



When Teacher Education Goes Mobile: A Study on Complex Emergence

Quando a formação de professores se torna móvel: um estudo sobre emergência complexa

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ABSTRACT: The popularity of mobile devices brings on new challenges for teacher education. Based on complexity theory, this qualitative study¹ seeks to better understand the dynamics of a social group, especially the conditions for the emergence of learning in a mobile educational experience. Sixty in-service teachers in Brazil participated in a six-week course via WhatsApp. The analysis of the answers to questionnaires and the corpus generated by the teachers' interactions indicate that the devices' mobility favored interactions, control distribution, and social repertoire of possibilities. The findings also indicate that the teachers recognize the potential of mobile technology for mediating learning experiences.

KEYWORDS: mobile learning; whatsapp; teacher education; complexity theory.

RESUMO: A popularidade dos dispositivos móveis traz novos desafios para a formação de professores. Com base na teoria da complexidade, este estudo qualitativo busca compreender melhor as dinâmicas de um grupo social, especialmente as condições para a emergência da aprendizagem em uma experiência educacional móvel. Sessenta professores em serviço no Brasil

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participaram de uma iniciativa de educação continuada via aplicativo WhatsApp por seis semanas. A análise das respostas aos questionários abertos e do corpus gerado pelas interações dos professores indicam que a mobilidade dos dispositivos favoreceram interações, distribuição de controle e o repertório de possibilidades. Os resultados também indicam que os professores reconhecem o potencial da tecnologia móvel para mediação de experiências de aprendizagem.

PALAVRAS-CHAVE: aprendizagem móvel; whatsapp; formação de professores; teoria da complexidade.

Introduction

Literature shows us that existing technologies are not immediately replaced by new ones, but rather coexist and interact with one another for a period of time (BRIGGS; BURKE, 2010). Technologies do not necessarily compete with one another and are oftentimes complementary. What generally occurs is an adaptation, with new media occupying distinct functions and niches.

This is also the case with CALL (computer-assisted language learning) and its sub-area MALL¹ (mobile-assisted language learning). With the advancement and consolidation of CALL, “many new and exciting applications of digital technologies for second and foreign language learning” are on the rise, including mobile devices and applications (SMITH, 2017, p. 1). Although the use of mobile devices may run concurrently with the use of fixed devices, such as desktop computers, “the flexibility that MALL offers to the learner has expanded the possibilities for CALL, and the use of MALL has the potential to exceed that of non-mobile CALL” (CHEN; CARGER; SMITH, 2017, p. 29).

The discussions on mobile technologies have been incorporated into CALL-specific conferences, journals, and books, as opposed to being addressed in isolation. In language teaching, there is a perception that the emergence of new technologies does not imply breaking away from the technologies used thus far, but rather, a continuity or parallel use of these resources, as is the case with fixed devices and mobile devices (PEGRUM, 2014).

Likewise, in incorporating digital technologies and mobile learning,² one does not give up on resources, such as books, computer labs, movies,

² In this paper, MALL and m-learning are used interchangeably.

music, among others, which have been used in the language classroom for years. Instead, different technologies are appropriated, depending on the learner's or the teacher's contextual demand. Inspired in Bauman (2000), it is our understanding that the appropriation of both mobile and fixed technologies is fluidic, as current conditions are highly volatile and ever-changing. In this sense, we share Pegrum's (2014, p. 10) thoughts that "in tandem with a new sense of space and place, a new sense of time is emerging [...]". Digital technologies, especially mobile devices, "allow us to uncouple time both from the biological clock and from the traditional sequencing of events". We understand that the ubiquity and mobility underpinning certain types of digital technologies reflect the fluidity and volatility of liquid modernity as the boundaries of time and space become increasingly thinner. These innovations invite us to reflect upon teacher education as a continuous and complex process, as mere knowledge of technological tools no longer suffices. We, teachers, must be able to adapt not only the tools to our situated context, but also ourselves to constant change.

Studies in CALL teacher education have contributed significantly to discussions on the reality and complexity of integrating technology in language teaching. With the popularity of mobile devices, CALL faces new challenges, mainly those concerning MALL, as we have yet to understand the impact of these devices' mobility and ubiquity on teacher development and practice. In this sense, our discussions will center on the use of mobile digital technologies in teacher education, considering that, despite an expressive number of studies on the use of mobile devices in language learning, discussions on the use of m-learning in the context of teacher education are still lacking.

Based on complexity theory, especially the conditions for the emergence of learning, this qualitative study seeks to better understand the dynamics of a social group. To reach our goals, we (i) look into the presence of the conditions for the complex emergence of knowledge, namely: diversity, redundancy, neighbor interactions, distributed control, and enabling constraints; (ii) the role these conditions play in teacher's education initiatives; and (iii) teachers' perceptions and actions emerging from a mobile educational experience. Qualitative and interpretative methodology provides an in-depth understanding of both conditions and the emergence of knowledge in this social group. We now move on to the theoretical discussions underpinning this study.

1 Complexity and the conditions for complex emergence

In the last three decades, the study of complex systems in physical and social sciences has made it possible to articulate relevant new concepts and methodologies for research in these areas.

In Applied Linguistics, a considerable number of studies have investigated the acquisition of second language as a complex phenomenon (LARSEN-FREEMAN; CAMERON, 2008; ELLIS; LARSEN-FREEMAN, 2009; LARSEN-FREEMAN, 1997; PAIVA, 2005, 2013; VAN LIER, 1996, 2004).

According to van Lier, the language learning context can be viewed as “a complex system in which events do not occur in linear causal fashion, but in which a multitude of forces interact in complex, self-organizing ways, and create changes and patterns that are part predictable and part unpredictable” (VAN LIER, 1996, p. 148).

Davis and Simmt (2003) discuss the contributions of complexity science to understand the mathematics learning and teaching classroom, which is characterized by a complex learning system. According to these authors, complexity science “is concerned with a range of nested learning systems, which include the co-implicated processes of individual sense-making and collective knowledge-generation”, and learning, in this context, “is understood in terms of ongoing, recursively elaborative adaptations through which systems maintain their coherences within their dynamic circumstances” (DAVIS; SIMMT, 2003, p. 142).

These learning systems are constantly influenced by internal or external actions, and their reaction to these changes may trigger a self-organization process. In other words, complex learning systems are usually robust and self-organize in the event of changes. They react to changes so as to seek equilibrium and maintain their coherences.

According to Davis and Sumara (2006), complexity theory has contributed to the understanding of conditions that must be in place to allow the emergence of such expansive possibilities. The authors emphasize that these conditions have been applied, for example, in efforts to re-establish devastated ecologies, within the corporate sector to improve the viability and productivity of various industries, as well as in social learning systems like the classroom. For Davis and Sumara (2006, p. 135), “this knowledge has also been adapted and elaborated by a handful of educational researchers to structure classroom and research collectives.” According to these

authors, the conditions for emergence are: diversity, redundancy, neighbor interactions, distributed control, and enabling constraints (coherence and randomness). In this study, we discuss these reciprocal and interdependent conditions for emergence in learning systems.

Diversity in social groups involves differences and specificities as multiple and interrelated roles and points of view. Individual capacities and characteristics allow the system to respond adequately to different situations. As Davis and Simmt (2003, p. 148) point out, “internal diversity is seen as a source of possible responses to emergent circumstances.” Diversity, therefore, is a fundamental element for the emergence of the system’s collective intelligence. Redundancy involves similar aspects, which are seemingly duplicated, albeit essential to maintain the system’s solidity and consistency. Put quite simply, this term refers to “duplications and excesses of sorts of features that are necessary to particular events” (DAVIS; SIMMT, 2003, p. 150).

Diversity and redundancy are complementary. If on the one hand diversity has to do with the particularities of the elements of the system, contributing to the repertoire of the system, redundancy, on the other hand is used to refer to similarities or sameness among agents that contribute to a system’s capacity to maintain coherence and to the emergence of an intelligent collective. Davis and Simmt (2003, p. 150) argue that, although the term redundancy “tends to be associated with aspects that are unnecessary or superfluous and that contribute to inefficiency”, this term pertains to the qualities that “are utterly necessary, intelligent, collective”. Therefore, redundancy plays two important roles in the system: “[f]irst, it enables interactions among agents. Second, when necessary, it makes it possible for agents to compensate for others’ failings” (p. 150).

A given system’s responses depend greatly on that system’s internal diversity and redundancy, which allow for innovative answers to new circumstances, which is described by Varela, Thompson and Rosch (1991) as intelligent behavior.

In a complex system, the actions of individual agents are capable of affecting others’ actions, defined as interactions between neighbors. Interactions between neighbors involve not only people, but also ideas, questions, and other manners of representation.

According to Davis and Sumara (2006, p. 5), “most of the information within a complex system is exchanged among close neighbors, meaning

that the system's coherence depends mostly on agents' immediate interdependencies, not on centralized control or top-down administration." Neighbor interactions can ensure information exchange and knowledge development within the collective and lead to the emergence of more complex possibilities.

In the educational context, "the notion of decentralized should be interpreted neither as a condemnation of the teacher-centered classroom nor an endorsement of the student-centered classroom" (DAVIS; SIMMT, 2003, p. 152). In this perspective, control is never centered, but rather distributed or shared within the classroom community.

Davis and Sumara (2006, p. 146) argue that the issue "is not whether the condition of distributed control is present in a social collective", but rather "the question is whether or not that condition can be meaningfully brought to bear on the development of concepts and interpretive possibilities." In a complex system, most of the information is exchanged among near neighbors and control is decentralized, arising in localized activities.

Enabling constraints are the structural conditions that determine the balance between coherence (shared intention of a collective) and randomness (unexpected possibilities) in a complex system. Complex systems "are rule-bound, but those rules determine the boundaries of activity, not the limits of possibility" (DAVIS; SIMMT, 2003, p. 154). Some constraints may not only reduce the number of alternatives, but they can simultaneously create new possibilities.

As Davis and Sumara (2006) point out, researchers can rely upon these conditions to understand the classroom or other formal or informal learning systems. Davis (2008), in exploring the possibilities of complex theory in educational research, argues that this area has historically borrowed interpretative "frames" from other domains with a certain degree of adaptation. To that end, in considering complexity theory, we do not simply seek to describe complex phenomena, but, rather, draw on its possibilities and implications for learning through mobile devices and digital applications and for educating teachers in this context.

2 Digital Mobile Technology and Teacher Education

The practices emerging from digital technology are created in a relation of complementarity and co-existence with those already consolidated. Thus,

if laptops and desktops once allowed us to interact with one another from home or from work, mobile devices give us new possibilities for interaction through mobility and ubiquity. They may also serve as a bridge between formal and informal learning environments, in addition to enabling situated learning opportunities that combine localities, times, technologies, or social scenarios (KUKULSKA-HULME, 2013; NICHOLAS; NG, 2015).

Mobile devices can be used for quite a few things, including gaining access to the internet, downloading applications, creating content, and sharing resources, to name a few. However, the affordances of mobile devices give learners and teachers “considerable reach and power” (PEGRUM, 2014, p. 15), as they allow the devices to be used on the move either in school, facilitating the formation of groups, with students walking around the classroom or school, or in multiple situated contexts outside the school.

According to the UNESCO’s *Policy Guidelines for Mobile Learning* (2013), “today mobile technologies are often common even in areas where schools, books and computers are scarce” (UNESCO, 2013, p. 10). As mobile phones become more affordable, more people, especially those in impoverished areas, are likely to own and use them. A number of projects have shown that mobile technologies provide educational opportunities for learners. However, “to capitalize on the advantages of mobile technologies, teachers need to be trained to successfully incorporate them into pedagogical practice” (UNESCO, 2013, p. 31). UNESCO’s guidelines add that the pedagogical use of mobile learning requires quality teacher-education as teachers will have to rethink their roles.

We agree with Kukulska-Hulme (2009, p. 158) that teacher education “is not determined by technology. Neither is technology likely to be a determining factor in the context of teacher development and practice.” The author, quoting Beetham and Sharpe (2007, p. 6), emphasizes that if we are to consider technology a social and cultural phenomenon, it “cannot but influence the ways in which people learn, and therefore what makes for effective learning and effective pedagogy.”

Kukulska-Hulme (2015, p. 281) claims that language learning is one of the areas that have benefitted the most from mobile learning most of the time. According to the researcher, one of the reasons is “the nature of language learning content which largely lends itself to being divided up into portions that are suitable for access on mobile devices”. The author, quoting

Kenning (2007), highlighted that mobile technologies support opportunities for situated language learning in real-world settings. The language-learning issues that Kukulska-Hulme (2015) points out may equally well be used for teacher education, considering that teachers do not need to depend on school permission, laboratories, and face-to-face meetings for their continuing education. These days, with digital technologies, they can shift away from fixed places and times, and seek resources in different manners of continuing education, whether individually or collectively.

Almeida and Araújo Jr. (2013), Baran (2014), Crompton (2013), Pegrum, Huwitt and Striepe (2013), Santos Costa (2013), and Royle Stager and Traxler (2014) underscore the need to develop studies on teacher education through mobile digital technologies, emphasizing that the role of teacher education requires further investigation. Likewise, they emphasized that this could be used as the basis for future initiatives, local or otherwise, involving the allocation of public or private resources.

In this study, we turn our attention to the emerging dynamics and events during the interactions within the groups through the lens of complexity.

3 Method

This work fits into the molds of the qualitative paradigm chosen to better understand the experiences on the use of mobile devices in a continuing education initiative. According to Denzin and Lincoln (2006), qualitative research seeks to understand the phenomenon based on the significances conferred on it. It attempts to understand the emerging patterns in a teacher education initiative using mobile technology (*Whats.App*), to interpret and make sense of the richness of teachers' experiences in this context, as well as to understand the way they interact in this context. It is our understanding that the discussions on the conditions of complex emergence in Davis and Sumara (2006) are useful in explaining observed actions and events of teachers' continuing education initiatives in a qualitative and interpretive manner.

3.1 Teacher continuing education project via WhatsApp application

This research was conducted during a continuing education project, Taba Eletrônica,³ focusing on digital mobility, mediated by a mobile technology application called WhatsApp. This application is mainly used in mobile devices, but it can also be accessed in personal computers through WhatsApp web (WHATSAPP, 2018). WhatsApp joins a number of features, including text and voice messaging; the sending of photos, videos, and pdf files; in addition to voice and video calls. Internet access to the application is free (mobile connection or Wi-Fi, according to availability), and the potential to mediate communications has made it quite popular in Brazil. It should be emphasized that to use the WhatsApp Web or the WhatsApp Desktop, the user must keep the cell phone turned on as the application for the computer is only an extension that mirrors the messages and conversations of the user's cell phone. It simply extends the functions of messaging services from cell phones to computers. Teachers learned to appropriate this tool's features to create multimodal materials, and interact through written messages, and through WhatsApp voice recording, in addition to sharing resources, to name but a few of the features.

After the team responsible for the project posted a call on Facebook, teachers from all over the country signed up to take part in the six-week course in 2016 on the use of mobile devices in the language classroom.

The tasks in this project relied on the following pillars: (i) familiarization with different mobile applications – WhatsApp functions (location, audio, text message, etc.) – and recognition of genres circulating in mobile platforms, such as selfies, braggies,⁴ and memes; (ii) material development based on the features of mobile devices, such as cameras, GPS, among others; and (iii) discussions on approaches that may be incorporated to m-learning. Participants were requested to interact only in English during the course.

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³ Taba Eletrônica is a teacher education project from the School of Letters of The Federal University of Minas Gerais, coordinated by the first author of this paper.

⁴ Braggies: A 'braggie' is an image posted to social networks designed purely to show off.

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3.2 Participants

Sixty in-service teachers from urban and rural areas from different states of Brazil took part in this continuing education initiative via *WhatsApp*. The teachers worked in different education levels (K-12), with the majority of them (71.4%) working in high schools. Some of the teachers worked in private schools, but the majority (74.6%) worked in the public school network. The majority had Wi-Fi access at home (97.3%) and at work (90.4%), or, when necessary, searched for Wi-Fi networks when they were in public places (74%). All of the teachers had smartphones and used the *Whatsapp* application, especially to communicate with friends, family, and workmates.

Participants were divided into two groups: 1A and 1B, by order of registration, and were given the same treatment: the same mediators, tasks, and length of continuing education. This division had two purposes: it served to facilitate mediation and allay educators' fears that the vast number of messages generated via WhatsApp could create difficulties for some of the teachers to keep up with the interactions.

3.3 Data collection and analysis

Data was based on the interactions generated during the course, and screen captures of these interactions were taken and saved by the researchers for data analysis. We preserved the area code for each post to illustrate the variety of places, for example, + 55 86, + 55 31, + 55 91, etc. The interactions that occurred during this course were used to identify the conditions of complex emergence during the course and to discuss the patterns that emerged from these interactions. Two open-ended questionnaires were also used. The first one aimed to gather some demographic data on the participants, particularly their profile and familiarity with the *WhatsApp* application. This questionnaire was also used to learn whether or not the participants used their mobile devices to develop

their professional skills prior to the course. The final questionnaire aimed to understand the participants' perceptions regarding the integration of the mobile devices and applications for promoting learning opportunities in the language classroom. Data analysis was developed from complex-emergence conditions, as proposed by Davis and Sumara (2006), to better understand the events from the participants' experiences and perceptions.

4 Findings and Discussion

Quite a few discussions on mobile learning revolve around the social and educational impact of this new type of teaching and learning. However, as Pegrum (2014) reminds us, the affordability of mobile devices cannot be overlooked, considering that they precede the affordances of these devices. The more affordable the devices are, the faster they will spread throughout the population and allow education initiatives to take place. In this sense, the new generations of smartphones with their native applications (browser, camera, GPS, etc.) and free applications, such as *WhatsApp*, have favored the dynamics of communication, sharing, and collaboration.

In these groups, made up of teachers who voluntarily signed up for the project, we were able to notice evidence of the pervasion of smartphones in society. The appropriation of these mobile digital devices has enabled the formation of groups whose interactions are only possible because of these devices' ubiquity and mobility. In this context, where technological innovations have sped up the pace of social changes, one can clearly notice language teachers' desire to seek continuing education and rethink their role as educators. Evidence of the appropriation of mobile technologies for professional teacher development was also found in the answers to the first questionnaire, when teachers were asked whether or not they used their smartphones for teacher development. Out of the sixty participants, only five informed that they did not use this application to that effect. The answers indicated that teachers searched for texts that were of interest to their education, saved and shared resources with their colleagues, researched materials for classroom use, read news in English, among other things.

Teachers also reported that they appropriated the computer, whether because of its convenience or because of constraints related to their mobile devices. The following examples illustrate these points:

I use my home computer for work. I only use the smart phone when I'm out of the house. I don't like to read on the small screen. I only use it for work if I have no other choice.

For professional purposes, I still basically use the computer. The cell phone is more frequently used for personal and professional phone calls and text messages.

Sometimes I [use mobile devices] in emergencies if I can't have access to a computer. But I always prefer a computer for that.

Although the teacher education program's focus was on integrating mobile devices, the fluidity of mobile or fixed technologies, depending on their affordances for a given task, runs in line with the discussions in Briggs and Burke (2010), which point out that technologies coexist and may be used complementarily depending on their users' needs and convenience.

4.1 Diversity and Redundancy

Diversity is present in the interactions in the course as teachers shared their varied experiences based on their contexts from around the country. That, in essence, ensured the system's intelligence; i.e.: its diversity in expanding the possible responses of the collective unit. Diversity can also be found in the answers to the questionnaire for both groups 1A and 1B. The work developed by teachers at different teaching levels (elementary/middle/high school, language institutes, colleges/universities) constitutes one of the elements of diversity.

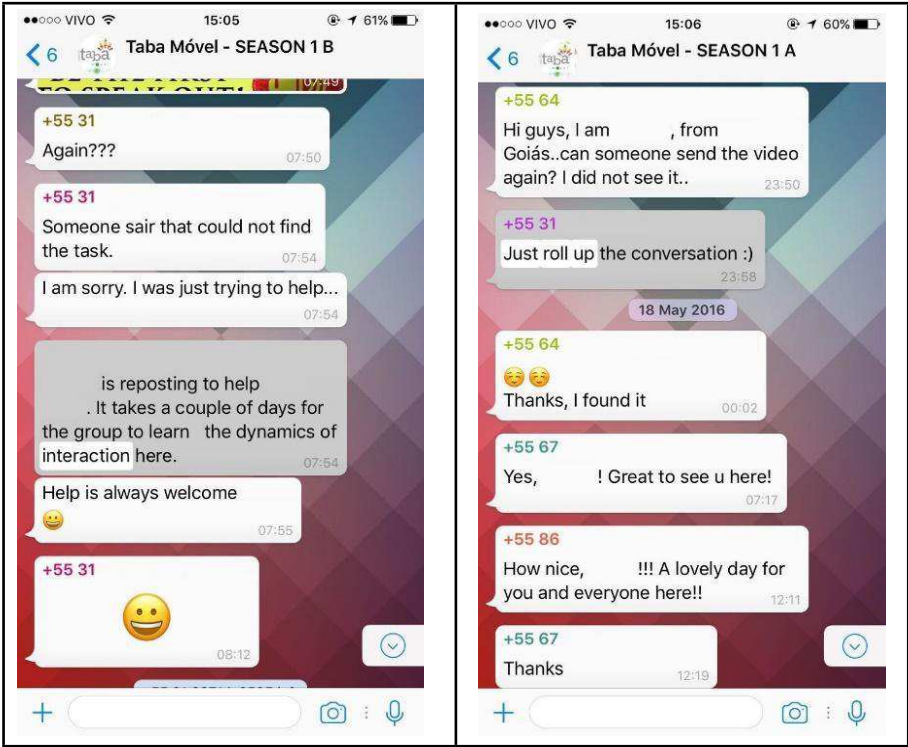
As for the commonalities, **redundancy**, the teachers' answers to the first questionnaire demonstrate that they are familiar with the use of *Whats.App* (100% of the answers), and they use Wi-Fi at home (97.3% of the answers). In addition, they say they can browse the Internet, write messages, send and share text and images, silence groups, clear conversations, among other things.

The appropriation of these features and the perception of their affordances have enabled the collective construction of knowledge and the emergence of the group unit. Participants' proficiency in English and education also configured in elements of system redundancy by allowing interaction among the agents. In addition to allowing interaction, redundancy allows the system to evolve by making it possible for agents to compensate

for others' failings. Thus, the fact that many teachers possess different skills favors the evolution of the system, the flow of the activities proposed, and the development of the continuing education course.

As teachers began to adapt and acquaint themselves with the flow of messages, some needed support. Upon learning of a certain doubt concerning a task, one of the participants reposts the activity for the colleague to develop it, as can be seen Figure 1 – group 1B. In the same figure, group 1A shows how teachers' familiarity with smartphone mechanisms helped a colleague locate the video during a task, allowing the task to be performed. Reposting tasks became necessary to give sequence to the activities, although at times it did seem to bother one participant or another.

FIGURE 1 – Examples of redundancy



As mentioned above, many participants from the group had a certain familiarity with the application. This made it easier for the participants'

questions and difficulties with the tool to be resolved quickly by their peers. In this sense, the solution emerged from the collective possibilities ensured by redundancy or commonalities of the groups participants.

If it had not been for the commonalities of the group participants, the teacher would not have found the post in group 1A and would probably have to wait for one of the mediators of the project to solve the problem. As one of the peers noticed the problem, he immediately used his skills to repost the task. The same happened in group 1B, when one of the teachers explained to his peer how to find the video that had been posted previously. Both examples show that the interventions were made as soon as the problems emerged, allowing for the flow of discussions. Both events also demonstrate distributed control, since the group members' skills allowed interactions to flow before the educators became aware of the problem. In this sense, the solutions emerged from the collective and not necessarily from an action centered around the mediator.

4.2 Neighbor interactions

Concerning the use of mobile devices in classroom practices, 75% of the respondents affirmed that they have used mobile devices for teaching English. In the teachers' own words: "Browser/Camera/WhatsApp/Social Media/Voice Recorder/School Wi-Fi/Other apps", "Twitter, mobile games such as QuizzUp", "Duolingo" make up a big part of the resources used in their practices, which indicates familiarity with mobile applications as well as a recognition of their potential for language teaching and learning even before the continuing education experience.

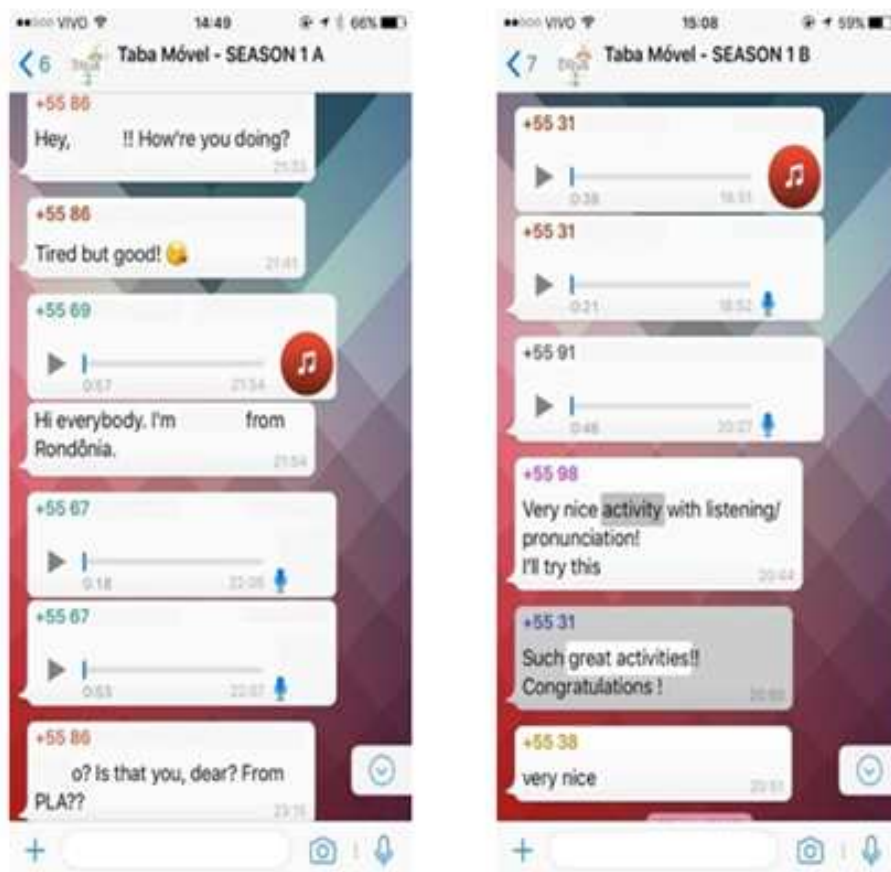
If, at first, before this experience, teachers appropriated mobile technologies to teach and learn in isolation, during the sessions, they had opportunities to learn from their peers and create a repertoire of possibilities from their interactions. These issues were pointed out in the responses given in the final questionnaire. For example, when asked if they favored listening to a given colleague's audios, most participants revealed that they had listened to the audio messages of all their colleagues: "I followed everyone in general"; "I followed everyone equally"; "I paid more attention to recordings posted by the colleagues from my state of Goiás" are some of the responses that confirm participants' interest in their peers' posts.

These actions characterize a type of **neighbor interaction** that relies on the possibilities of the input produced by members through the voice recording application. The answers provided for the reasons that led teachers to listen to the audios demonstrated that, in addition to interactions on the integration of mobile devices, teachers appropriated the group's oral output to improve comprehension and pronunciation. Sample answers illustrate these appropriations by several participants: "What motivated me the most was to try to understand spoken English"; "I wanted to hear, make sure I understood everything, learn what was new and different [...]"; "Paying attention to others' pronunciation helps me improve my own".

Other actions geared towards the development of oral skills, most noticeably speech production, were reported in the final questionnaire. Upon being asked about possible strategies to produce audios, many teachers reported the following actions: "Yes. I wrote down what I wanted to say. I read it and recorded it on my cell phone"; "I listened once and if I didn't like it I recorded it again"; "I used the 'slide to cancel' option"; "Before I'd use a 'voice recorder' app where I would record and then hear everything before sending it". These days I speak right into the *WhatsApp* and generally use the app's slide to cancel"; "Like, I planned out what I wanted to say"; "I would record it and show it to my husband"; "Yes, I sent a message to a friend". It is worth mentioning that the opportunities for oral practice that emerged from the continuing education experience indicated that this initiative served purposes other than those initially planned.

The following examples illustrate that the teachers interacted orally right from the start. Some, however, chose to 'rehearse' their own audios before sending them. Figure 2 shows two examples of recordings with a music note symbol placed to their right, indicating that the teacher first shared the audios to listen to them before posting to the groups. The interactions in Figure 2 also demonstrate exchanges of experiences by means of oral texts interspersed with written texts at the teacher's convenience.

FIGURA 2 – Examples of neighbor interaction focusing on oral texts

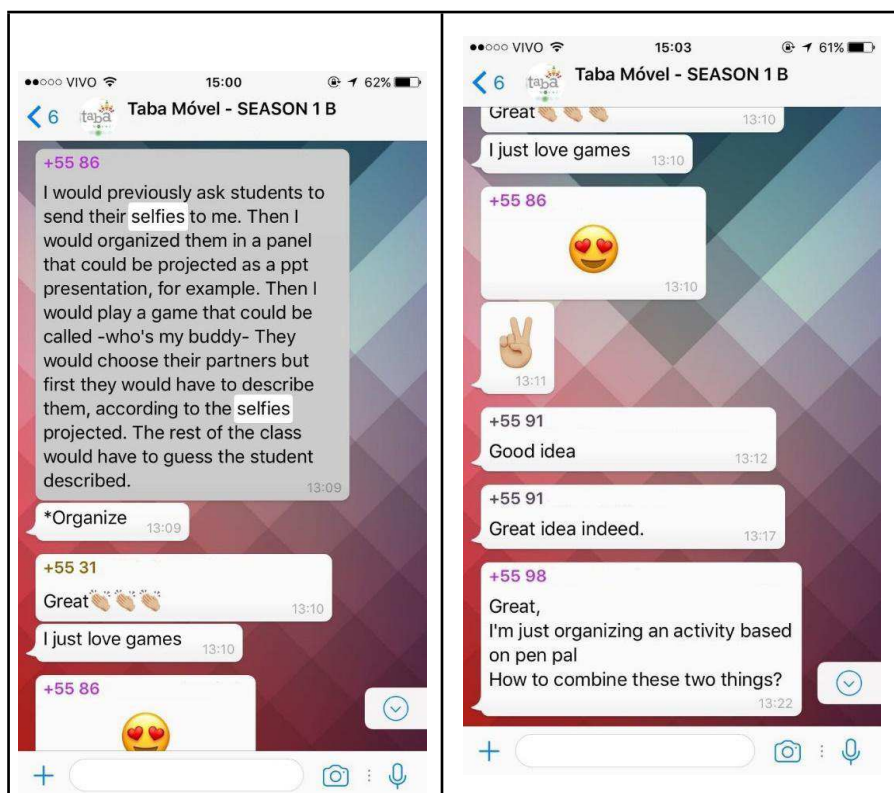


Notably, the teachers exchanged experiences from their situated contexts. In group 1B's first audio, a teacher reports on an activity he conducted in class that was inspired by the discussions on the use of mobile learning in his group. This teacher asked his students to take snapshots of their neighborhoods and share them in class. Another teacher promptly replied that he, too, had the same idea. His students, however, did not feel comfortable doing this because of the crime rate and lack of security in their neighborhoods.

The **neighbor interactions** took place through both oral and written messages, which made the mobile learning experience possible, in turn “triggering a transition from a collection of me’s to a collective of

us” (DAVIS; SIMMT, 2003, p. 150). The teachers’ messages regarding the integration of m-learning in the language classroom enabled the emergence of a teacher’s collective. The following interactions on the use of selfies and braggies for language learning via *WhatsApp*, show that one’s suggestion or ideas become a property of the collective. Another point worth mentioning is that a peer’s actions influence the others. This can be seen when the teacher in Figure 3 inquires how he could combine games with pen pal activities, triggering new pedagogical possibilities.

FIGURE 3 – Examples of neighbor interaction focusing on triggering new pedagogical possibilities



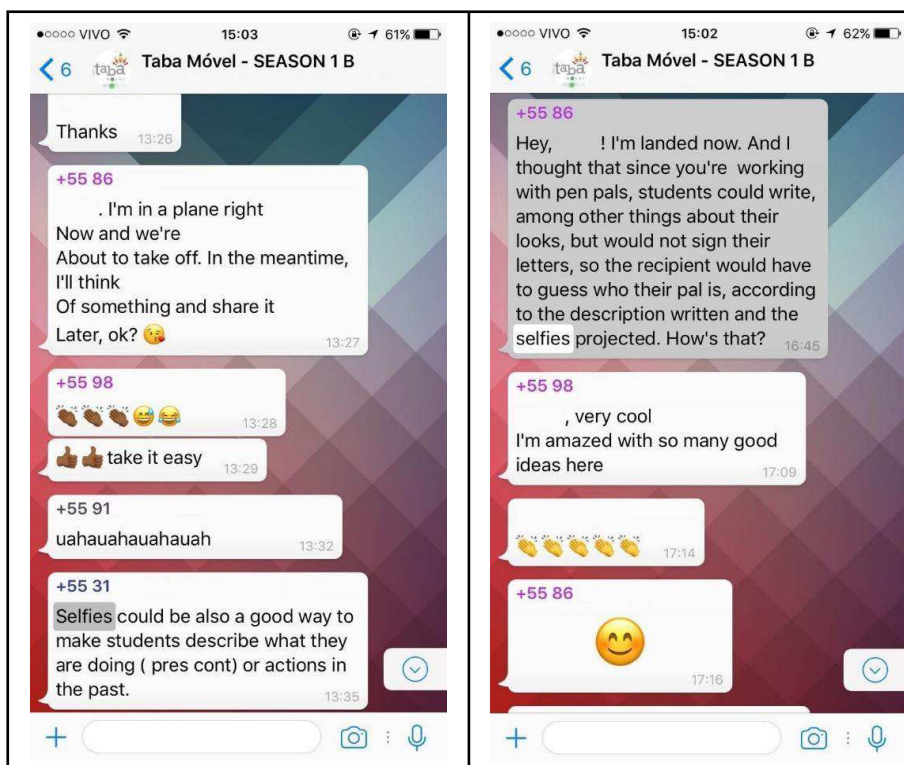
The brainstorming of ideas on how to use selfies for teaching English was possible due to accessibility and immediacy, features of the ubiquitous nature of m-learning. One of the tasks, posted at 12:52, asking the teacher to share ideas on how to integrate selfies and braggies in the

language classroom, triggered a sequence of over forty messages (both oral and written) within four hours. That in essence shows the potential of m-learning for educational activities, especially involving people from various locations.

In the following examples, part of the sequence of these interactions, a teacher boarding a plane notifies the group that she will take advantage of her flight time to come up with some ideas on the matter, making her peers laugh with her peculiar participation. As soon as the plane lands, the teacher resumes her contribution to the group.

As the information remains in *WhatsApp*, unless purposely removed, the teacher did not have difficulty retrieving it. It is worth pointing out that the permanency of the information played an important role in communication among peers and enabled the group's flow of interactions.

FIGURE 4 – Examples of neighbor interactions focusing on ‘just in time’ and ‘on demand’ communication from a plane

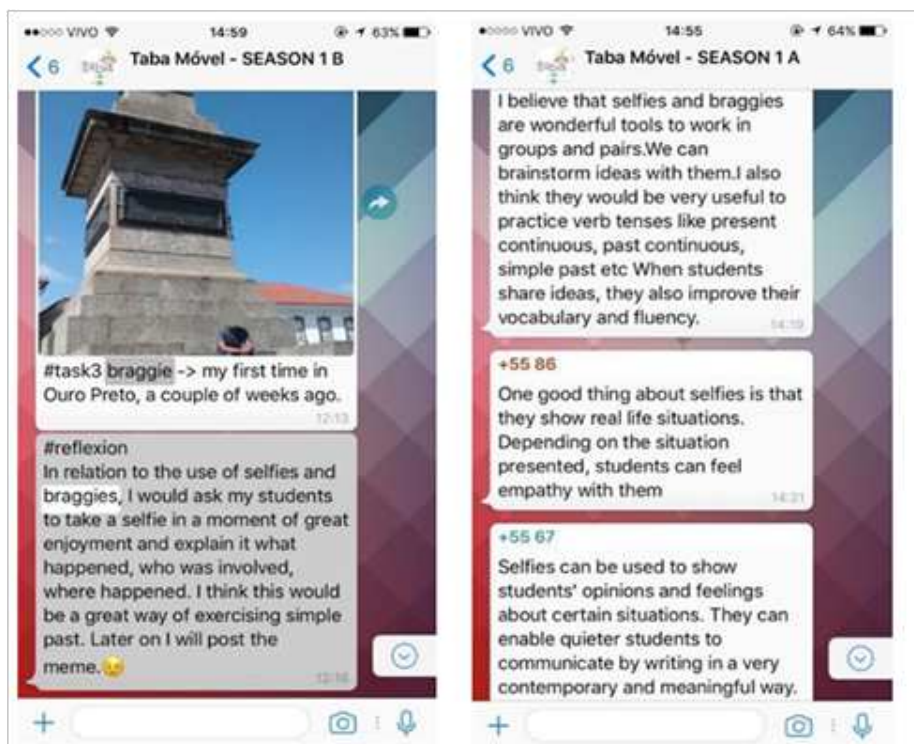


As can be observed in the interaction in Figure 4, one's relationship with information obtained or provided via mobile devices changes considerably depending on how readily available the device is and on the features that allow 'just in time' and 'on demand' interactions without necessarily having to put other activities on hold. Being able to read interactions from an airplane seat using a smartphone is not as cumbersome as retrieving a laptop from a carry-on bag or having to wait to access a desktop computer.

The interactions displayed in the following images demonstrate that teachers sought to discuss different ways of developing their students' language skills, such as the case of the participants of group 1A, which reflect on how braggies and selfies circulating in social media could be exploited for grammar and writing development and opinions, recognizing the relevance of these authentic texts for language learning. Another type of recurrent post throughout the interactions has to do with the teacher's own language development, which can be observed when one of the teachers in the group 1B asks the meaning of ASAP. These types of posts with questions about meaning or pronunciation occurred naturally, revealing both the value and the potential of the learning possibilities that emerged in the situated contexts of interaction. These interactions were favored by the 'just in time' nature of m-learning, which allows for 'on demand' interventions.

To this end, Pegrum (2014) affirms that the affordances of m-learning need to slot into the in-between spaces and times of our lives, the places we wait, the moments we kill, but which the right tools let us turn into learning contexts.

FIGURE 5 – Examples of neighbor interactions focusing on developing students' and teachers' language skills



4.3 Enabling constraints and distributed control

Evidence of **enabling constraints** were observed in the group's interactions. One of the rules (constraints) required the group to interact in English only. In this respect, one of the participants lacked the language proficiency to follow his colleagues' discussions. The teacher's insistence on interacting in Portuguese triggered responses from the participants, who kept asking him to comply with the English-only rule, culminating with the teacher's withdrawal from the project.

Occasionally, if Portuguese "found its way in", the participants themselves would switch to English. An example is the interaction when the participants were voting on "best meme" produced by their colleagues, and one of the them voluntarily interacted in Portuguese: "esse do he man" (the one about He Man). In his words: "Kkkk *esse do* he man. Ops... let me switch to English again ahahaha". Occasionally, if Portuguese "found its way

in”, the participants themselves would switch to English, as can be seen in the following interaction when one of the teachers, on voting on the “best meme” produced by his colleagues, voluntarily interacts in Portuguese “esse do he man (the one about He Man). In his words: “Kkkk esse do he man. Ops... let me switch to English again ahahaha”.

Pedagogically, enabling constraints are about establishing sufficient limits to advise learners and provide sufficient freedom to allow for the emergence of the unexpected. In this sense, although one of the norms of the group was to interact in English, the input produced individually and collectively fostered opportunities for language practice and learning (i.e.: an ‘enabling constraint’), which is the case of the opportunities the teachers used to improve their oral skills.

It is important to highlight that the design of the tasks is configured as an enabling constraint, given that in a pedagogical context, it works as a structured condition. At the same time, it is in the course of interactions that these conditions foster varied responses. Although the themes and tasks defined the structure of the course, they also promoted a certain level of flexibility through which the participation occurred and new themes emerged. In this light, enabling constraints and distributed control are both complementary and intertwined. The expansion of the proposed themes as well the emerging themes can be exemplified by the analysis of participants’ interactions in both groups, as summarized below in TAB. 1.

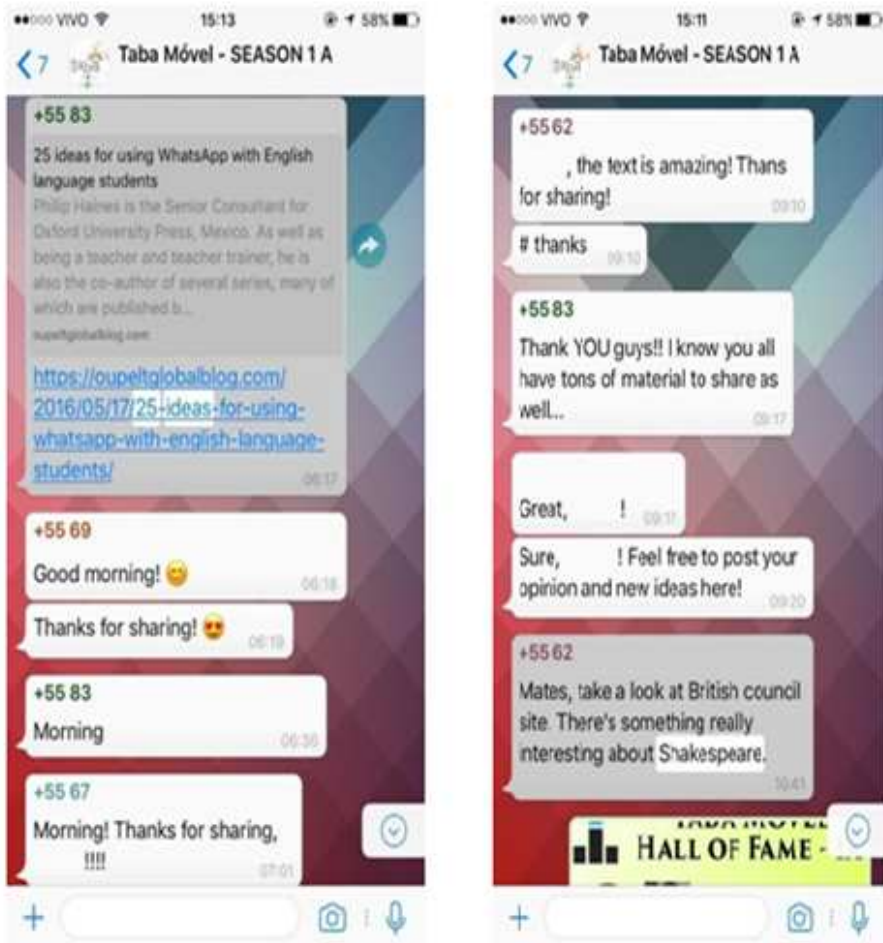
TABLE 1 – Participants’ interactions in both groups

Interactions in the groups	Group 1A	Group 1B
Development of tasks	341	498
Comments about their peers’ activities	136	149
Spontaneous interactions (including topics on grammar, literature, teaching resources, to mention a few.)	115	748

In both groups, the interactions were geared toward the development of tasks, questions, and spontaneous comment about their peers’ activities. Although these structured conditions enabled the system’s response to the task, the **distributed control** during the course of interactions allowed the teachers to become coauthors of the repertoire of pedagogical possibilities by responding to each given task as well as proposing new topics for discussion.

Another example of **distributed control** is illustrated in the interactions in Figure 6 when one of the participants of group 1A sends a link to a text on the integration of *WhatsApp* at 6:17 a.m. The dispersion of control was a recurrent dynamic and promoted opportunities for collaboration among peers, who usually replied with texts and emojis showing appreciation and encouraging interaction.

FIGURE 6 – Examples of distributed control



These interactions also showcase the individual as well as the social nature of MALL if we consider that the flow of the interactions is nurtured both by the individual and the social practices in which he/she is embedded.

Just as the interactions on the use of mobile technologies occurred in a decentralized manner, so too did the aforementioned spontaneous appropriation of audios to develop oral skills, considering that this appropriation emerged out of the teachers' interest to improve his/her language skills, thus involving perception and action without interventions or suggestions on the part of the educators. This appropriation of audios to develop oral skills emerged spontaneously during the course, which indicates that nothing in the system is fixed, but rather it is dynamic and changes according to its contextual demands.

Postulating decentralized control does not mean giving up the control of the classroom/course environment, but rather the mobilization of competencies, in which all agents collaborate in the construction of shared knowledge. According to Davis and Sumara (2006, p. 48), "a key element in effective teaching is not maintaining control or relinquishing control but, rather, in dispersing or distributing control across the network of relationships in the classroom."

In addition to exchanging ideas and experiences about the use of mobile applications while carrying out the tasks, teachers validated the use of *WhatsApp* as a reliable ally to foster the use of the foreign language among students. On being asked to describe their opinion about the use of WhatsApp to develop oral and writing skills, teachers quickly pointed out the following:

I think it's pretty helpful, it's an additional resource to help improve students' oral skills. Another upside is the fact that students have more contact with the language and are not restricted to the confines of the classroom.

I believe these tools are valid in the classroom and can make students feel more motivated to learn and use the language. Besides, these tools allow us to improve the four skills (reading, listening, speaking, and writing) and can be used regardless of the grammar topic being taught, for example.

I find it particularly interesting, I usually create WhatsApp groups for my students and the exchange of messages always helps them and helps me as well. Thoughts become quicker over time and when least expected, you're not thinking about how to write. You simply do it.

Teachers also pointed to some constraints in the use of smartphones in the context of English, such as screen size for text reading, technical

issues (cell phone configuration, students' Internet connection at school and at home), and the possibility of students being distracted by other subjects during activities.

5 Conclusion

From the analysis of the data generated during the teacher education initiative, we found evidence of the conditions for complex emergence, as proposed by Davis and Sumara (2006): enabling constraints, diversity, redundancy, distributed control, and neighbor interaction.

Some of the constraints present in the teacher education experience include focusing on the integration of mobile devices and applications by creating material and discussing their use in the language classroom, using English during the interactions, using features (audio, images, written messages) from mobile devices and applications to interact. These enabling constraints structured the necessary conditions for the teacher education program to take place.

The presence of diversity can be verified not only through the demographic aspects of the group, but also through the teaching experience of each participant who contributed with interactions in the group. The fact that all of the groups' participants were English language teachers, that they were interested in discussing the integration of mobile devices in the classroom, and that they were familiar with *WhatsApp* figure as features of redundancy in the groups. These features allow for interaction among the participants and the maintenance of the coherence of the groups as a system. Redundancy also contributes in such a way that the participants take on different roles, in turn compensating for future failures or difficulties that may arise from the other participants.

As seen in the aforementioned conditions, the distributed control plays an important role within the system, as it creates a robust network that balances efficient communication and improves resources so as to foster the emergence of collective possibilities.

Neighbor interaction enables the creation of a collective repertoire that is smarter than the smartest in the collective. During the tasks, the teachers had the opportunity not only to propose and discuss pedagogical possibilities in MALL regarding their teaching context, but also to learn how MALL can be integrated in other contexts, as well as take advantage of the resources produced collectively for their own linguistic development.

These conditions played an important role in both groups, as they allowed teachers to move around in their groups as apprentices, teachers, or co-educators, and appropriate the digital, pedagogical, and linguistic resources to develop a collective repertoire of possibilities. These conditions, coupled with these teachers' perceptions and actions via mobile technology, favored the emergence of the collective unit of the two groups as well as other emerging patterns, such as: (i) the validation of continuing education initiatives via mobile devices, especially *WhatsApp*; (ii) the recognition of *WhatsApp*'s features as a tool that can favor interaction among peers, both in continuing education practices and in classroom practices; (iii) the recognition of the potentialities of MALL to develop language skills in the EFL classroom; (iv) the teachers' appropriation of the input collectively produced for the practice of English and development of language skills, especially oral skills; and (v) the validation and appropriation of peers' experience and the creation of a collective repertoire of pedagogical possibilities to integrate mobile devices in language learning.

We acknowledge that the small number of participants allows for no broad generalizations. Despite this limitation, these findings have important implications for the analysis of other contexts and reflection regarding the integration of m-learning in teacher education, as well as the limitations and possibilities of this modality in the context of language learning and teaching. This study points to implications of the need for further research that would include the investigation of the integration of m-learning in teachers' classroom practices and the patterns that may emerge from them.

The results obtained from this work indicate that MALL (a subset of CALL) can contribute to discussions on teacher education and the use of digital technologies in language learning, adding new possibilities to the field. To that effect, we are inspired by Kukulska-Hulme in her vignette, *Shiny technology masks seismic change*, which can be found in Pegrum (2014, p. 22), in which she says that if on the one hand "mobile learning changes nothing" considering that "mobile learning is just an adjunct to, or an extension of, existing educational practice", on the other hand, "mobile learning changes everything" if we consider that the popularization of mobile devices in society opens up opportunities for millions of people to learn languages. Moreover, students can finally choose what, with whom, and how they want to learn, in addition to being able to capture, share, and communicate experiences from real-time situated contexts.

These ideas can also be applied in teacher education via mobile devices. On the one hand, the use of mobile devices ‘changes nothing’, considering that teachers can rely on books, face-to-face courses, computers, etc., for their education. On the other hand, this resource can ‘change everything’ if we consider that teachers can integrate their continuing education with their day-to-day routine, choosing ‘what, with whom, and how’ to improve their professional development and practice. In addition, the popularization of cell phones empowers teachers by enabling them, either individually or collectively, to have more contact with English, while increasing their chances of participating in communities of practice and making it possible for them to develop their technological competence in ever-changing times.

Contribution of authors

We certify that Junia de Carvalho Fidelis Braga authored these sections of the article: Digital Mobile Technology and Teacher Education, and Method. Antonio Carlos Soares Martins authored the following sections of the article: Introduction and Complexity and the conditions for complex emergence. The section Findings and Discussion was written collaboratively.

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