Mobile-Enabled Language Learning Eco-System

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ABSTRACT
This paper provides an overview of a Design-Based Research (DBR) study which resulted in a prototype of the Mobile-Enabled Language Learning Eco-System (MELLES) and replicable design principles to guide development of practical innovative mobile learning interventions. The MELLES solution was generated to augment in-class practice of ESP skills with learning embedded in real-life dynamic communicative situations. The solution was developed over multiple cycles of design, development, and testing which involved students and practitioners representing all relevant fields. The study and design activities were conducted at a Canadian community college and were guided by the Ecological Constructivist framework which evolved as a result of the initial stages of the project. The DBR methodology and the study outcomes are discussed along with the key features and various interdependent components of the MELLES system.

Author Keywords
Mobile-Enabled Language Learning (MELL), English for Special Purposes (ESP), Ecological Constructivism, MALL, Design-Based Research (DBR), contextualized learning

INTRODUCTION

A longitudinal Design-Based Research (DBR) study exploring the design of a Mobile-Enabled Language Learning (MELL) solution resulted in two key outcomes, specifically a MELL system prototype and a set of corresponding design principles. The study addressed the problem of inadequate aural skill acquisition among adult English for Special Purposes (ESP) students at a Canadian community college in Toronto. Previous research identified both aural and oral competencies as critical for students' academic and professional success (Palalas, 2009). The reported interventionist study drew on four years of research which had explored this problem in-situ and identified m-learning, situated in the real-world context, as an appropriate approach for augmenting in-class ESP instruction. Hence, the DBR study sought a flexible solution which, while engaging learners in interactive communicative tasks, would also afford individual listening practice at the time and place convenient for the learner. Moreover, a need for belonging to a community of learners and communicating with peers had to be addressed in the design under investigation. Accordingly, the main purpose of the study was to produce a MELL intervention which would offer flexible contextualized ESP practice - learning that involves interaction with others but at the same time is personalized to learner preferences. Effective utilization of students' own mobile devices as well as working around data plan and wireless connection limitations were two other pieces of the MELL puzzle.

Eighteen months of rigorous data collection and analysis coupled with the design activities resulted in the Mobile-Enabled Language Learning Eco-System (MELLES). The system evolved from individual m-learning object prototypes to a *whole* network of actors, learning tasks and resources integrating the environmental supports with the help of mobile technologies. The evolution of the investigated educational intervention necessitated a revision of the theoretical framework guiding the study. Hence, the initially selected Socio-Cultural Theory was replaced to provide a more holistic and contextual theoretical model required to fit the MELL design advocated by the participant feedback. Ecological Constructivism was thus adopted as the theoretical framework for the remainder of the project. This ecological paradigm demonstrated to be appropriate for MELL design and practice. It melded together all the essential elements of an effective MELL solution which is described in this paper using an ecological lens.

METHODOLOGY

This research adopted the DBR approach which demonstrated to be suitable for this participative interventional study engaging learners and practitioners to investigate educational problems and solutions in their original setting. An overview of the DBR method, its procedures, participants, as well as data collection and analysis activities are presented in the sections below.

Design-Based Research (DBR)

The following definition of DBR captures the salient characteristics of this method as demonstrated through the study:

> A systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories. (Wang & Hannafin, 2005, p. 7)

The inherently multi-cycle process of creating effective technology-based solutions necessitates recursive steps to be carried out over an extended period of time. Accordingly, the outcomes and feedback of the iterative design, development, implementation and evaluation activities were fed back into the successive cycles of the study to facilitate the design of an educational intervention reflecting the requirements of the study participants. At the same time, the participative and collaborative character of the process allowed for interactivity and cooperation amongst practitioners, students, experts, and the researcher. Being grounded in a naturalistic setting and focused on issues of everyday practice, the study resulted in practical solutions leading to reusable design principles. The DBR approach also provided an appropriate framework to examine the complex educational needs and solutions holistically resulting in the design of a multi-component mobile learning system. Lastly, this flexible structure afforded gradual refinement and creation of two interdependent outcomes: the MELLES intervention and the corresponding theory in the form of design principles.

In order to address the complexity of the context and ensure a systematic approach, a proven DBR model was adopted - the Integrative Learning Design Framework (ILDF) (Bannan, 2009). This comprehensive four-stage model offered a methodical framework allowing for "rigorous, research-based cycles within a technology-based instructional design process" (p. 53). The framework comprises four phases: (1) Informed Exploration, (2) Enactment (3) Evaluation: Local Impact, and (4) Evaluation: Broader Impact (out of scope of this research). While the IDLF model guided the macro and micro cycles of the process, the key research question served as the pivotal element of this multidimensional study.

Research question

The overarching research question, repetitively asked at the various stages of the study, inquired what characteristics of the MELL intervention were considered vital for its design to be effective and pedagogically-sound: What are the characteristics of an effective, pedagogically-sound MELLES for students' mobile devices, through which adult ESP students in a community college enhance listening skills, while expanding their learning outside of the classroom?

It is worth noting that, based on the findings of the Informed Exploration phase, the question evolved from its original version and consequently the notion of a learning object was replaced with that of a MELL ecological system. The attribute of being pedagogically-sound referred to an intervention (1) created and evaluated following the main theoretical framework of Ecological Constructivism, and (2) designed to promote learning of listening skills. In terms of the effectiveness of MELLES, it was measured by participant feedback on perceived learning as well as their satisfaction with the design of the intervention and the learning experience.

The intervention was designed for ESP college students studying at the college programs in the area of business, accounting, hospitality, and technology. Using their own mobile devices students piloted MELLES in the streets and at landmarks of Toronto, where they interacted with the tasks and interlocutors in a dynamic language environment, which both supported their language practice and challenged them to make meaning and communicate.

Research design

The study encompassed three phases: Informed Exploration, Enactment and Evaluation: Local Impact. These phases overlapped resembling what in software design would be referred to as an agile approach with the results of both formal and ad-hoc feedback being dynamically integrated into the design. The focus of the first phase was on needs analysis, audience characterization, literature review, as well as the development of the conceptual model and theoretical framework. The Enactment phase concentrated on the design of the prototype, as well as testing and refinement of both the model and the design principles. The third phase, the Evaluation phase, entailed testing, piloting, and evaluation leading to further theory and design refinement. In addition, ad-hoc feedback was exchanged across all cycles of the three phases thus allowing for more responsiveness to changing design requirements. Figure 1 provides an overview of the timelines, main activities, data, participants, and outcomes of the three phases.

Data collection and analysis

Mixed data were collected throughout the project as specified in Figure 1 below. All qualitative data were analysed using the NVivo9 Qualitative Data Analysis System. The manifold iterations of coding and re-coding resulted in several recurrent themes distilled based on their relative frequencies. To reflect participant feedback, these themes were organized into two super-categories: Pedagogy and Technology and indicated the design features deemed by participants as vital for the desired MELL intervention. They were then validated by the quantitative data, collected through the surveys, and analyzed with Excel and the SPSS statistical predictive analytics software. The ensuing findings encapsulated the essential characteristics and elements of MELLES discussed below.

Participants

This interdisciplinary study benefited from contributions and feedback from 163 students (excluding the 191 students from the Mobile Device survey), eight professors from a variety of George Brown College programs — School of Computer Technology (3), School of Design (2), School of Business (1), Centre for Hospitality and Culinary Arts (1) and the Intensive English (IEP) program (1)—as well as two external IT and mobile programming experts. The Digital Design professors contributed their expertise in the design of content for mobile devices as well as in interactive game design. One IEP and three Communications (COMM) professors offered their knowledge of ESP and language learning.

Two School of Computer Technology professors shared their extensive applied knowledge of wireless technologies and mobile programming. Students from the above-mentioned departments were involved in two different roles: two cohorts of Digital Design and Computer Programmer Analyst students as designers and developers, and five groups of IEP and COMM students, representing eight different college programs, participated in the pilots and evaluation of these designs.

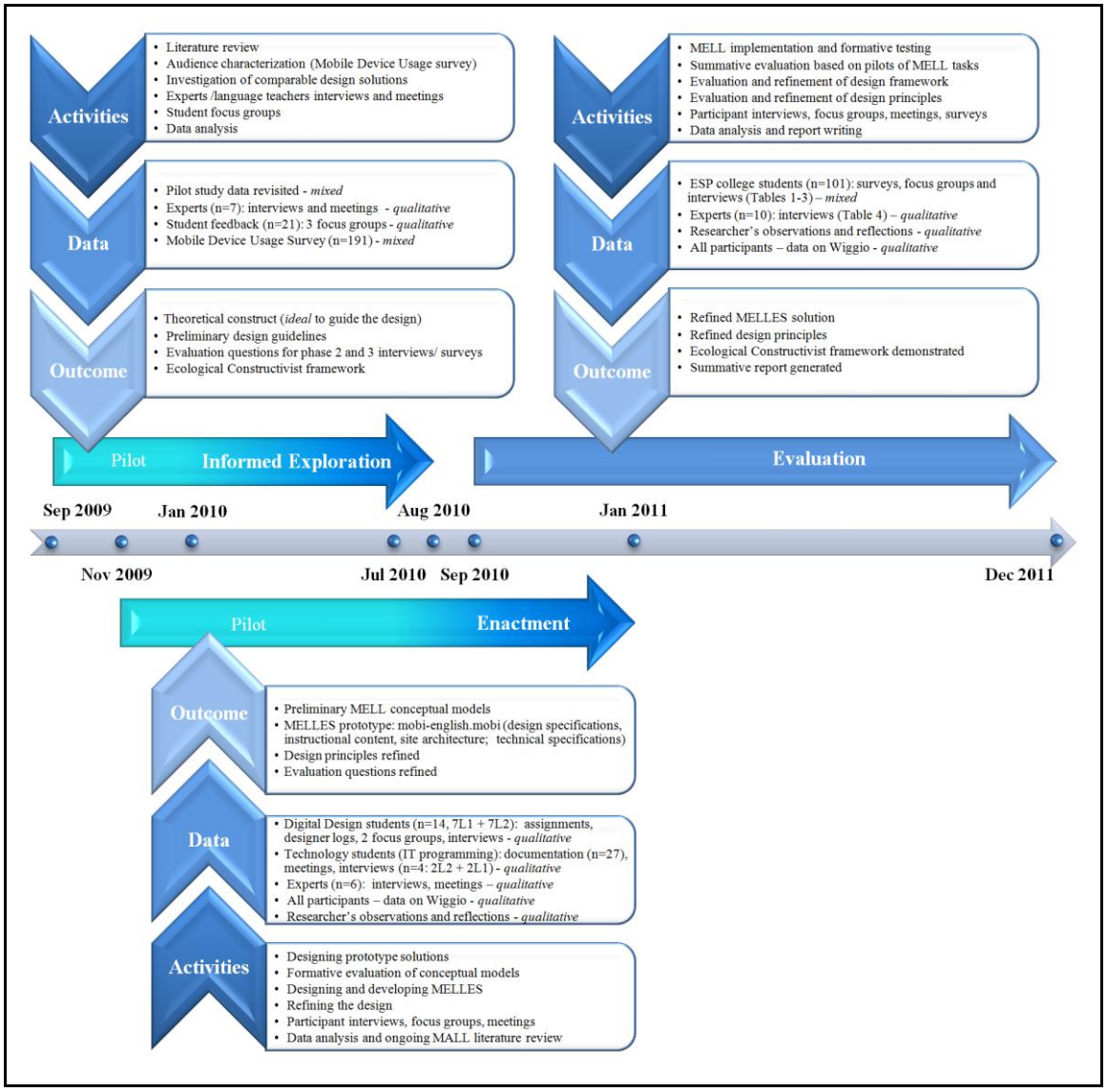

Figure 1. DBR phases: Timelines, main activities, data, participants, and outcomes.

LIMITATIONS

There were two key limitations to the study with the scope of DBR being the principle one. Due to the complexity of the studied system, some of its constituent elements could not be examined in-depth (e.g. cross-platform development). A decision was made to choose the breadth over depth of investigation. Moreover, with respect to measuring MELLES effectiveness, students indicated high satisfaction with the system based on their perceived learning and positive learning experience, but no evidence of learning was collected through formal tests of students' language proficiency.

Other limitations resulting from the nature of the DBR methodology included the overwhelming amounts of data, having impact on data collection and analysis procedures, difficulty managing multiple DBR activities and coordinating participants over the stretch of the study, as well as the intensity, complexity and messiness of the context.

In terms of the researcher role, while she was able to rely on a team of practitioners and experts, the researcher had to wear many hats during the study. She had to assume the roles of an investigator, project coordinator, instructional designer and theorist, software designer, evaluator, m-learning Subject Matter Expert, and negotiator. That resulted in having to assume the conflicting roles of advocate and critic of the MELL design. Another challenge resulting from the joint role of designer and researcher was having to evaluate own intervention designs which put the researcher objectivity and reflexivity to test. The next three sections provide a brief overview of the DBR phases and their key findings.

PHASE 1: INFORMED EXPLORATION

During Informed Exploration, data were collected through mixed methods from students and practitioners who had participated in the pilot of the mobile solution before the DBR study, as well as from Digital Design and Programming students who were working on MELLES prototypes as part of their course assignments. The college-wide Mobile Device Usage Survey was also deployed and its findings enriched the understanding of how students use mobile technologies. The outcomes of this phase formed the basis for the subsequent DBR activities. The *ideal* model was created reflecting the main characteristics of the intervention as identified by the participants. These were translated into the first set of design guidelines. The Ecological Constructivist framework also evolved at this stage.

Phase 1 Findings: Emerging Themes

Starting with the Informed Exploration phase and throughout the two other phases qualitative feedback was captured in text, images and audio files. To conduct rigorous data analysis, all data sources were integrated into the NVivo system, and codes were generated in a cyclical fashion. Thematic codes were assigned to phrases and sentences through repetitive thematic analysis always going back to the main research question. The set of categories and sub-categories that were eventually developed was a result of many coding sessions spreading across the DBR phases with the final set of categories (Table 1) emerging when all the aggregate data was revisited in the final stage of the data analysis. The quantitative results are excluded here for reasons of length and because the subsequent qualitative analysis not only validated the quantitative findings but provided a much more elaborated and informative perspective.

Phase 1 Findings and Discussion: Emerging Ecological Constructivist framework

Phase 1 also produced an ecological framework referred to as Ecological Constructivism (Hoven & Palalas, 2011). The ecological paradigm demonstrated to be an appropriate approach for the exploration of the MELLES system. The specific context of learning listening in the real-world with the help of mobile technologies required a theoretical framework which supported a more holistic and systemic approach to the process of learning - mediated by mobile technology and interaction with other people as well as its context. The Ecological Constructivist metaphor aimed to capture the interconnectedness of psychological, social, cognitive, and environmental processes as well as the co-existence of pedagogical and technological elements interplaying in a dynamic real-life language learning environment. Ecological Constructivism integrates the Socio-Cultural Theory constructs of (1) knowledge co-creation being socially and culturally mediated with the help of tools, and (2) those tools being applied in active learning (3) targeting real-life communicative goals. It also melds Vygotsky's notions of (4) ZPD and (4) scaffolding as well as (4) co-dependence of individual cognition and collaborative learning. It stresses that the fluid nature of the changing context and the active engagement of learners are both required to co-construe knowledge. The notion of context affordances was also introduced and defined as "a particular property of the environment that is relevant—for good or for ill—to an active, perceiving organism in that environment" (van Lier, 2000, p. 252). Accordingly, context affordances mediate the process of learning by providing linguistic cues and other meaning-making supports to those learners who perceive them. Mobile technologies enable noticing the affordances and interaction with those learning supports. All in all, the ecological metaphor emphasizes the wholeness of the MELLES learning system and the interconnectedness of all its elements.

PHASE 2: ENACTMENT

The Enactment phase entailed the design of the successive prototypes, testing and refinement of both the model and the design principles. Digital Design and Programming students as well as practitioners were very active creating, testing and recreating four functional prototypes of the MELLES system. Continuous evaluation of those prototypes, which was part of the concurrent Phase 3, allowed producing the final version of the mobile website which connecting the MELLES users with its resources and functionalities.

Phase 2 Findings and Discussion

The mobi-english.mobi website was constructed using the WordPress Mobile Pack, a reliable cross-platform tool. The website served as a gateway to all MELLES resources, as well as the hub of communication and interaction for learners and their facilitators. Eight listening tasks, which ESP students could access through the website, represented a range of approaches to listening skills acquisition, including individual and collaborative activities, two way communicative challenges and non-reciprocal listening practice. The tasks did not have to be completed in a linear fashion - any one of them could serve as an entry point into the MELLES network. All tasks were related and fed into each other. Following the key principles of ecological thinking—relationships, connectedness, dynamic process and fluid context in which all elements interact to form a web—the prototype solution was designed to encourage collaboration and interaction, thus interlinking the members of the learning community. Consequently, students were asked to complete some of the tasks in groups or pairs. They were also encouraged to co-create multimedia artefacts and evaluate each other's work by leaving comments and rating their audio recordings. Communication was enabled through more traditional channels, such as email and telephone, as well as by blogging, phlogging (blogging by phone), and by exchanging audio recordings.

MELLES included both learning tasks requiring students to be at a particular location and those that could be completed at the time and place of their chosing. Blending learner autonomy with peer and expert support was a significant aspect of how the system functioned. In addition, to provide support in the form of scaffolding, resources and motivation, the system had to be resource-rich and consistently stable. It was the role of the moderator to step in when the instability was

apparent. Based on the participant feedback, MELLES was designed to function like an eco-system connecting the actors, resources, and the context of learning at any time, any place, and any point of the learning process. Figure 2 presents two screenshots of the MELLES interface: mobile and desktop.

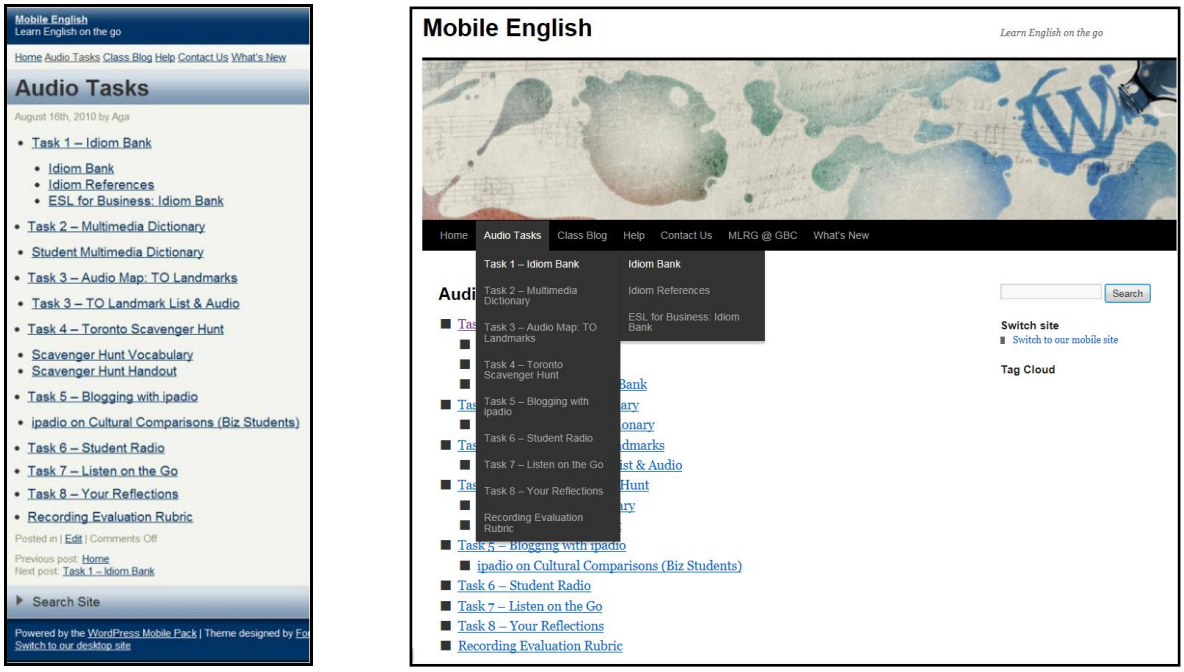

Figure 2. Screenshots of mobi-english.mobi (mobile and desktop interfaces)

PHASE 3: EVALUATION - LOCAL IMPACT

Phase 3 included testing of the MELLES software and piloting the tasks and the complete system by the target users. Speakers of English as a second language from a number of College programs completed the tasks and evaluated the MELLES system. Practitioners and the students, who were involved in the design and redesign of the intervention, also shared their input. As a result of the analysis of that feedback the design and corresponding design guidelines were refined and finalized. The gist of the qualitative data is provided in the table of the most frequent themes below (Table 1). These themes indicate the features and functionalities of the system identified as its most vital elements.

Phase 3 Findings: Key Research Outcomes

The Evaluation phase refined and finalized the following key outcomes:

1. a practical model of a MELL system was created for ESP practice and future studies,
2. the theory evolved to produce the MELLES design principles and the Ecological Constructivist framework, and
3. the DBR method was thoroughly tested and optimized.

Essential Elements of MELLES **Codes (NVivo Nodes)**	Reference Freq Stdnts	Rltv Freq Stdnts	Reference Freq Practn	RltvFreq Practn	**Ref Freq Total**	**Rltv Freq Total)**
PEDAGOGY						
PEDAGOGIC PROCEDURE - How	**444**		**38**		**482**	
Grouping	**164**	***33%**	**14**	***35%**	**178**	***33%**
group work	**120**	****40%***	13	****54%***	133	****41%***
collaboration and peer support	*71*	*70%*	*5*	*63%*	*76*	*70%*
interaction and communication	*33*	*33%*	*4*	*50%*	*37*	*34%*
share learner-generated artefacts	*16*	*16%*	*4*	*50%*	*20*	*18%*
individual practice	31	31%	0	0%	31	28%
pair work	13	13%	1	13%	14	13%
Motivation	**67**	***34%**	**2**	***13%**	**69**	***32%**
motivating factors	30	30%	0	0%	30	28%
fun-enjoyment	37	37%	2	25%	39	36%
Scaffolding - help from teacher	**55**	**54%**	**6**	**75%**	**61**	**56%**
Feedback	**47**	***16%**	**4**	***17%**	**51**	***15%**
need for feedback	18	18%	1	13%	19	17%
classmate feedback	18	18%	1	13%	19	17%
teacher feedback	11	11%	2	25%	13	12%

Listening practice	**38**	**38%**	**0**	**0%**	**38**	**35%**
Recording own voice	**31**	**31%**	**4**	**50%**	**35**	**32%**
Pre and post activities	**28**	**28%**	**6**	**75%**	**34**	**31%**
Integrated skills	**14**	***7%**	**2**	***16%**	**16**	***7%**
need for integrated skills	6	6%	1	13%	7	6%
speaking supports listening	8	8%	1	13%	9	8%
CONTENT - What	**250**		**9**		**259**	
Authentic speech	**58**	***29%**	**0**	***0%**	**58**	***27%**
need for authentic speech	51	50%	0	0%	51	47%
accents	7	7%	0	0%	7	6%
Vocabulary	**31**	**31%**	**3**	**38%**	**34**	**31%**
Directions & explanations	**28**	**28%**	**1**	**13%**	**29**	**27%**
Communication skills	**22**	**22%**	**0**	**0%**	**22**	**20%**
Support materials & resource	**23**	**23%**	**1**	**13%**	**24**	**22%**
Socio-cultural knowledge	**22**	**22%**	**2**	**25%**	**24**	**22%**
Pronunciation	**16**	**16%**	**1**	**13%**	**17**	**16%**
Relevance - work & program related	**15**	**15%**	**0**	**0%**	**15**	**14%**
Listening skills	**22**	***11%**	**1**	***7%**	**23**	***11%**
listening skills - general	14	14%	0	0%	14	13%
listening comprehension	8	8%	1	13%	9	8%
Task length	**7**	**7%**	**0**	**0%**	**7**	**6%**
Variety of topics	**7**	**7%**	**0**	**0%**	**7**	**6%**
CONTEXT - When and Where	**127**		**10**		**137**	
Real-life practice	**59**	**58%**	**4**	**50%**	**63**	**58%**
Outside classroom	**42**	***21%**	**4**	***25%**	**46**	***21%**
outside classroom practice	25	25%	2	25%	27	25%
blended classroom and outside	17	17%	2	25%	19	17%
Context affordances	**26**	**26%**	**2**	**25%**	**28**	**26%**
ACTORS - Who	**38**		**2**		**40**	
Learning community	**38**	**38%**	**2**	**25%**	**40**	**37%**
TECHNOLOGY						
FUNCTIONALITY - How	**75**		**2**		**77**	
Audio player functionality	**31**	**31%**	**0**	**0%**	**31**	**28%**
Audio files quality	**13**	**13%**	**0**	**0%**	**13**	**12%**
Mobile and computer	**12**	**12%**	**1**	**13%**	**13**	**12%**
Text support	**12**	**12%**	**0**	**0%**	**12**	**11%**
Inherent device affordances	**7**	**7%**	**1**	**13%**	**8**	**7%**
TECH CONTEXT - When and Where	**23**		**8**		**31**	
Flexible on-the-move access	**19**	**19%**	**0**	**0%**	**19**	**17%**
Cross-platform	**4**	**4%**	**8**	**100%**	**12**	**11%**

Note. Rltv Freq Total = relative reference frequency -both students and practitioners. (*) = the average of sub-categories.

Table 1. Evaluation qualitative findings—main themes (Essential elements of MELLES)

SUMMATIVE DISCUSSION

The design guidelines distilled from the research data encompassed both substantive and procedural knowledge: they identify the critical characteristics of MELLES as well as strategies required to incorporate these features in the design (Table 2). Due to the scope of this paper, any further discussion of the procedural design principles and the rationale for their inclusion had to be omitted (see Palalas, 2012, for an in-depth discussion of the design principles).

Essential Characteristic (***Substantive Emphasis***)	**Strategy** (***Procedural Emphasis***)	**Rationale** ***(in order to …)***
2 Learner-generated linguistic artefacts (audio, video, photos, images)	• Include audio recordings (video, images, photos) created by students in response to communicative tasks • Share and showcase learner-generated artefacts • Provide tools for recording, editing, upload and viewing/listening on-the- go (or demonstrate the usage of device built-in tools) • Provide clear directions on creating artefacts • Build in a rating system for artefact evaluation • Accompany website peer eval. by expert feedback • Encourage creativity	• Encourage autonomous and creative learning • Promote meaningful learning through creation, construction, and sharing of artefacts • Enhance individual and group motivation • Support cognitive processes through hands-on construction of artefacts • Blend creativity and competition in learner-generated artefacts exchange • Encourage abstract and creative thinking leading to engagement and motivation • Promote learner ownership and agency

Table 2. Design principle example.

It is worth noting that the participants agreed that none of the individual elements of the MELLES educational intervention could exist on their own, instead they were interconnected and supported each other. For instance, students could not produce any audio recordings (pedagogical principle 2) without the MELLES artefact authoring tools (technological principle 5) or expert facilitation (pedagogical principle 4). Most importantly, the mobile technology was viewed as the glue and enabler of all the pedagogical features which facilitated situated learning and the acquisition of aural skills. The abbreviated substantive guidelines, both pedagogical and technological, are presented below.

Design Principles

The ten pedagogical essential characteristics of MELLES include:

1. Balanced combination of individual and collaborative (group work) tasks;
2. Learner-generated linguistic artefacts (audio, video, photos, images);
3. Game-like real-life communicative tasks;
4. Expert facilitation: scaffolding, feedback, and coordination;
5. Feedback mechanism (immediate and delayed);
6. Focus on authentic listening tasks in the dynamic real-world communicative situations;
7. Support of self-paced individual audio tasks feeding into/preparing learners for the real-life tasks;
8. Integrate all four language skills but focus on listening outcomes;
9. Linguistic resources (task-related): relevant vocabulary, dictionaries, pronunciation, clear task directions and explanations, examples of language usage;
10. Support of out-of-class learning with in-class (f2f) instruction and practice (blending in-class and out-of-class).

To enable the above pedagogical features, the following technological components should be integrated into the system:

1. One-point access to all resources;
2. Exchange and communication platform;
3. Scalability, flexibility and adaptability of the system;
4. Scalable rating scheme (from artefact to learning structures to the whole system);
5. Multimedia (including text) - artefact authoring, management and usage capabilities;
6. Cross platform and multi-technology support;
7. Integrated technology support and tutoring/instruction;
8. Personalized user progress tracking capabilities.

The interdependencies between pedagogical and technological constituents formed a network of relationships which, combined with the actors and the learning context, resulted in the Mobile-Enabled Language Learning Eco-System.

Mobile-Enabled Language Learning Eco-System (MELLES)

The holistic approach encapsulated in Ecological Constructivism put more emphasis on the interdependence of the MELL solution components and the context in which they were intended to be used. The constituent elements of the recommended system need to co-exist for the intervention to promote learning. In fact, it is imperative for the MELLES components to interact and maintain a dynamic balance, as exemplified by the combination of collaborative and individual language activities.

Considering the multiplicity of elements recognized as critical for the effective mobile design, and how they interrelate and support each other, MELLES has to provide a learning environment in which the parts of the system could interact in various configurations promoting the flexibility and evolution of the whole system, and most importantly, enabling seamless mobile learning experience.

Hence, the central feature of the MELLES approach is the coexistence and the relationship of its learning tasks, learners, facilitators, the dynamic language environment in which these tasks are completed, as well as the technology that enables and mediates the learning process and the collaboration between the actors involved in the process. Mobile devices enable communicative exchanges, storage and access to ESP content, learning support and scaffolding. They also help capture linguistic evidence by way of learner-generated artefacts and assist in interaction with contextual affordances used for linguistic action. In addition, the MELLES network of peers, experts and authentic language speakers facilitates learning by means of authentic discourse, feedback, resource sharing and social support.

Additionally, MELLES instruction should encourage dynamic interaction with the English speaking environment to help decode the meaning offered by the real-life language situations. Regular in-class instruction should also be combined with the out-of-class practice and linked into a cohesive learning experience via the MELLES platform and its communication management tools. Furthermore, offering on-demand connection to the system promotes social, cognitive, teaching, and emotional presence (Swan et al., 2008). This results in a collaborative network which has become the predominant structure of the recommended MELLES solution. All in all, MELLES provides mobile access to people, linguistic resources, and context affordances (Hoven & Palalas, 2011) mediating real-life language practice.

Accordingly, new knowledge is generated across the web connecting (1) language, (2) mobile technology, (3) artefacts, (4) learners, experts and (5) other speakers, in (6) a real-life context of learning which all co-mediate the learning process (Figure 3).

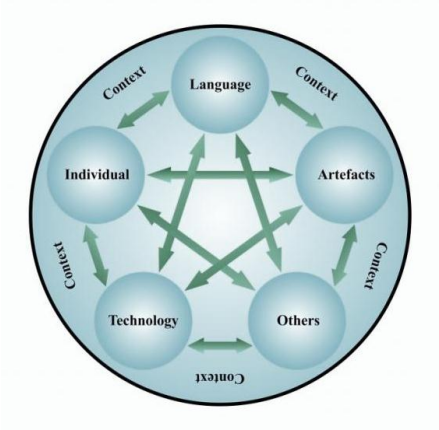

Figure 3. Interconnected elements of the MELLES learning context

SUMMARY AND CONCLUSIONS

Guided by the research question the study resulted in the evolution of theory and practice. The study resulted in a set of replicable design principles to guide the design and development of practical innovative mobile learning interventions. These guidelines are formulated to help practitioners to select and apply the substantive and procedural principles suitable for their specific design in their own contexts.

Guided by current second language learning pedagogy and a Constructivist framework, the original theoretical framework was reconceptualized during the first phase of the study to use a more systemic ecological metaphor. As a result, Ecological Constructivism was proposed as a theory of learning which matched the MELL design requirements emerging from the study. The ecological metaphor offered a holistic lens through which to examine the complex process of learning situated in a dynamic language environment. It also facilitated the investigation of the many dimensions of technology-assisted second language learning amongst adult learners in the out-of-class real-world context. Accordingly, the MELLES approached the learning of listening within the context of *whole* language learning experience, that is, (1) practicing listening as part of a *whole language system* (including four language skills, communication versus grammar, socio-cultural competencies), (2) learning it in the *whole context of students' life* (accommodating their busy schedules and interest), (3) co-construing knowledge as part of the *whole learning community*, and (4) actively practicing listening in the *whole communicative context* of the real-life language situations that learners encounter. The systemic perspective on the MELL intervention stresses the wholeness and connectedness of the constituent parts of the learning context. It also supports *whole* learning by providing mobile tools which connect the learner with facilitators and peers, learning tasks and instructions, linguistic resources and supports, as well as context affordances which learners can perceive.

To that end, the MELLES prototype, offers a network of artefact exchange and communication tools that can be used wherever and whenever. It is an innovative model for learning aural skills in an authentic language setting using learners' mobile devices. It was tested and retested for its applicability in the dynamic, often messy and unpredictable context of language learning. Hence, it provides a practical model for replication in similar educational contexts and further studies.

Finally, the DBR methodology adopted in the study was tested, adjusted, and optimized for the specific environment. In the process, the DBR approach demonstrated to be valid, useful and informative for educational context.

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