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A Proposal for an Integrated Evaluation Framework for Mobile Language Learning: Lessons Learned from SIMOLA – Situated Mobile Language Learning

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Abstract: The main aim of this paper is to share our experiences and lessons learned from a MALL project, the EU LLP Project SIMOLA. The SIMOLA project focused on user generated or crowd-sourced language content to support mobile, situated and collaborative learning [Petersen *et al*., 14] via an Android-based app called LingoBee. This paper will analyse key elements for successful mobile language learning by considering two different but complementary fields of investigation: the neuroscience of learning and mobile language learning. Furthermore it will propose an integrated framework to evaluate mobile language learning tools, which could potentially be used by learning designers and teachers. To demonstrate the evaluation framework, it will be applied to the SIMOLA app, LingoBee, to see if and how it meets the identified criteria.

Keywords: MALL, Mobile Language Learning, Critical Success Factors, Neuroscience of Language Learning, User-Generated Content
Categories: Technology Enhanced Learning

1 Introduction

Technology developers, language learners and teachers have been taking advantage of the affordances of new technologies for learning and teaching in recent years. In particular, mobile devices such as smartphones and tablets have played a central role in supporting the learning process both in and outside school. Mobile Learning has emerged as an area of research, where the focus has evolved from a technology-centred view e.g. [Quinn, 00] and [Traxler, 05] to learning anytime, anywhere and anyhow [Sharples, 06], to fostering a new culture of thinking and learning. Language learning has been one of the areas where mobile learning, or MALL (Mobile-Assisted

Language Learning) has played a central role. Early examples include the use of online dictionaries available on mobile devices, utilizing the device's ubiquitous nature. As the devices evolved, their capabilities were leveraged to enhance the learning support; e.g. by using the camera to support vocabulary learning [Joseph, 05], by using the location and positioning capabilities for situated and contextualized support e.g. [Ogata, 08] and [Petersen *et al*., 09] and more recently to support collaboration, knowledge sharing and user generated learning content through cloud based technologies e.g. [Pemberton *et al.*, 09].

The main aim of this paper is to share our experiences and lessons learned from a MALL project, the EU LLP Project SIMOLA. The SIMOLA project focused on user generated or crowd-sourced language content to support mobile, situated and collaborative learning [Petersen *et al.*, 14] via an app called LingoBee. This paper will analyse key elements for successful mobile language learning by considering two different but complementary fields of investigation: the neuroscience of learning and mobile language learning. Furthermore it will propose an integrated framework to evaluate mobile language learning tools, which could potentially be used by learning designers and teachers. To demonstrate the evaluation framework, it will be applied to the SIMOLA app, LingoBee, to see if and how it meets the identified criteria.

Innovative ICT based learning design and evaluation typically focuses on technical and pedagogical issues, whilst the neuroscientific background is often overlooked. Recent findings in this field could instead provide a sound basis for effective MALL programmes, helping to identify success factors and preventing learning failures. Several key factors of the neuroscience of learning correspond to key MALL structural elements, so points of convergence can be usefully exploited to enhance the learning experience and overall results.

In 2006, Naismith and Corlett identified and presented five Critical Success Factors that play a part in the success of mobile learning projects, these were: access to technology; institutional support; connectivity; integration and ownership [Naismith and Corlett, 06]. In 2013, Stockwell and Hubbard produced the Ten Principles for Mobile Language Learning: 1. mobile activities, tasks and apps should distinguish both the affordances and limitations in terms of the device and the learning environment, 2. Reduce multi-tasking and environmental distractions, 3. Planned push, but with learner controls, 4. Maintain equity, 5. Plan for a range of learning styles, 6. Be aware of how learners already use their devices and how they may need new skills, 7. Chuck the learning activities, 8. The task needs to fit the technology and the environment, but also the technology and the environment need to fit the task, 9. Learners should be taught how to use their devices effectively for language learning, 10. Provide motivational and preparation support for both teachers and learners. [Stockwell and Hubbard, 13]

Similarly, our experience with the SIMOLA project [SIMOLA, 12b] also confirmed that successful MALL projects depend on a number of factors and actors. Since our approach was based on the learners' engagement, learners and teachers played a central role in the success our project. In addition, the attitudes and policies of the education institution also played a role. In this paper, we share our experiences in the light of the framework proposed by Naismith and Corlett and principles presented by Stockwell and Hubbard and the relevance of these to successful MALL projects today.

User studies were conducted in six European countries, Hungary, Italy, Lithuania, The Netherlands, Norway and United Kingdom. Students learning the languages English, Hungarian, Lithuanian, Italian, Dutch and Norwegian and attending language classes were asked to use LingoBee to support their language learning process. It was presented by the language teachers as a means to collect and share language elements such as words and phrases that they came across in their everyday situations, with the teacher, their classmates and other language learners. The repository of language elements collected are available [SIMOLA, 12a]. Around 130 learners participated in the studies. The evaluations were conducted using pre- and post-intervention questionnaires, interviews as well as analysing the volume and variety of content that was crowd-sourced to the LingoBee repository. The analyses of the user studies have been reported in several articles, e.g. [Procter-Legg *et al.*, 14], [Petersen *et al.*, 13] and [Petersen *et al*., 14]

The LingoBee evaluations reported in earlier papers mainly focused on the results that were gained from analysing the questionnaires and interviews and a quantitative analysis of the content of the repository. In this paper, we reflect upon the experience as a whole and propose an evaluation framework for the benefit of other MALL researchers and educators. To establish the evaluation criteria, we collected and reviewed relevant data from the field of 'the neuroscience of learning' together with available set of indicators and factors from two models of 'mobile learning'. The proposed framework and the lessons learnt would be of use to those not only embarking on pilot projects, but also for those looking into how to progress towards mainstream implementation.

The rest of this paper is organised as follows: Section 2 presents the neuroscience background of the proposal; Section 3 describes the key two sets of factors for mobile learning and mobile language learning; Section 4 presents the evaluation framework; Section 5 evaluates LingoBee according to the proposed framework; Section 6 summarises the work and identifies future research directions.

2 Key neuroscience lessons for learning in general and language learning in particular

2.1 Neuroscience of learning

From a cognitive neuroscience perspective, learning involves forming and strengthening neural connections and networks. Neural connections - their creation and consolidation - are at the heart of this process. As Hebb discovered very early in 1949, connections between neurons are strengthened when they are simultaneously activated – in Hebb's words, neurons that fire together wire together [Hebb 1949].

This process can be summarised by the following passage from [Schunk, 12]:

> […] we are born with a large number of neural (synaptic) connections. Our experiences then work on this system. Connections are selected or ignored, strengthened or lost. Further, connections can be added and developed through new experiences (National Research Council, 2000). It is noteworthy that the process of forming and strengthening synaptic connections (learning) changes the physical structure of the brain and alters its

> functional organization (National Research Council, 2000) […] We tend to think that the brain determines learning, but in fact there is a reciprocal relationship because of the "neuroplasticity" of the brain, or its capacity to change its structure and function as a result of experience (Begley, 2007).

Neuroplasticity is therefore what the brain does in continuing to add, delete and reorganise synaptic connections and changing structurally. In this sense, neuroplasticity is what we call "learning". However, creating a new circuit is not enough for complete learning: circuits can be transitory and/or unstable if they are not tightly rooted into the brain's structure. The question is therefore not only how do we create new circuits, but how do we make them permanent. Moreover, plasticity has to be fed throughout life to be effective: neuroscience shows that learning a skill changes the brain but these changes revert when practice of that skill ceases. Hence, the principle "use or lose it" [The Royal Society, 11, v]. This is the situation with memory and with Long Term Memory in particular.

Studies tell us that good neural networks are built by stimuli/experiences containing elements such as novelty, intensity, and movement [Schunk, 12: 43]:

- Novelty: novelty attracts attention and the brain tends to focus on inputs that are different from what might be expected. This resembles very much the notion of informativity, as it is defined in information science and semiotics and linguistics (see, for example, informativity as one of the key properties of a text according to [Beaugrande and Dressler, 1981]). Novelty influences the filtering of information and helps focusing on something in particular;
- Intensity: louder or brighter stimuli get more attention;
- Movement: helps to focus attention.

Enriched environments, where novelty, intensity and movement play a key role, can lead to improved learning outcomes [Van Praag *et al*., 00]. The standard definition of an enriched environment is "a combination of complex inanimate and social stimulation". Environmental enrichment stimulates the brain through its physical and social surroundings: brains in richer, more stimulating environments have higher rates of synaptogenesis and more complex dendrite arbors, leading to increased brain activity. The effect of environmental enrichment was originally observed in rats and later extended to humans.

Research on humans suggests that lack of stimulation delays and impairs cognitive development, while interacting in rich environments and taking part in cognitively stimulating activities results in greater cognitive reserve.

Returning to the three key elements promoting the building of good neural networks, the third, movement, is an essential condition for what we call "situated learning" [Lave and Wenger 1991], that neuroscience considers as a very favorable for an effective and deep learning. Situated learning that takes place in the same context in which it is applied: it happens exactly where knowledge is needed or generated, feeding a mechanism driven by curiosity, creativity and practical needs.

Due to the embedment within activity, situated learning can be intended as the evolution of contextual learning, occurring each time a teacher relates subject matter to a real world situation. This concept, although not completely new as Dewey [Dewey 1896] previously advocated a teaching methodology tied to the child's experiences and interests. It has a constructivist basis: learning takes place when students can construct meaning based on their own experiences. Contextual learning, and fortiori situated learning, are both directly connected with problem-solving, self-regulation, and peer-learning. The awareness that learning can occur anywhere and in multiple contexts – or even across multiple contexts at the same time - is a constant.

Incorporating context into the learning process is effective; it involves both the brain hemispheres in the process, and therefore achieves a good, “meaningful”, type of learning. As [Schunk 2012: 40] points out:

> Brain research shows that much academic content is processed primarily in the left hemisphere, but that the right hemisphere processes context. A common educational complaint is that teaching is too focused on content with little attention to context. Focusing primarily on content produces student learning that may be unconnected to life events and largely meaningless. These points suggest that to make learning meaningful—and thereby build more extensive neural connections—teachers should incorporate context as much as possible.

Taking into consideration both hemispheres and their connections to learning leads us to another key factor in the learning process from the neuroscience perspective: emotions and hormones released by emotions (and vice versa).

Both the hemispheres deal with emotional processing, the right side is more active in processing negative emotions whilst the left deals with the positive. In any case, emotions play a major role in learning and memory: they can direct attention, that is necessary for learning [Phelps, 06]; they can influence learning and memory by releasing two important hormones produced by the adrenal gland: epinephrine and norepinephrine. Certain doses of emotion is strategic for learning, whilst too much emotion can generate the opposite outcome, stimulating the release of another hormone, cortisol, that correlates with negative stress conditions, that tends to inhibit learning.

Another hormone deeply involved in the learning process, and in reinforcement learning and memory consolidation in particular, is dopamine. Its function, release and increase or reduction, appears to be correlated to a complex system of reward prediction [Daw and Shohamy, 08] and [Morita *et al.*, 13]. Reward is a relevant component of motivation that plays a major role - potentially the key role - in learning. This is why rewards are essential in the gamification process, which is currently pervading many approaches to education.

Providing that learning is essentially a process of neural network creation and/or strengthening, on the basis of what is illustrated above, we can define a set of key factors inter-playing a major role in the learning process according to neuroscience.

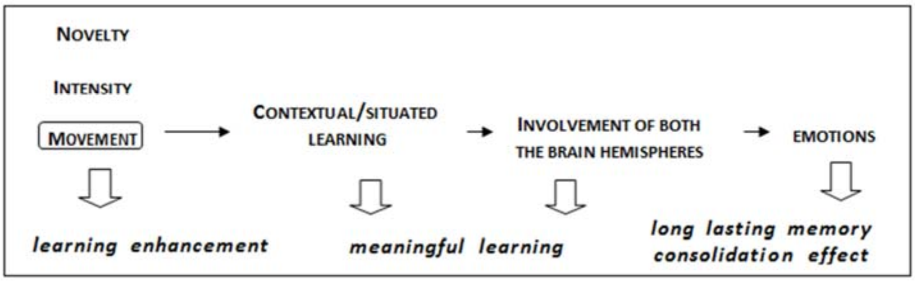

Figure 1: Key Factors for Successful Learning according to the Neuroscience of Learning

2.2 Neuroscience of Language Learning

Whilst interest in the neuroscience of learning in general is quite widespread among scholars, the situation with cognitive neuroscience of Second Language Acquisition is very different. Currently it is an overlooked area, as Goo pointed out in 2010, this aspect is currently not popular in mainstream research, and so relevant publications are rare [Goo, 10].

Even comprehensive account of neuroscience of language such as the Handbook of by [Stemmer and Whiteker, 08] only focus on already acquired language(s), without taking into consideration the learning process.

Some of the most relevant studies, such as [Schumann at al., 04], focus on the neurobiology of aptitude, motivation, procedural and declarative knowledge, memory and attention related to SLA. Some others, such as [Paradis, 04] and [Gullberg and Indefrey, 06] deal most with age effects, and especially on the Critical Period Hypothesis.

Concerning the issues addressed in this paper, it is interesting to note that according to Paradis the main difference between L1 and L2 learning lies in the gradual inability to acquire language incidentally, making use of the procedural memory system, whilst relying more and more on control processing over time. Incidental learning is something very similar to situated, contextual learning, therefore the considerations already made in relation to the general process of learning and the positive effect of situated and contextual learning can be considered valid for language learning as well.

[Howard-Jones, 14] stresses the concept of embodied cognition to understand how actions influence learning, e.g., via the enactment effect. He makes a direct equivalence between embodied and “grounded” or “situated” cognition, by explaining that memory is strongly enhanced if connected with a performance (mirror neurons are also involved in this kind of processes, so also people not directly involved in a performance but assisting to it can benefitting from it from an educational point of view). He refers to cases of increased language learning outcomes when the principles of enactment and embodied cognition are incorporated into teaching, by using gestures during classroom activities.

Embodied cognition and enactment refer to a strict link between mental content (cognition) and concrete experience, emphasizing the role of the body and biological constraints. This concept is close to that of situated and contextual learning, as it highlights the need, from a neuroscience perspective, of a strong integration with reality for a good, long lasting learning effect.

We can therefore observe a convergence of findings around a couple of factors, identified as key players not only in the general learning, but also in the language learning process. They are, first of all, the relevance of the integration between mind and body and between the cognitive experience and the concrete experience, for effective (language) learning. Effectiveness is quantified through a stronger and longer lasting memory, i.e. to a deep integration of the new content into the existing set of already stored content. In neuroscience terms, it means a constant integration of new neural connections into existing neural networks.

Secondly, incidental language learning [Paradis, 04], in relation to procedural memory system – the latter put in general terms is a deeper kind of learning - once again connects to the integration between cognition and concrete experience. At the same time, by emphasizing the incidental nature of this kind of learning, Paradis highlights the fact that good learning occurs spontaneously in a certain space and time, stimulated by something that catches our attention. What generally catches our attention is novelty, intensity and movement – and so we are again talking about contextual and situated learning.

We can therefore conclude that the elements previously identified, as key and strategic factors for learning, can be considered valid also for language learning. The above discussed references to the neuroscience of language learning seem to underline and increase the relevance of one main factor: the situation and situated learning.

3 Key lessons for mobile learning in general and language learning in particular

3.1 Critical Success Factors for Mobile Learning

Lessons learnt from experimentations carried out during the last decade have led to several different but often complementary models of successful mobile learning projects. We have chosen to focus on two of them, the first addresses general mobile learning and the second focuses specifically on MALL. A review of the two allowed us to identify points of convergence and divergence and to sketch a comprehensive evaluation tool framework to be integrated with the key neuroscience factors previously identified.

The first model is that by [Naismith and Corlett, 06]. They processed data and findings from mLearn conferences between 2002-2005 and identified five crucial factors for operating a successful mobile learning project. These factors are described by these authors as ‘Critical Success Factors’ or CSFs.

The first CSF is access to technology, intended as a practical constraint affecting the equity issue: “Whether provided for, or by the learner, successful mobile learning projects make mobile technology available […]There are many reasons for this including the need for equity, the desirability of a common platform (etc.)” [Naismith and Corlett, 06].

Institutional support, the second CSF, concerns the involvement of the whole learning context, i.e. not only teachers and students but also managers and other staff. This is related to the "environmental" nature of MALL, as it is intended to be without boundaries and should not encounter barriers such as, for example, the prohibition of taking pictures or connecting to the internet due to institutional rules.

The third CSF covers connectivity: "Successful mobile learning projects incorporate wireless network access, whether through local wireless LAN, or over the mobile telephone networks." [Naismith and Corlett, 06].

Integration, the fourth CSF, concerns the embedding of MALL projects into the learning context. It can be in relation to the curriculum, on one side, and/or with the students' real life experiences - but it can also be easily argued that the curriculum, is in fact, one of the students' real life experiences, so this factor can just be seen as integration with context in general.

Ownership of device, the fifth and last CSF, highlights the difference of impact on learning depending on owing the device vs. using an additional, ad hoc, one.

We summarize those CSFs in the table below, by suggesting a classification according to the main type of factor: technology, i.e. related to the specific features and functionalities of the devices; organizational, i.e. related to the overall learning system and setting, composed of all institutional and non-institutional agents and actors; and pedagogical, i.e. concerning the way teaching and learning is designed and implemented. It is worth remembering that this model is conceived for mobile learning in general, i.e. it is not focused on language learning in particular.

Five Critical Success Factors by Naismith and Corlett 2006					
	1	2	3	4	5
factor	access to technology	institutional support	connectivity	integration	ownership
type of factor	technological	organizational	technological	pedagogical	organizational

Table 1: Five Critical Success Factors according to [Naismith and Corlett, 06]

3.2 Principles for Mobile Language Learning

Having considered the main literature from MALL, ML, and CALL; Stockwell and Hubbard [Stockwell and Hubbard, 13] proposed Ten Principles for Mobile Language Learning. These principles are intended to support the design and implementation of mobile language learning applications; as well as relevant tasks using native mobile functionalities.

Principle 1 states that mobile activities, tasks and apps have to take into account the affordances and limitations of mobile devices and the environment.

Principle 2 recommends limiting multi-tasking and environmental distractions. It is not against multi-tasking per se - "mobile environments by their nature are likely to be distracting, and multi-tasking is a natural part of that environment" (page 8) – it is rather a caveat with reference to problems in learning generated from uncontrolled process.

Principle 3 concerns the so-called "push and pull mechanisms" whilst the pull mechanism is typically associated with the more traditional CALL, where the learner has to search or at least to find the way to access learning materials, the push mechanism pushes information onto the learners device, typically in the format of a text message (e.g. via WhatsApp). This can prompt learners to action [Stockwell and Hubbard, 13: 8], so MALL design has to plan when and how to push content to learners.

Principle 4 is about equity - affordance of devices but also gender, (dis)ability and any other possible inequality factors.

Principle 5 regards language learning styles and differences among learners in spaces and conditions of learning.

Principles 6 and 7 provide suggestions about how to deliver content in order to get the best impact: taking account of learners' usage, culture of use, coupled with the requirement for learning a new skill (principle 6); keeping mobile language learning activities and tasks short and succinct when possible (principle 7).

Principle 8 suggests that the learning task has to fit the technology and environment and vice versa, meaning that timing and space/context have to be taken into consideration when designing the MALL framework – giving special attention to the different possibilities due to the mobility of the learner as well as of the technology [Kukulska-Hulme, 13].

Principle 9 concerns learners' needs for guidance to effectively use mobile devices for language learning: "Although the device may claim to be intuitive, using them for language learning is not. Similarly, the literature from CALL on collaborative learning supports the idea that training for collaboration may be beneficial" (pages 9-10).

The last principle, no. 10, suggests to take into consideration and possibly involve multiple stakeholders, the most important being teachers and learners. They have to be provided with motivational and preparation support. This principle should be considered in relation with principle 2 limiting multi-tasking and environmental distractions) when the learning context is defined to prevent potential conflict with other types of learning occurring at the same time.

Similar to the approach taken with the five CSFs by Naismith and Corlett, below is a table summarising the ten principles for MALL by [Stockwell and Hubbard, 13]. In order to make the comparison between the two models easier and more readable, we have used the categories adopted with the first model. They are in fact very similar so the convergence to the same terminology is quite natural: when Naismith and Corlett refer to technology-related aspects, Stockwell and Hubbard use the term "physical issues" and the reference to pedagogy is the same. The only difference seems to be the definition of "psycho-social" issues by Stockwell and Hubbard, meaning a mix of aspects ranging from privacy, the need for support to increase the perception of mobile devices as learning tools. As the aspects taken into consideration within that scope could be easily attributed to pedagogical or organizational ones, it was easy to replace those definitions, in order to ensure consistency for the comparison.

Ten Principles for Mobile Language Learning by Stockwell and Hubbard, 2013 (1-5)					
	1	2	3	4	5
Principle	consider mobile devices' constraints	limit multi-tasking and distractions	push, but respect boundaries	ensure equity	consider language learning differences
type of principle	technological	technological	pedagogical	organizational	pedagogical

Ten Principles for Mobile Language Learning by Stockwell and Hubbard, 2013 (6-10)					
	6	7	8	9	10
Principle	consider learners' cultures of uses	keep learning activities short	ensure the task fits the technology and vice versa	provide guidance and training	recognize and accommodate multiple stakeholders
type of principle	pedagogical	pedagogical	technological	pedagogical	organizational

Table 2: Ten Principles for Mobile Language Learning according to [Stockwell and Hubbard, 13]

4 Evaluation Framework

In this section we propose the creation of a model for evaluating mobile language learning applications in the context of the research presented above.

This model is composed of a set of factors of different nature – neuro-scientific, technological, organisational and pedagogical. The model has been constructed this way to provide a comprehensive account of what plays a major role in ensuring effective language learning via mobile devices. The resulting evaluation framework is intended to aid learning designers, educational providers and teachers, in selecting the right tool, in planning and implementing activities and in evaluating results. The ultimate goal being, to improve the learning experience when employing mobile learning, to improve the learning outcomes.

The evaluation framework hereby presented integrates the criteria from the neuroscience field as well as from mobile (language) learning. Despite the limited number of studies used in our model, we know from the basis of our field trial experiences that most – if not all – of the important elements have been identified. Nevertheless, this is a first proposal, which can be refined, improved and enriched via evaluation trials and case studies.

In the following table, the two models for successful mobile learning are compared with each other and the findings highlighted from the neuroscience of learning. The factors and principles at issue are listed in the first column on the left, whilst the last column on the right points out the main outcomes of the whole comparison. The key factors/principles of m-learning are a summary of the five-plus-ten elements described above that have been gathered and synthesised to make the model shorter and easier to handle. Note that, in contrast to previous approaches, neuroscience comes last in this presentation, again for easier use.

	CSFs MODEL	PRINCIPLES MODEL	NEUROSCIENCE MODEL	COMPARATIVE REMARKS
TECHNOLOGY				
ACCESS: -equal access -connectivity	1; 3	4	--	Most relevant elements/indications: - take into proper account technological constraints when design learning environment - ensure good and equal access to technology and connectivity
MOBILE CONSTRAINTS: -multitasking -tech/task relationship	--	1; 2; 8	--	
ORGANIZATION				
INSTITUTIONAL SUPPORT	2	10		Most relevant elements/indications: - ensure institutional support and the involvement of all key stakeholders
OWNERSHIP OF THE DEVICE	5	--		
EQUITY	1	4		
PEDAGOGY				
Integration	4	--	situated learning	Most relevant elements/indications: - promote contextual/situated/incidental/embodied learning - provide guidance and support - promote personalized and adaptive learning
Push mechanism	--	3		
Learning differences	--	5-6		
Guidance & Training	--	9		

Table 3: Comparison between the Mobile Learning models analysed and the Neuroscience background

With reference to Bloom's taxonomy [Bloom *et al.*, 1956], we have organised the main evaluation criteria from the comparison illustrated in [Table 3] – excluding the neuroscience ones – onto three different levels. The first one, starting from the bottom, is made up of technological features. They create the base of the pyramid due to their structural relevance – it's quite tautological that technological aspects cannot be anything other than essential to technology-based learning. The second level is about organisational aspects, they are not as strategic as the other two – if the organisational layer is removed, the pyramid still exists. The top layer concerns pedagogical aspects. Results from the models previously analysed and based on our experience to date, pedagogical factors are crucial in achieving the expected result.

Last, but by no means least, we present a diagram of key neuroscience of (language) learning factors. Having summarise them as far as possible, we have linked the three elements that build good neural networks according to [Schunk, 12: 43] the creation of situated learning, seen as the convergence point of a series of elements and process and leading towards a good kind of learning that passes through the generation of positive emotions and the involvement of both the brain hemispheres.

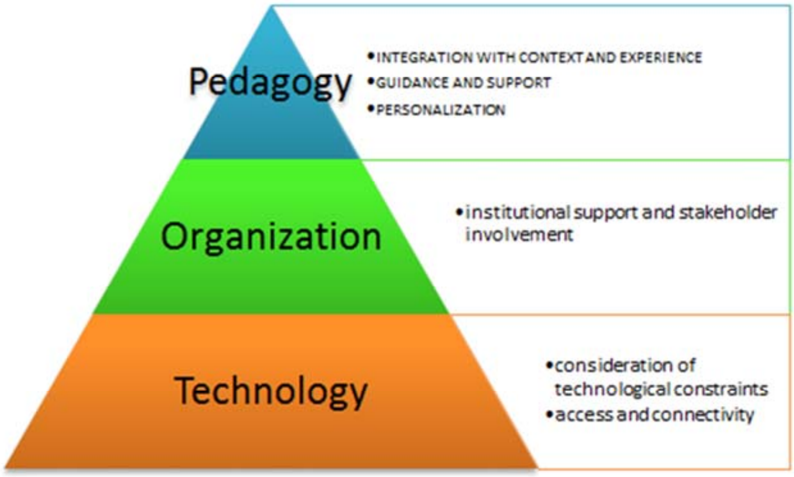

Figure 2: Pyramid of Successful Mobile Language Learning Design

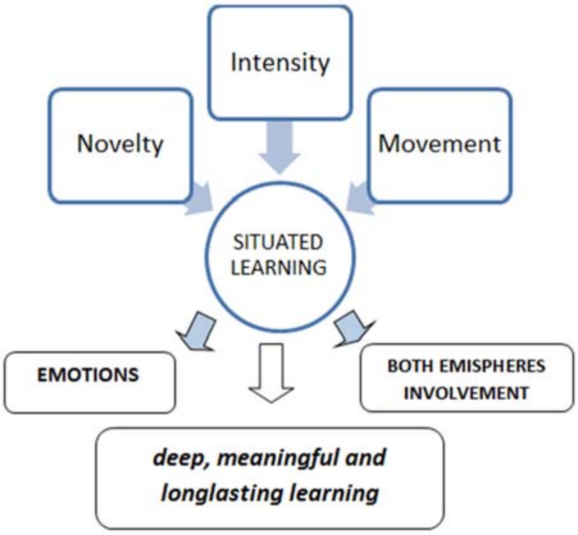

Figure 3: Diagram of the Key Elements and Processes to Obtain a Successful (Language) Learning.

5 Evaluating LingoBee

In this section we attempt to analyse and evaluate LingoBee according to the framework defined in the previous section. We start from the technology, organisational and pedagogy-related aspects, as schematised in the pyramid above, and then move onto consider the app from the neuroscience perspective, following the diagram drawn above.

5.1 Technological aspects

During the trials of the LingoBee app, access and connectivity were duly considered in order to favour learners' participation and active use of the app. These aspects also imply the ownership of device, representing an interface-element that can be related to other aspects – e.g. organisation and pedagogy. To overcome issues of ownership, and in consideration of the fact that ownership could affect regular use of the device, most of the trials were run with a device that was provided by the project for the duration of the trials. The devices provided were specific models of Android phones that were chosen as they would best support the app. Some trials had additional participants who used their own Android phones as well. The most prolific user of LingoBee in the Study Group (UK) field trials was a participant who downloaded the app onto her own personal Android device as well as using the Android phone provided during the trial. In some cases we observed problems and limitations of LingoBee use due issues with managing multiple devices (e.g. carrying their own personal device plus the Android phone provided during the trial).

Depending on the local connectivity conditions of each field trial, different approaches were taken, e.g. in Norway only the device was provided as there was great wifi coverage on campus. In the Study Group (UK) trials participants were provided with the device and a contract including data, and a similar approach was taken in Italy. Providing devices with contracts significantly increases the costs of providing the devices. In the UK trials issues surrounding limiting the users ability to run up significant additional charges existed. This was in part to do with the choice of using a group contract, rather than offering a contribution towards the cost of a mobile phone contract. The different solutions adopted ensured adequate connectivity to all participants, and differences in the use of LingoBee were not due to any connectivity problems.

The design and development of the LingoBee app took place within the SIMOLA project, as the core part of an experimentation largely based on a participatory design process. LingoBee was the outcome of a deep re-shaping process of the previous Cloudbank app, developed within a six-month project funded by the UK Joint Information Systems Committee (JISC) to explore the use of novel technologies in the Higher Education sector. Cloudbank was a lightweight, mobile- and web-based system that enabled international students in the UK to pool and negotiate their knowledge and understanding of the local language and culture. The system allowed students to collect, annotate and tag interesting or intriguing language- and culture-related content found in everyday life, including text, images and other media. Cloudbank was formatively evaluated with international students and EFL teachers over a period of five weeks at the International Study Centre (ISC) at the University of Sussex, UK. The results of the evaluation led to a range of design recommendations on how the system could be improved and further developed to better meet the needs, expectations and preferences of students and teachers. After securing funding from the European Commission's Lifelong Learning Programme (LLP) to develop and evaluate the system on a European scale, these recommendations provided essential design guidelines for the development of LingoBee. Apart from changes relating to the now international context, such as the ability to localise the user interface for different cultures and the ability to create user groups for separate target languages and regional contexts, several new features in LingoBee were informed directly by the CloudBank evaluation:

User identities and profiles: While Cloudbank was an anonymous system where content was not associated with its contributor, LingoBee introduced user identities and links content to specific users. To make this acceptable to users concerned about privacy, the signup procedure only requires minimal information and makes the completion of a full user profile optional.

Multiple entries: CloudBank essentially worked like a Wiki where content submitted by one user could be edited by everybody else to successively extend and refine it, LingoBee therefore abandoned wiki-style content editing and instead provides functionality to add and browse multiple definitions, comments and media per entry.

Content ratings: LingoBee integrates a rating mechanism that promotes popular content to the top of the list of definitions whilst weaker contributions sink down and become less visible.

Categories: While CloudBank had an advanced tagging system supporting user-defined categorisations of content and tag filtering for the creation of ad-hoc interest groups, student feedback indicated that they did not understand the concept of tagging. LingoBee consequently abandoned the unused tagging system and instead introduced categories which could be selected and customised by teachers for each user group.

Pronunciation support: While CloudBank provided audio-recording functionality to enrich entries with spoken examples of how words might be used or with contextual soundscapes, students emphasised that pronunciation support could be the single most helpful feature of the system. LingoBee provides Text To Speech (TTS) functionality but at the same time supports user-generated audio allowing teachers to record pronunciation examples.

In addition to these higher-level changes aimed at broadening the range of pedagogical use cases and to improve students' learning experience, several other changes were made to make LingoBee more useful and usable than its predecessor. These included improvements to the user interface with revised terminology, more friendly colour scheme and support for swipe gestures, as well as technical improvements such as support for offline operation and multiple screen resolutions.

Figure 4: Detail view in the LingoBee mobile application. Annotations indicate new and improved functionality relating to user groups, user profiles, text-to-speech functionality, support for multiple definitions or notes per entry, favourites list, content ratings and content moderation

5.2 Organisational aspects

Institutional support concerns the involvement of the whole learning context, i.e. not only teachers and students but also managers and other staff.

In our experience, institutional policies in the field trials were generally supportive of mobile learning or neutral regarding it, with differences according to each field trial location. For example, at Bellerbys College, Oxford, the institutional policy was one of the least supportive as at the time mobile phones were not allowed to be used in the classroom. Notices in each classroom stated that they were not to be used in class. At the start of the trials the other teachers were asked to support the trial, but not specifically told to allow the phones to be used in their classrooms. This certainly hampered the first set of trials as it was an additional barrier for the students involved to overcome. When the second trial was started the researcher/teacher taught them for a higher percentage of their lessons and allowed and encouraged the students to use the mobile phones in class. This second trial group was far more successful at integrating the use of LingoBee into their everyday learning as discussed in [Adlard *et al.*, 12], [Procter-Legg *et al.*, 14], [Petersen *et al.*, 13] and [Petersen *et al.*, 14]. At the University of Campobasso, Italy, there was no specific rule (and there is still no rule) about mobile phones in class, each teacher is allowed to decide his or her own policy.

5.3 Pedagogical aspects

In light of our experiences with LingoBee, the integration with real life is more than a success factor: it is a pre-condition of mobile learning, due to the nature of the mobile experience per se. The issue is, rather, the degree in which users can incorporate mobile learning into all other learning and non-(explicitly)-learning experiences. Integration with the curriculum can be relevant, but it depends on the specific purposes of the project and on the students' needs. This is a very crucial aspect, lying at the intersection between pedagogy and neuroscience grounding of the overall approach. We will get back to this point below when analysing LingoBee in the neuroscience perspective.

Regarding the so-called "push and pull mechanisms", push system can prompt learners to action [Stockwell and Hubbard, 13], so MALL design has to plan when and how to push content to learners. Our experience with LingoBee confirmed the relevance of this issue and that is the reason why we reflected upon the need of seeding the app by providing a small set of already created and packaged content when starting using the app. Initial reflections on the trial of Cloudbank suggested that 'seeding the system with model entries might be helpful to learners' [Pemberton and Winter, 11]. This approach was taken on a limited basis by some of the trial groups to test out whether this was the case.

Learners' needs of guidance to effectively use mobile devices for language learning is a very crucial issue. As we experienced directly with the first round of trials with LingoBee, it is a mistake to take it for granted that learners will automatically engage with language learning because they are digital natives. As they are digital savvy, students are assumed to be ready, motivated and autonomous in performing the tasks they are asked to do. This can be really misleading: on the contrary, light but constant and targeted support is needed for the learning to be successful [Petersen *et al*., 14].

In previous works we analysed the findings of the trials in order to achieve an understanding of this aspect. We analysed the general teaching philosophy of teachers involved in the trials, with specific references to the teaching/pedagogical approach, the teacher's familiarity with technology and, above all, the learner-centred vs. teacher-centred approaches to the trials.

We concluded that the degree to which learner contributions were encouraged and supported – with contributions discussed in class, contributions added outside of lessons influencing the content of future lessons etc. - was positively correlated with a higher engagement, higher level of content creation and, finally, higher proficiency level in target language. This latter aspect displayed also a "reverse effect": Cloudbank results which appeared to show that the higher the language competency of participants was, the more likely it was that the user group would be successful when left to their own devices." [Adlard *et al*., 12].

5.4 Neuroscience related aspects

As we tried to schematise in [Figure 4] above, the most powerful factor to get a positive learning effect from the neuroscience perspective is the close integration with context. Several different terms and descriptions have been given and reported above, such as contextual, situated learning, embodiment, incidentality, enactment. Each of them highlights a peculiar aspect of one single concept describing the active creation of a quite sudden, unpredictable relationship between the learner and a particular object selected among a number of others due to its characteristics of novelty, intensity and movement. The close integration of the learner with the environment – conceived as a whole potential learning scenario – favours the involvement of both the brain hemispheres, while the pleasure given by the creative content creation and sharing process activates the release of key hormones for long-lasting memory fixation.

LingoBee app is conceived and developed, since its first release as Cloudbank, to make possible and promote the creation, the processing and the enrichment of the knowledge relationship described. It is intrinsically contextual and situated learning-oriented, due to its functionalities – multimodality and crowd-sourcing *in primis* - and, of course, to its native mobile nature.

We analysed several aspects of this learning process in other papers, also investigating the creativity potential LingoBee helps to develop and spread [Petersen *et al.*, 14]. Creativity is something difficult to explicit but it has a close, direct implication with, first, the mentioned factors of novelty, intensity and movement, and, secondly, the integration of these elements with the learning object and the previous knowledge of the learner in the situated learning process. We observed the unpredictable, spontaneous occurrence of peculiar moments of learning creation, stimulated by the casual convergence of attention to something that in a certain time and space attracts us for its beauty or strangeness, and we called them "LingoBee moments" [Adlard *et al.*, 12]. They are similar to what some authors call "eureka moments" or "a-ha moments" [Kounios and Beeman, 14] , and are the best examples of what LingoBee can do to enhance effective language learning while meeting all key neuroscience of learning constraints.

6 Summary and Future Work

In the previous sections we tried to identify the main factors that influence the success of mobile language learning activities.

This research has been conducted in two distinct fields: the neuroscience of learning/of language learning, on the one hand, and mobile learning/mobile language learning, on the other. The decision to include neuroscience came from the intention to provide the evaluation process with a stronger scientific background, to be directly linked to the more traditional empirical research.

On the basis of the results obtained, we tried to outline an integrated evaluation framework, associating technological, organisational and pedagogical elements to neuroscience ones. We applied the resulting framework to provide an overall evaluation of the LingoBee app, developed within the SIMOLA EU funded LLP project. The authors of this paper took direct part in its technical development (Winter) and/or its testing (Cacchione, Petersen and Procter-Legg) in different EU countries (Italy, Norway and the UK respectively) with different target groups. The evaluation results confirmed the validity of the app in terms of correspondence to the established evaluation criteria, also highlighting considerable room for improvement, already identified during the testing phase.

The main evaluation outcome can be summarised as follows: the key issue, at the crucial convergence between neuroscience and pedagogy, is how much the app can promote real contextual language learning, because this is the best kind of learning that mobile technology can offer and it is the most effective in terms of creation and consolidation of strong and stable neural networks. Beyond the specific results about LingoBee and the related suggestions about possible improvement areas, the value of this proposal lies in offering an open tool to perform pre-, in itinere and post-intervention evaluation in case of new mobile language learning paths.

As far as we are aware, there are few evaluation schemes and none of which includes neuroscience, so this integration represents the main value added by our proposed framework. The field of neuroscience is growing in importance, even though, studies specifically focused on language learning are still very few and far between. In this sense, the framework can act to further promote interest in the neuroscience of language learning. It also helps to promote the evaluation practice whilst, at the same time, trying to unify the different existing models.

Different and interesting development scenarios are taking shape, not only in relation to LingoBee but also in relation to other mobile language learning tools. The validity and usability of our framework can be further assessed by the future evaluation of other language learning apps currently available. In this scenario, both the framework and the apps to be evaluated can be improved. Several studies have recently been conducted about mobile learning apps, exploring their design and functionalities, but none focus on a comprehensive evaluation scheme, e.g,. [Fallon, 13], [Huber and Ebner, 13], [Khaddage and Lattemann, 13], [Harmon, 12], [Godwin-Jones, 11]. Some others, such as [Kim and Kwon, 12], present evaluation criteria very similar to those we have taken into consideration for technology, organisation and pedagogy.

On the other side, the framework can be used to design new mobile language learning tools and environments. Given the current technological and socio-economical trends, it is easy to forecast that the mobility of the learner and of the device [Kukulska-Hulme, 13] will continue to expand and increase, by conquering new spaces and times in our lives. Instructional designers, learning technologists and teachers have to be ready to take on this challenge for the benefit of larger and expanding groups of different users, and to make use of affordable, friendly and flexible tools to make critical and scientifically-grounded didactical choices.

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