values. The reported affordances indicate the need for a new value system if the adoption of mobile learning is to take place in formal education.
**Keywords:** Mobile apps. Teacher development. Teacher instruction. Adoption of innovation. affordances.

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CONECTANDO, ARRASTANDO E INTEGRANDO: AFFORDANCES DE APLICATIVOS MÓVEIS E ADOÇÃO DA INOVAÇÃO NO CONTEXTO DE FORMAÇÃO E PRÁTICA DO PROFESSOR

**RESUMO:** Apesar da adoção dos dispositivos móveis na sociedade, ainda temos a aprender sobre a percepção dos professores do potencial desses artefatos como inovação para seu desenvolvimento profissional e prática. Este estudo visa responder estas questões: que propiciamentos dos aplicativos móveis os professores percebem para seu desenvolvimento profissional e prática? O que esses propiciamentos revelam sobre os atributos em Rogers (2003), a saber: vantagem relativa, compatibilidade, complexidade, testabilidade e observabilidade? A análise das narrativas de onze professores indica que estes percebem os propiciamentos de seus dispositivos móveis para seu desenvolvimento profissional. Sobre a instrução, eles relatam que a falta de equipamentos nas escolas e a necessidade de um currículo que inclua o uso de tecnologias emergentes podem indicar um baixo grau de compatibilidade, atributo relacionado a valores do sistema social. Os propiciamentos relatados apontam a necessidade de um novo sistema de valores se quisermos adotar a aprendizagem móvel na educação formal.
**Palavras chave:** Aplicativos móveis. Formação de professor. Prática de sala de aula. Adoção da inovação. Propiciamentos.

## INTRODUCTION

Mobile devices have unquestionably changed how we communicate. Most people were first drawn to cell phones because of practicality and time saving, enabling them to receive and make calls anytime anywhere. Newer generations of these devices continue to provide individuals with access to information and connectivity at an unparalleled rate.

The advancements in mobile technologies and the amazing number of apps developed have stirred up a substantial amount of enthusiasm in educators to find ways to incorporate mobile technologies in teacher development as well as possibilities to shift academic environments from traditional approaches to mobile learning (mLearning) instructional strategies (GUNTER; REEVES, 2017).

Despite society's rapid adoption of mobile devices, we have yet to gain an understanding whether teachers, adopters, or potential adopters of these devices, perceive their potential for mediating professional development and classroom practice, i.e., two different ideas or innovations relating to the use of mobile devices.

This study investigates mobile application affordances in these contexts and what these affordances reveal regarding the adoption of innovation in Rogers' (2003) terms. Specifically, the study aims

to answer the following questions: what types of mobile application affordances do teachers perceive for their professional development and instruction? What do these affordances reveal regarding the following perceived attributes of innovation: relative advantage, compatibility, complexity, trialability, and observability? The ensuing discussions will be based on the concept of affordances (GIBSON, 1986) and on the theory of diffusion of innovation (ROGERS, 2003).

## THE DIFFUSION OF INNOVATION

What is diffusion? For Rogers (2003, p. 6), "diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication in that the messages are concerned with new ideas". Rogers emphasizes that "diffusion is a kind of social change, defined as the process by which alteration occurs in the structure and function of a social system. When new ideas are invented, diffused, and are adopted or rejected, leading to certain consequences, social change occurs" (ROGERS, 2003, p. 6). The process of the diffusion of innovations counts on four main elements: innovation, communication channels, time, and the social system.

### INNOVATION

Rogers defines an innovation as "[…] an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (ROGERS, 2003, p. 12). If an idea should strike an individual as new, it could to be considered an innovation regardless of when the idea was first introduced. He further adds that "[t]he perceived newness of the idea for the individual determines his or her reaction to it". For Rogers, "[n]ewness in an innovation need not just involve new knowledge. Someone may have known about an innovation for some time but not yet developed a favorable or unfavorable attitude toward it, nor have adopted or rejected it" (ROGERS, 2003, p. 12). According to Rogers, some innovations take longer than others to be adopted. It took cell phones, for instance, but a few years to reach widespread adoption in the U.S. It took decades, however, for seat belts to catch on. In his research, Rogers proposes the following characteristics to help explain the course of adoption of an innovation: *relative advantage*, *compatibility*, *complexity*, *trialability*, and *observability*.

For Rogers (2003), *relative advantage* entails perceiving an innovation as better than the thing it replaces. In Rogers' terms, this may be determined by components such as social-prestige factors, convenience, and satisfaction and measured by economic terms. The bottom line: for an innovation to be adopted, it must be perceived as advantageous.

*Compatibility* is "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters" (ROGERS, 2003, p. 15). If an innovation is not compatible with a society's values and norms, it will take long to be adopted (if at all). A new value system would need to be embraced for the innovation to spread. One example is the use of contraceptive devices in countries where religious beliefs discourage birth control.

*Complexity* refers to people's perception of whether an innovation is as easy or difficult to understand and use. In general, easier-to-understand ideas will catch on more quickly than those that call for developing new skills.

*Trialability* refers to the possibility of experimenting an innovation on a limited basis. A trialable innovation represents less uncertainty to individuals considering using and possibly adopting it, as they can learn by doing.

*Observability* is the extent to which others can see an innovation's results and benefits. "The easier it is for individuals to see the results of an innovation, the more likely they are to adopt" (ROGERS, 2003, p. 16). This can be easily understood through Rogers' example of solar water-heating adoption in some neighborhood clusters in California. By seeing the innovation in place, neighbors become intrigued by it and ask for evaluation information about it.

For Rogers (2003), innovations that pass the test of relative advantage, compatibility, trialability, observability, and less complexity, will be more quickly adopted. These may not be the only qualities affecting rates of adoption. Past research, however, indicates these are the most important ones in explaining adoption rates.

## COMMUNICATION CHANNELS

Rogers (2003, p. 18) defines communication as "the process by which participants create and share information with one another in order to reach a mutual understanding". The researcher adds "a communication channel is the means by which messages get from one individual to another." For him, "diffusion is a type of communication channel in which the information that is exchanged is concerned with new ideas". These communication channels consist of the media (TV, newspapers, the Internet) and network structures.

### A SOCIAL SYSTEM

Rogers (2003, p. 23) explains that "a social system is defined as a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal. A social system's members or units may be individuals, informal groups, organizations, and/or subsystems". For instance, they may consist of the peasants in a village, a high school's faculty, doctors in a hospital, or a group of consumers. All members cooperate to solve a common problem and reach a mutual goal.

### TIME

Time may be understood here as the chain of events that unfold as soon as an individual learns of an innovation. Rogers (2003, p. 21) states that knowledge is followed by persuasion, decision, implementation, and confirmation: it takes time to learn of an innovation and form an attitude toward it. From then on, an individual must decide whether to adopt or reject it. If adopted, the innovation must then be implemented, which will eventually lead to confirmation or discontinuance of the adoption.

## THE CONCEPT OF AFFORDANCE

With roots in ecology, the concept of affordance, as set forth by Gibson (1986), refers to the relationship established between the agent (in our case, human beings) and other elements situated in a given ecosystem. The fact that individuals are situated in a given context implies that they relate to their surroundings, that is, to other individuals or to existing elements present in that environment. The individual can see potential significance in whatever surrounds him/her. And this perception allows him/her to capture the affordances and the possibilities to act on that perception for action. Put quite simply, that an object can be used for one purpose does not mean it cannot be used in other ways. For example, Gibson (1986) points out that a stone can double as a projectile and does not mean that it may not be used as paperweight, book support, hammer, and so on.

The concept of affordance has been used in several academic areas as a cornerstone for new discussions that have broadened its original meaning. Starting with the complexity of the notion of perception, Norman (2004), a product design researcher, defends that "perceived affordances" specify a set of possible activities, though these affordances are of little relevance if they are not visible

to the user. Norman (2004, 1999) claims that it is the designer's job to ensure that relevant and desired actions are perceptible to the user.

Norman's discussions (1999, 2004), albeit from a product design standpoint, contribute toward branching out this concept to several other areas, especially if we consider that, like Gibson's (1986), his discussions underscore the relevance of the agent's perception.

Norman's and Gibson's discussions influenced Al Ibrahim (2014), for whom 'the environment, if it is designed (not natural e.g. rock or tree), has intended affordances.". He also points out that "[h]ow the actor will interpret the properties of the environment is based on her/his past knowledge, needs and experiences which vary from one actor to another." (p.74)

Taking account of Norman's (1999) conceptual refinement, van Lier (2004) distinguishes between objects with natural affordances and those with sociocultural affordance. van Lier (2004) argues that just as the chairs, hammer tools, doorbell and other artifacts were created with specific purposes in mind, contained in their designs, they carry with them historical-sociocultural information from when they were created. In this way, van Lier (2004) differentiates objects with natural affordances from objects with socio-cultural affordances because the latter signal affordances in a special manner that is especially obvious to humans. However, this researcher emphasizes that the environment is full of potential significances and that interaction with the object, with natural or socio-cultural affordances, can feed perception and activity, carrying significances – new affordances, signs and activities – as well as a differentiated perception. For van Lier (2004), the agent possesses skills, capacity, aptitude, etc. that can lead to differentiated perceptions.

Both Al Ibrahim (2014) and van Lier seem to agree that the agent can perceive the intended affordance of a cultural artifact and act upon it for its original purpose or perceive new and differentiated affordances.

Braga (2017) points out that smartphones, tablets, and their native applications, for example, hotspot, camera with audio and video, speakers, microphone, etc., are socially constructed artifacts whose original affordances are evident to some users; particularly, the 'tech-comfy', a term coined by Pegrum (2014) to refer to individuals who easily acquaint themselves with the use of technology. Braga shares van Lier's (2004) thoughts that the agent's skills, capacity, aptitude, etc., can lead to differentiated perceptions. We agree with Braga's (2017) opinion that familiarization with mobile applications may favor the emergence of affordances and the acknowledgement that the environment is full of potential significances. However,

this familiarization does not ensure that these users will capture affordances and act toward learning in educational contexts.

Braga, Gomes Jr, and Martins (2017), based on discussions by Burden and Atkinson (2008) and McLoughlin and Lee (2007), consider pedagogical affordances the appropriations of technological tools by educators for pedagogical purposes. These researchers likewise hypothesize that the affordances of the technological tools are not predefined in their particular functionality. Thus, the pedagogical use of the tool or application is not defined by its specific design (BURDEN e ATKINSON, 2008). In this perspective, the authors point out "the possibilities of use for a certain functionality of the tool may not be obvious or apparent and, in some cases, the pedagogical affordances only arise in specific conditions and contexts." (p. 57).

Braga, Gomes Jr, and Martins (2017) discuss the pedagogical affordances that emerged during a course for English teachers, via WhatsApp, on the use of mobile devices and application. In their findings, the most recurrent affordances refer to the use of audio materials produced during the interactions via WhatsApp to develop the oral skills of the teachers themselves. While reflecting on pedagogical affordances for improving their students oral skills, the teachers used voice recording functionalities during the course to improve their own pronunciation based on their peers' productions, to develop their oral comprehension in English, to use authentic language, to mention a few affordances.

It is worth pointing out that pedagogical affordances tend to emerge in situated educational contexts and from contextual demands. In this respect, we corroborate the opinion of Young, Toman, DePalma, and Znamenskaia (2000) that the emergence of these affordances in educational contexts can arise out of interactions and "by guidance from a relative expert, working on a shared task, toward a shared goal" (p. 300), especially in continued education initiatives that emphasize learning by doing. As such, the relationships that the agents (be they learners or teachers) establish with mobile resources can lead to differentiated affordances, as they are influenced by the situated context, as is the case with teacher training, development and instruction.

## MOBILE LEARNING

Mobile devices enable flexible and 'on-the-go' learning experiences and are capable of supporting new teaching and learning alternatives in both formal and informal learning contexts. The

deployment of different teaching and learning resources while we move in different places, and at any time is not particularly innovative since we already use different mobile technologies such as games, toys, books, and notebooks in a similar manner. However, as Saccol, Schlemmer and Barbosa (2011) point out, the diffusion of mobility through Mobile Wireless Information and Communication Technology (MWICT) enables us to remain connected through wireless networks at any time and place. Apart from this mobility, we can avail of computer network connections to choose the resources that we deem most appropriate at any time.

Mobility, associated with mobile devices and with their affordances, becomes one of the key elements of mobile learning. Mobility as a focal issue in the most recent literature (WOODILL, 2011; PEGRUM, 2014) takes account of not only the learner but also the learning, in addition to the devices.

As Pegrum (2014) points out, in dealing with mobility from the m-learning perspective, it is vital to differentiate what is portable from what is mobile. Pegrum (2014, p. 5), inspired by Puentedura (2012), distinguishes the two concepts: "portable devices are normally used in Point A, closed down, and opened up again in point B, while mobile devices may be used at Point A, Point B and everywhere in between, without stopping.".

For Pegrum (2014), mobile learning allows for three levels of mobility. First level mobile devices can be used to gain access to the Internet, download applications, create content, share resources with colleagues, and participate in learning communities. At this level, "the learner typically moves little, if at all during the learning experience, which takes place in one or two fixed and largely unchanging locations" (p. 16). In these types of educational situations, mobility is little explored if we consider that the devices are treated as portable more than mobile, as per Puentedura (2012). Regarding the second level, educational activities require greater mobility, which in turn requires students to collaborate and work in pairs or groups and move around. Pegrum (2014, p. 17) points out that "in some scenarios, the learners are mobile, even if the learning experience itself isn't affected by changing locations."

At the third level, learners or students can directly seek out the necessary resources in different contexts and integrate them into their learning process through different sources, such as online peers, teachers, and resources among others. This perspective involving the device, the student, and the learning conveys the mobile character Web 2.0 resources, as learners in situated learning events can capture, (re)organize and (re)produce content generated by themselves and

shared in a network with others who jointly or individually will (re) use them as learning materials. The mobility of devices, students and learning may be aligned with the approaches that integrate the real situated context and the learning, enabling "movements across communities that promote not only locally embedded but locally informed learning" (PEGRUM, 2014, p. 9).

Some specific features of m-learning found in the literature indicate that this modality of learning is paradoxically individual and social (KUKULSKA-HULME, 2013; PEGRUM, 2014; TRAXLER, 2009), just-in-time and bite-sized (PEGRUM, 2014). This type of learning empowers individuals, who become agents and co-designers of their own learning (PEGRUM, 2014) and can be personalized, situated, formal or informal (HOLDEN et al., 2015; KUKULSKA-HULME, 2013). In this paper, we have used Crompton's (2013) definition, as it includes the four central tenets of m-learning. Crompton (2013, p. 4) define mobile learning as "learning across multiple contexts, though social and content interactions, using personal electronic devices".

Several initiatives have contributed to diffuse mobile technology in the educational context. In North America, the Ecosystems Mobile Outdoor Blended Immersion Learning Environment (EcoMOBILE) program enables high school students to use their devices to explore the surrounding areas of certain ponds. In South Africa, the Dr. Math project offers tutoring to assist high school students with their math homework. In language learning, studies by Holden and Sykes (2013), Levy and Kennedy (2005), Thorton, and Houser (2002, 2003, 2005) demonstrate that mobile learning can promote language skills development opportunities. Regarding teacher education, Pegrum (2014) presents the 'iPad for Access' project, a Brazilian initiative by the Casa Thomas Jefferson and the United States Department of State. In addition to facilitating the learning of English and the digital literacy of low-income students, this project promoted the training of 250 teachers who now use their own smartphones and tablets to integrate mobile technology in the context of language learning. Apart from the development of digital literacy, the teachers who participated in the 'iPad for Access' project experimented with student-centered educational approaches, paving the way for the integration of mobile media into their future practices.

If, on the one hand, growth can be seen in studies geared toward the potential of mobile learning in several classroom contexts, studies from the perspective of teacher education are still at an early stage. Studies by Crompton (2013) and Hwang and Tsai (2010), among

other works in the area, indicate that the role of mobile learning in teacher training and practice needs to be better investigated, as results could underpin new initiatives, whether through individual or institutional projects, as well as for more comprehensive future initiatives involving the allocation of public or private funds.

The use of mobile technology has become the core of both global and local public policies. This is the case of the United Nations Educational, Scientific, and Cultural Organization (UNESCO),[1] which launched guidelines for the integration of mobile devices in education and whose core aims include: the consolidation of literacy among youth and adults to provide support for their digital literacy and reading opportunities, as well as the enhancement of the quality of education as regards support for teachers and their professional development. One of the great benefits of mobile learning identified by UNESCO (2014) is to ensure that learning inside and outside the classroom is mutually supportive. As such, teachers could, for example, employ the resources available on their mobile devices to interact with communities made up of work colleagues and study partners; watch and attend lectures; or search for new alternatives for their classes at any time and place.

The diffusion of innovation, represented here by the explosion and continuous evolution of mobile devices in our society, does not necessarily determine the innovation. The innovation will actually be determined by the use and meaning that we make of the technology. In the case of this study, the manner in which the teachers perceive the affordances of mobile media could indicate the adoption of this innovation.

## THE STUDY

This study, which conforms to the methodological and ethical issues of scientific research in the human sciences, relied on the participation of eleven graduate students enrolled in an instructional design and technology master's program in a large and renowned university in southeastern United States. These students are also in-service teachers[2] in different schools and areas, some of whom work with students with special needs and gifted students. The program focuses on the integration of technology into the curriculum through the design, delivery, and evaluation of technology into the content specific curricula. These programs prepare teachers to build their skills in the use of various technology solutions and then create ways to integrate technology into their classroom.

This study used a qualitative methodology and the data analysis is interpretive. The data was based on reflective narratives following these guiding questions: 1) Do you use handheld technologies to support your professional learning? If so, describe/ explain how you use them. Do you use tablets and smartphones in your teaching practice? If so, describe your best integration ideas and strategies when using them, including the apps you used.

With those questions in mind, this paper presents the findings and discussions of this study based on the theoretical considerations regarding mobile learning, affordances and the theory of the diffusion of innovation presented in the preceding sections.

## FINDINGS AND DISCUSSION

The research participants considered themselves to be familiar with mobile devices. Expressions like "The ability to access online professional development and learning tools from nearly any location is very liberating"; "A lot of students in my situation also have full-time jobs, so utilizing apps available away from home is definite a benefit", and "Through my mobile phone, I can use the internet to save a great deal of time and effort" are recurrent in the narratives of these teachers and show that many of them already use these devices in their practices.

Reviewing the participants' narratives enables us to determine that they perceived the affordances endowed by mobile devices and applications to improve their continuing education. The connectivity of mobile devices was one of the perceived affordances. This perception led each participant to act upon it. The following excerpts point out different ways in which connectivity can be appropriated to develop academic activities:

> My professional learning is supported in part by handheld technologies such as smart phones and tablets. […] I use these tools to improve my educational experience in several ways. For example, […] The [Institution] mobile app is a virtual dashboard to university-related information including campus events, maps, academics, Knights mail, and Webcourses.
>
> 1) I use the mobile apps […] to check e-mail, access all of my course materials and communication, access library materials and stay informed about events occurring at [Institution], such as career fairs, student exhibits, theater events, etc.
>
> 2) I check my school emails on a regular basis to stay updated with my teachers and peers.
>
> 3) I have found that these devices truly reflect the name "mobile" as I have used them a number of times to check my discussion postings, my assignment due dates, or simply to check on a grade.

The use of browsers and Internet connectivity to gain immediate access to university platforms to access academic activities are recurrent themes in the narratives. Teachers observed the potential of connectivity to capture its affordances. The use of the mobile apps to check maps and events, school emails, library course materials, career fairs, student exhibits, etc. demonstrate the perception-action relationship concerning the use of connectivity of mobile devices. The ability to have anytime and on-the-go connectivity allows students to stay updated, enabling greater academic engagement.

We dare say that the "perceived affordances" in Norman's perspective – connectivity, mobility of the device and applications – may have contributed to the emergence of new affordances and actions regarding the teachers' professional development. Thus, these affordances in the design of mobile applications play an important role in contexts in which learning is mediated by technology.

Another affordance endowed by search applications is the possibility of tagging sites of interest and downloading apps, as shown in the following excerpts:

> 1) The most basic, everyday tool that I use is Google/Google Chrome. I love that the browser saves my bookmarks and preferences across all of my devices. This makes connectivity so much easier.
>
> 2) I've downloaded the Canvas App on my iPhone. Through this app, I am able to receive messages from my professor and teammates. I am also able to check my assignments and even access modules to read.

In addition to site tagging and app downloading, mobile devices allow website synchronization and storage for future access. Apart from storage, this affordance generates the possibility for future actions, such as 'recalling' and 'content sharing' as shown in the quotations below:

> 1) The cooperative search between Chrome and Diigo makes it possible to easily recall and share content, including the items you had forgotten you had saved!
>
> 2) I like to use this app [Readability] to save general interest articles from the Web so I can read them later. The interface is very clean and makes reading Web articles or blog posts on my iPhone or iPad very easy. I can also tag the articles for easier retrieval later.
>
> 3) It is hard to remember teaching without access to mobile technology! Although I do not use them regularly during daily instruction, my iPhone and iPad are with me throughout the day. I do, however, use both regularly to stay connected to the world outside my classroom, and have found both to be versatile tools for professional development.
>
> 4) When I find an article that I believe will be useful in the future or is one that I want to share with my colleagues, I send it to my Evernote account.

> 5) My smartphone is my primary mobile learning device because I take it everywhere and use it to increase my access to information and my participation in personal learning communities.

In addition to perceiving affordances to access information such as library materials, career fairs, texts, etc., the teachers recognize that connectivity allows the storage of resources through social bookmarkers (Diigo)[3] and notetaking apps (Evernote),[4] Google tools (Docs, Slides, etc.) for future consultation. Other perceived affordances include sharing resources, collaborating among peers, and participating in communities of practice as is the case of teachers using apps to connect to the world outside the classroom and share resources and content with colleagues and students.

The activities that the teachers describe indicate the presence of an adoption-of-innovation process in the context of professional development. If at first smartphones and tablets are used for phone calls and for social everyday interactions, expressions like: "I use these tools to improve my educational experience in several ways" and "It is hard to remember teaching without access to mobile technology". These comments seem to indicate that a mobile device can provide advantages other than those relating to its original purpose.

Thus, as users, teachers point out several advantages to using mobile devices from their perception of connectivity-related affordances. For example: typical affordances of those devices such as portability and ease of use, mobility, accessibility anytime and anyplace are also seen as advantages by this social group. The examples below illustrate these points:

> 1) Having 24/7 access to class content, announcements, grades, etc. from any device is very useful.
>
> 2) Advantages of mobile learning include convenience, ease-of-use, accessibility, professional networking, and exposure to resources not otherwise available.
>
> 3) Time saving professional development and lesson plan ideas are readily available online.
>
> 4) I need an easy-to-carry, lightweight device that serves some functions of a laptop, but also has the apps I enjoy.
>
> 5) I enjoy the experience of reading textbooks on a tablet. It is easy to access chapters from the Table of Contents in an e-book. Bookmarks or highlighting provide additional benefits in digital form.

In addition to *relative advantage*, other characteristics of an adoption-of-innovation process can be found in these excerpts from teachers' narratives. The fact that mobile devices are part of the

research participants' day-to-day school / work activities strongly indicates that these devices are compatible with the values of this social group. Teachers demonstrate in their quotes that they view mobile devices as convenient and easy to use and carry around. In other words, as Rogers (2003) puts it, they possess the attributes of innovation: compatibility and complexity.

Regarding other mobile apps, the teachers use social networks and social media for professional development via mobile devices, as the following excerpts demonstrate:

> 1) It was with a bit of reluctance that I explored YouTube. In my mind it was, at best, a site for unflattering home videos and, at worst, a site for raunchy ones. I must admit I am a YouTube convert! Whenever I need something explained and know that visual instructions will be more helpful than written instructions, I head to YouTube. I love that you can search for videos and read viewer feedback before you even watch the video.

> 2) The main advantage of using my smartphone for professional learning is that I am able to select topics or individuals that I am interested in listening to or learning from and I can access learning opportunities on demand, from anywhere. When I am at work or at school all day I don't have time to read professional articles, or I feel guilty taking the time to read when there are other "hands-on" tasks that I have to get done. Being able to listen to podcasts after school while I am preparing my classroom for the next day, or while I am driving home, or running after work allows me to stay current with professional knowledge without the need to devote my time solely to reading. When I do have some extra time to read -- if I am waiting for an appointment, for example -- I like having my reading instantly available and ready on my smartphone. Having current information "pushed" to me through subscription services is also very helpful because I don't have to go out and search for the information.

Capturing resources for teacher development through audio and video is another affordance the teachers perceived. It is worth pointing out that these teachers also perceive the potential of mobility and appropriate it to develop activities on the go: "while I am driving home", "if I am waiting for an appointment", etc., besides relying on peer feedback for problem solving in social networks like YouTube. This appropriation, in addition to showing relative advantage of mobility used for educational purposes, may serve as an opportunity to experience innovation. As Rogers (2003) claims, *Trialability* refers to opportunities of experiencing a given innovation, which can take place through formal education or peer interaction in an informal manner.

If in the 1990s "the use of cell phones in automobiles, restaurants and public places helped emphasize their conferral of status on potential buyers", making them highly observable in our society (ROGERS, 2003, p. 265), nowadays, smartphones and tablets

can be seen in quite a few contexts in which teacher development is taking place. The teachers' narratives show not only the affordances of mobile devices for their professional development, but also how these devices are used as mediators for peer interactions and for participation in learning communities. This movement from the individual to the collective makes the innovation highly observable and points to a certain degree of *observability*. Thus, the following attributes found in the narratives on teacher development via mobile devices: *relative advantage*, *compatibility*, *complexity*, *trialability*, and *observability* seem to be strong indicators that the process of adoption of this innovation is in course and gaining ground among teachers.

As for the affordances perceived for instruction, one type of action that emerged from these affordances is the use of mobile applications for classroom management. Some of these apps have been used for notifying students' behavior in class, in addition to reminding students of homework and assessments while keeping parents informed of assigned activities as shown in the following excerpts:

> 1) In my teaching practice, I use my smart phone and tablet, as well. One app that I use regularly is Class Dojo, a classroom management app for student behavior. This app has proven to be very successful and the kids absolutely love hearing the notification that they have received points for good behavior. What I normally do to make it more interesting is that while using my Mimio board to teach the day's concept, I will have Class Dojo open, yet hidden. I use my smart phone to award points for good behavior. The kids have no idea if they are the ones receiving points until the end. But, it certainly is fun watching them all sit up and suddenly become attentive when that sound goes off.
>
> 2) This year I also began using Remind, formerly known as Remind 101, to send out text alerts to students and parents. This one-way tool has proven to be a great way to remind students about homework and upcoming assessments and keep parents in the loop.

The findings indicated that assessing homework is a concern reported in other narratives. To assess students' homework, one of the teacher resorts to a mobile app to give real-time feedback and pinpoint major problems, making correction more efficient by giving special attention to students who struggle and by learning the overall result of the class performance. The following excerpt is a clear illustration of this:

> 1) Over the summer I found a tool called **ASSISTments** and I have begun using it with my students this year. They are able to enter their homework answers into the online site or through the mobile app while they work through the problems. They receive real-time feedback on their answers. In class I am able to view each students overall performance and performance by problem. Additionally, I can identify which problems were missed by a large percentage of students. If the

> program notices a common wrong answer I can see that as well. Homework review is much more efficient because I can address homework problems that the students struggle with rather than the ones they have mastered.

In addition to perceiving the affordances of mobile applications for class management and promoting learning opportunities with feedback, the research participants recognize the potential of these applications to create other types of learning opportunities. Using cameras and other applications to create/record and edit images and create videos are some of the resources the participants have integrated in their classes, as shown in the following examples:

> 1) I also like using my camera on both my smart phone and my iPad for the purpose of a photo editing assignment. I take a picture, send it to my file on the whiteboard, and then upload the picture in iPiccy to demonstrate a fun way to edit pictures.
>
> 2) There are a few applications that I use regularly in my classroom for instructional purposes. LearnZillion and Virtual Nerd both produce math videos for students. They are professionally made and well developed. We watch them in class and I also post them for students to watch at home. LearnZillion has recently begun creating lesson plans to go with the Common Core Standards. The few that I have tried have been engaging, with the right balance of inquiry and direct instruction.

Other tasks regarding the use of applications for creating multimodal texts, planning, organizing sharing ideas, and making the learning experience more interactive are also reported. The following example shows how Mind Maps can be used for organizing and creating ideas as well as for interacting with peers in the classroom and in school:

> 1) Mind Maps give students an outlet for planning, organizing, and creating ideas. The Mind Maps are colorful, full of various shapes and connectors, and are easy to create. This is especially true with the iPad because students can create maps just with the swipe of a finger. The website will give you a one-month free trail before you by it. This application has a wonderful function to help students create, save, edit, and share their own work with others. Students loved that experience, after we were done with the Mind Maps, they printed and pasted their examples on the gifted wall on display for the whole school to see. We then published some of the best Mind Maps in the school newsletter, then had students vote for their favorites.

Although in examples 22, 23, and 24, mobility is underexplored – the devices are treated as portable as opposed to mobile, falling under Pegrum's *when-the-device-is-mobile* category –, the fact that the device is at hand facilitates creating and sharing materials during classroom activities. Another point is that mobile learning is capable of mediating bite-sized activities, like videos for example, which can be accessed anywhere and anytime as shown in example 23.

Other affordances perceived in the narratives lead to the appropriation of applications for interactive tasks. Tools like Padlet, Doceri, Socrative and Kahoot are used for mediating interaction as well as providing individual and collective learning. Evidence of question sharing on the Padlet, student's engagement in problem solving with Doceri, Socrative and Kahoot can be illustrated as follows:

> 1) I have also embedded a **Padlet** wall onto the website so students can post questions.
>
> 2) When I do use my iPad in class I have found that it works very well with an application called **Doceri**. The Doceri app allows me to control my desktop remotely, giving me mobility. The program has a whiteboard feature, so I can write on my iPad and have it project onto the screen. It is also a great way to engage students because you can give them the iPad and let them work out problems. I have also found that students enjoy using their cell phones, tablets and laptops with **Socrative** and **Kahoot**. With both of these apps teachers can create interactive, competitive quizzes that students complete on their mobile device. It is amazing to see how students come alive when they are competing with each other! Kahoot has an extensive bank of teacher created quizzes that are publicly shared. So, you can most certainly find one "on the fly" that would meet your needs.

Notably, one of the research participants seeks out resources in other contexts to inform her classes. By promoting opportunities for her students to become co-designers of pedagogical content, this teacher uses mobility in its full potentiality considering that, in the activity she proposes, the device, the learner, and the learning are mobile. This can be illustrated in the following example:

> 1) I have also had students use digital cameras on their smartphones to record images and video for scavenger hunt activities on college campus visits.

The example illustrates that the environment is full of significances. The excerpt indicates that the teacher not only captures the affordances of the object (designed to take pictures and record videos), perceivable in Norman's perspective, but also acts upon the object's pedagogical possibilities. And in doing so, she proposes activities in which her students became the agents of their own learning. It is worth mentioning that although this teacher was able to perceive and act for pedagogical purposes, not always are the affordances visible, desired or discovered as stated by Gibson.

The evidence of affordances for instructions via mobile device seems to indicate that the research participants perceive mobile learning as advantageous for teaching and learning. Statements like "students in the 21st century how to learn on their own" and "The globe is changing from the industrial to the knowledge world […].

Mobile devices allow students to do their assignments, research, studying and learning at school, home, or wherever they are" are recurrent and point to Rogers' *relative advantage*.

In addition, the research participants report positive learning experiences via mobile devices. In the words of one of the teachers: "I have only begun using mobile devices recently, but it has already changed the way that I teach because I know that we have information and resources available on demand if we need them. This makes for a more flexible and adaptable learning environment for the students". *Trailability* shows less uncertainty for adoption of mobile learning in the context of instruction, as it is possible to learn by doing.

Although it is a consensus among research participants that the advantages of mobile learning far outweigh the disadvantages, these participants perceive affordances that limit their appropriation and actions of mobile devices in class. Lack of connectivity, battery life, parents and school support, and accessing apps that cause distraction during classes are recurrent in the narratives as shown in the following statements:

> 1) Some disadvantages of mobile learning can sometimes be connectivity or battery life.
>
> 2) The main barrier I have faced in integrating mobile learning is the Internet connections at my schools.
>
> 3) For the few students that do not have a mobile device, accessibility away from home is a real issue. Unfortunately, my school does not have a program in place for students to access a mobile device on an as needed basis.
>
> 4) Another concern that I have with mobile technology is that students do not always use it as requested. Instead of participating in the activity, they choose to go to social media sites, Snapchat with their friends or send text messages.
>
> 5) Using the mobile devices can be difficult to use in the classroom because they require parent permission. In Saudi Arabia, using mobile devices and internet (especially with social networking) required the permission of the parents.

Even though teachers do not report any pedagogical difficulties in integrating mobile devices in their teaching practice, and despite positive feedback from students, the limitations reported are viewed as hurdles to the adoption of mobile devices in the context of instruction. These hurdles seem to be related to the macro systems in which the classrooms are nested. Lack of school equipment, the need to ask for parental consent to use mobile devices in school, as mentioned by one of the teachers who is getting ready to teach in her home country, and the need of a curriculum that includes the use of emergent technologies

may be considered indicative of low degree of compatibility. These barriers have been reported in the research as a hindrance for teachers to integrate mobile devices even when they see the values of using them in the learning context (GUNTER; REEVES, 2017). As Rogers (2003) claims, compatibility is one of the pillars of innovation as it is related to a social system's values and the affordances reported by the teachers seem to indicate the need for a new value system if the adoption of mobile learning is to take place in formal educational.

## CONCLUSION

From the narratives gathered, the researchers have found evidence of the teachers' perception of mobile device affordances for professional development. Teachers perceive the potential of functionalities typical of mobile devices, such as connectivity and ubiquity; capture these affordances for actions such as accessing resources online (courses, library materials, etc.). Other actions include informing about events, checking emails, and keeping up to date. Moreover, teachers download apps such as Canvas app,[5] enabling communication with peers and teachers as well as the development of academic tasks, i.e., information and resources that circulate within their learning communities. In addition, they capture the affordances of mobility and carry out all these actions from any location and at any time and place. This, in essence, brings to the fore the flexible nature of these devices and their potential for mediating learning in a seamless manner.

These actions, regarding professional development, reveal that the diffusion of innovation is in progress: mobile apps and devices are seen as tools for mediating learning (relative advantage and trialability), as well as easy to use and convenient (little complexity), and their appropriation renders the adopters' digital literacy visible to the academic community (observability). In this line, the adoption of mobile devices for professional development opens up new communication channels through which learning is individually and collectively constructed. A cyber mobile village emerges as a social system whose members cooperate to accomplish common goals.

As for the adoption of ubiquitous and mobile technologies for classroom instruction, the researchers have found evidence that the teachers recognize that todays' students speak digital, as emphasized by Prensky (2003) and others. They are using and discovering ways to integrate mobile devices into their everyday teaching. Although there is

evidence that teachers are integrating m-learning in their classrooms, by giving students opportunities to access videos and create multimodal texts, the most recurring pattern found in the narratives point to the use of the devices for classroom management such as: giving feedback on students' behavior and checking students' overall performance.

This evidence seems to indicate that the adoption of mobile technologies for classroom instruction is still incipient if one considers the stages of diffusion in Rogers (2003). The appropriation of these devices for learning and mediation is still peripheral, as there is little evidence of tasks by which a student co-authors his/her own learning process. Furthermore, even if recognized by the teachers, the potentialities of mobility have been underexplored, considering that most of the tasks proposed were done inside a classroom and did not involve resources of other situated contexts. The findings of the adoption of innovation for classroom instruction may be impacted by the constraints that several teachers pointed out in using mobile technologies in the schools where they work and in the other systems in which they are nested.

For adoption to take place, there has to be a change in paradigm by both the administration and faculty, considering that the adoption of mobile devices for classroom instruction requires the use of approaches that contemplate the student as an agent of his own learning process. These approaches, coupled with the functionalities of mobile devices, can promote learning opportunities that allow students to choose what, when, and where to learn.

Since this is a qualitative study, the findings are restricted to a group of participants. New qualitative and quantitative investigations are required to carry on discussing the diffusion of innovation regarding the use of mobile technologies in educational settings.

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## NOTAS

[1] http://unesdoc.unesco.org/images/0022/002277/227770por.pdf

[2] As this article is on teacher education and instruction, and the participants are in-service teachers, it refers to them as teachers as opposed to graduate students.

[3] Diigo is a social bookmarking website that allows users to bookmark and tag Web pages. Available at: https://www.diigo.com.

[4] Evernote is an app designed for note taking, organizing, and archiving. Available at: https://evernote.com.

[5] Canvas is a company which provides mobile apps and forms for data collection and sharing.

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