State of the art on orchestration techniques of mobile learning activities

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Abstract—**The purpose of this article is to do a literature review on orchestration activities of mobile learning that is used in the context of field trip scenarios or museum visit. Indeed, much work has been done in this area however; we do not find a general framework for the design and the implementation of these mobile learning activities.**
For this reason, in this article, we did a study on the different orchestration systems of resources and learning activities that are able to support the collaboration and location of learners and their historical during the course of the field trip.

Keywords— Mobile learning; field trip; scenarisation; orchestration; recommendation;POI; learning activities

I. INTRODUCTION

With the development of mobile technologies and the widespread use of smartphones, the users integrate these new devices in their learning processes. In this context, mobile learning has been recommended to motivate learners during field trip [1] because it allows visitors to build their own knowledge by collaborating with the others.

However, this device of learning must be individualized and learner-centered because it is a located process which integrates an implicit collaborative that occur wherever visitors have problems to solve or knowledge to share [2]. Field trips or museum visits can enhance the training system because they direct the process of learning by allowing mobile learners to better construct their own knowledge [3].

In the spatiotemporal context, orchestration manages in real time learning activities such as reading text, video viewing, testing, feedback, work group, etc. but it generates significant costs of tutoring. On the other hand, the learner must control these choices and his path, and should not undergo the tutoring actions imposed by the instructor of the visit [4].

In this article, we will make a state of the art on different technical of the orchestration of mobile learning activities by focusing on their strengths and their weaknesses in order to define a software framework for the design and execution of mobile learning scenarios. In the Section 2 of our article, we presented an overview on some definitions of the mobile learning. Then, in Section 3, we focused on the dimensions that can be integrated into the framework of the scenarios of field trip. In Section 4 of our article, we explained the spatiotemporal characteristics related to our mobile learning scenario. Finally, in the last section, we cited different techniques of the orchestration of mobile learning activities that can be applied in the context of field trips and museum visits.

II. MOBILE LEARNING

Mobile learning has become a very popular topic of research because there are many areas of research that address the topic from different points of view.

Y. Laouris defines mobile learning as a function which depends on several parameters such as time, space, the learning environment, content, technology, learner profile and the used method [15]. A. Derycke considers mobile learning as a e-Learning version that is adapted for mobile learners in the aim to deliver distance learning in media like Smarphone, IPod, IPad, games console, etc. [6]. According to M. Sharples, mobile learning can be defined as a personal and public process able to explore the knowledges and the linking of different contexts involving other people and interactive technologies [21]. M. Laroussi think that mobile learning is only part of a whole that contains learning tools, infrastructure support, contexts and people are distributed in time and space. It allows learning in context, but also through contexts [16].

In our opinion, the definition of mobile learning is always about to change because it must adapt each time to new physical, technological and educational contexts that are closely related to various fields of application.

III. DIMENSIONS RELATED TO OUR MOBILE LEARNING CONTEXT

The dimensions used in the context of educational visits or museum visits can be divided in two: kinds: Dimensions that are independent of application domain such as location, type of Smartphone, etc. [9] and dimensions that concerns the context of the learning process as the learner profile, the activities to do, social aspects, etc. [10].

A) The time dimension

The time dimension can be used as part of a field trip to determine the time zone and the present time of the learner. It also clarifies the beginning and end of a visit, duration of

activities, time consultation of a resource and the schedule job. For example, you can annotate the pictures and videos associated with a museum visit by their time creation related to their locations. This Dimension can also be used as a temporal relationship for example: after, before, in, starting from, since, etc. for doing the real-time management and the planning tasks of mobile learning [11].

B) The spatial dimension

This dimension describes the physical location of a learner in a geo-referenced system using geographic coordinates. It can also specify a virtual location in a network with an IP address.

C) The dimension of devices

This dimension concerns mobile devices (PDA, the Smartphone, laptop, tablet, etc.) and pervasive devices (large LCD screens, terminals, fixed sensors, loudspeakers, etc.). It also describes computing resources (CPU power, the bandwidth, drivers, operating systems, etc.) and specific educational tools to Learning activities of the learner in a specific context.

D) . The dimension of the learning

In some systems it is necessary to measure characteristics of the environment around the user in order to trigger an alarm or to regulate the Operating system. The information acquisition of this dimension can be made by techniques and sensors such as photodiodes, color sensors, infrared and ultraviolet sensors, thermometers digital, microphones, etc. [12].

E) The content dimension of learning

The term "learning object" emerges since 1990 through LOM (Learning Object Metadata), which offers a standard in the early 2000s. The appearance of LMS engenders the technical operation of learning objects hence the appearance of SCORM that enriches LOM standard by including an aggregation and an execution environment model to monitor the activity of a learner in a LMS. Ten years later, the creation of IMS Learning Design allows the integration of the activities in the design of learning situations [13].

F) The user dimension

The user in our learning system is the learner, the visitor, the instructor (teacher), tutor (guide), etc. It can be described by information which is collected by the system. This information is classified into two parts: A section describing general information about the user such as name, surname, age, date of birth, nationality, mother tongue, etc. The other part concerns the goal by learners after the visit according to their preferences, interests, etc.

G) The dimension of the scenario

There are many models that can be used for modeling the scenarios in the literature: the IMS LD model [14], the Hierarchical decomposition model, the task model hierarchical [15], the graph model, and the model of workflow or the UML activity diagram. The choice of one of these models depends on the specificities of the behavior model to adapt for the mobile scenario

IV. THE SPECIFICITIES OF A FIELD TRIP SCENARIO

According to [16], the activities of the field trip may generally be divided into three distinct phases: 1) "pre-trip" phase that allows for planning the field visit, 2) the displacement itself as a second phase, and finally 3) "post visit" phase that include follow-up activities such as visit reports, presentations, tests and / or feedback.

The first phase is dominated by the work of the teacher, while field visit and the last phase are based much more about the activities of learners. The location of the visit could take place outside of the classroom, while the phases "pre-trip" and "post trip" may occur inside or outside of the Classroom [17].

When teachers plan the visit, they must prepare tasks to be done by the learners during their field trips. These tasks are very specific to the domain of learning and to the formal objectives of the field trip. However, during their displacements, the mobile learners will undertake several activities that can differ of the assigned task and goals. The majority of activities done by learners concern the data collection through photos, video recordings, conducting interviews or note taking. The last phase of the visit is usually performed inside the classroom by small groups or with the whole class. The focus will be made on results of the educational visit and data collected. Generally, learners will present their results to the teacher in classroom for more discussions and reflections.

For this, the educational visit scenario is divided into three parts [3]: 1) the first part called "Static layer" contains a set of main activities to do as part of the lesson plan predetermined by the teacher. This layer aims to conserve the consistency of the mobile scenario thanks to the supervised learning. 2) The second part (the layer of variants by profile) allows customizing the content of the training in order to respond to spatiotemporal context that depends on the profile of the learner and the history of the visit. In a given context, teachers can individualize the mobile learning path by eliminating variants that are not relevant to field trip objectives. 3) And the last part (the open part) of this mobile scenario is executed in unexpected circumstances that define an unexpected context during the design phase. These new variants emerge in real time during the course of the visit and must be well documented in the "post trip" phase to enrich the mobile learning scenario.

V. TECHNIQUES OF THE ORCHESTRATION OF MOBILE LEARNING ACTIVITIES

The pedagogical scenario can be defined as: "A scenario is defined as a description performed of unfolding of a learning situation aimed the appropriation of a specific set of knowledge, specifying the roles, activities, resources, tools, services and outcomes associated with the implementation of the activities"[18].

The term 'orchestration' refers to the real-time management of educational graphs whose activities are located in distinct

planes (individual, group, class, community ...) and link layers of digital and physical information [19].

One among the problems of the Learning Technologies is the adaptation of educational resources depending on the location and the historical of the learner. In general in learning environments, the orchestration of mobile scenarios helps organize resources and learning activities to motivate learners to construct their own knowledge with the others.

Mobile devices can be used to provide learning resources to learners almost anywhere and anytime but the main platforms of learning do not allow teachers to contextualize learning activities. Therefore, the tutors cannot anchor activities or learning resources to their right places during the field trip [4].

For this, we will present the different technical of orchestration able to help the learner during his field visit.

These techniques can be categorized into two approaches: 1) the centralized approach using a LMS (Learning Management System) or a CMS (Content Management System) for the orchestration of mobile learning activities and 2) a decentralized approach based on other environments more specific to the context of learners.

A) The centralized approach

As part of a field trip scenario, there is two types of learning: 1) formal learning which is explicitly designated by the instructor of the visit through the objectives to achieve, the resources to read, the activities to do during the visit 2) and Informal learning that is not structured with educational objectives because it has an unintentional character of the part of the learner.

For that, this approach should find a balance between an environment centered on the teacher that respect the structure of the scenario script of the visit (objectives, resources and activities) and a learner-centered environment that is based on personal activities, interactions and Collaboration [20].

In this context, we classified various works on field trips in the two approaches:

1) The teacher-centered approach

This approach is based on the use of a LMS that ensures a global view of the teacher on all activities of learners. However, there several types of prototypes are enrolled in the context of this approach. For this, we decided to classify these works as follows:

a) Use of plugins in the LMS

The adaptation of content available in E-learning version to the reduced screens of smartphones causes problems linked to the display resolution, the visibility of documents, etc. Therefore, the M-Learning applications can be considered as extensions of tools offered under the E-Learning.

For example, in the Open Source world, there is a MLE-Moodle plugin that adds the M-Learning functionality to Moodle for creating scenarios such as quizzes, or final tests, etc.

b) Integration Web 2.0 technologies in LMS

As part of learning, Web 2.0 technologies such as blogs, wikis, etc. can be integrated into a LMS in order to benefit of the contributions of active teaching imposed by the instructor during the course of the visit. These technologies allow learners to make a collaboration orchestrated by the instructor of field trip. For example, the integration of blogs or wikis, etc. in the Moodle 2.0 platform reduces the rigidity of learning activities offered by the LMS.

c) Use of CSCBLs

Contrary to previous work on CSCL (Computer Supported Collaborative Learning) platforms that have shown their incapacities to manage learning mobile activities, CSCBL (Computer Supported Collaborative Blended Learning) platforms can be used in the context of field trips.

This kind of platforms may allow Collaboration based on the use of a LMS and the orchestration done by the instructor. It coordinates the activities occurring in different places thanks to new mobile technologies [21].

d) The language IMSLD

The IMSLD language seems well adapted to the context of field trip or museum visit because it offers conceptual framework that puts the activity in the central of the process of educational design. Then it identifies the relationship between activities, roles and resources.

This language defines three design levels (A, B, C). Level A is used to describe the basic elements of the learning unit and common elements to all learners. Level B is used to define control conditions for the conduct of the scenario and properties related to different roles. Level C, by a notification system enables the orchestration of activities and gives them the ability to run the same learning unit in different ways [22].

On the other hand, an IMSLD course can be integrated into an LMS structure. For example, in the case of Moodle, the integration of IMSLD is performed using the resource, "Add IMS Content Package file"

e) The mashup platforms

This kind of learning platform can be used in context of field trips to integrate APIs or Web Services necessary for taken into account of the location of learners and collaboration.

For example, using the Google Maps API for location of learners who are enrolled in an E-learning platform can be considered a good example of mashup platforms.

In [23], the authors show another example of application of composition (mashup) through an ubiquitous annotation system. This environment allows students and teachers to edit, annotate and publish some learning content during the course of the visit.

Moreover, the authors of [24] developed a Wiki based on a geo-spatial mashup platform for mobile collaborative learning. This work can be considered as another example of mashup platform that can support collaboration of learners during the visit.

Thereafter, Table I summarizes the main characteristics which may be included as part the teacher-centered approach.

TABLE I. CARACTERISTICS OF TEACHER-CENRED APPROCH

Works	LMS plugin	LMS + Web 2.0	CSCBL	LMS + IMSLD	Mashup plateform
Support the spatiotemporal context	No	No	Yes	No	Yes
Interaction between participants	Chat+ forum	Chat + forum	Chat + forum	Chat + forum	Chat + forum
Enrichment scenario	Instructor	Instructor	Instructor	Instructor	Instructor
Real-time collaboration	Chat+ wiki	Chat+ wiki	Chat+ wiki	Chat+ wiki	Chat+ wiki
Integration of 3 phases of field trip	Yes	Yes	Yes	Yes	Yes
Support the unexpected Context	No	No	No	No	No

2) The learner-centered approach

Personal Learning Environment (PLE) is based on the Web 2.0 services and social networks. They focus on the user who will build his learning environment by the aggregation of web services and social networks relevant to a given center of interest. The concept emerged from the appearance of Web 2.0 services and the reaction of the institutional control of the learning environment [25].

Thereafter we have cited the work that enables integration of field trip scenarios based on the learner-centered approach.

In the "Ambient Wood" application, the context is mainly supported by the use of the GPS system to define the location of learners and provide relevant information and services. This is done for the activities of the exploration phase of the fauna and flora in the forest. PDA learners provided information in response to readings from sensors on humidity and light at a specific location or an indication of the physical presence of a student in a particular location (via GPS). This application integrates the notion of context management based on the geographical location but does not allow learners to interact with each other to build new knowledge through the exchange of comments or resources [26].

In [27] and [28], the authors study the birds and butterflies using mobile devices. During the field trip, students will take pictures and try to compare them with those already stored in the database accessible via an ad hoc wireless network. This type of application focuses on outdoor activities but gives little interest to the enrichment of the learning scenario of the visit. On the other hand, the evaluation activities and the analysis of feedback are done during the finalization phase.

The ENLACE project [29] focuses on enriching the mobile activities with learning resources because it allows a seamless integration of learning objects in the system. However, the architecture adopted for this project does not support real-time changes associated with different suggestions of learners.

In the RAFT project [30], a system was developed to support the creation of mobile applications that facilitate data collection during the visit and the integration of the collaborative activities after the field trip. This project can be considered as a new paradigm of learning, because it supports constructivist learning process in real-world contexts. One of its main objectives is to generate metadata for each new context of the visit. However, the difficulty lies in the combination of activities during the visit and the choice of activities to do in class.

LEMONADE ("Learning Environment for Mobile Network-Able Devices") is an environment that allows flexible creation of mobile learning scenarios. It offers flexibility to provide a generic approach for the description of scenarios associated with the full cycle of field trip. LEMONADE combines the activities done on the ground with other classroom learning activities as brainstorming or group activities. However, this tool cannot be used in the case of a learning scenario that cannot be planned in detail during the design phase [17].

Table II summarizes the main characteristics that can be integrated into the frame of a learner-centered approach.

TABLE II. CARACTERISTICS OF LEARNER-CENRED APPROCH

Works	Ambient Wood	[27] [28]	ENLACE Project	RAFT Project	LEMO-NADE
Support the spatio-temporal context	Yes	Yes	Yes	Yes	Yes
Interaction between participants	Chat	Chat	Chat	Chat	Chat
Enrichment scenario	Instructor learner	Instructor learner	Instructor learner	Instructor learner	Instructor learner
Real-time collaboration	No	Exchange comments	Exchange comments	Exchange comments	Exchange comments
Integration of 3 phases of field trip	pretrip+ visiting phase	Yes	pretrip+ visiting phase	Yes	Yes
Support the unexpected Context	No	No	No	No	No

B) The decentralized approach

The scenario of field trip is characterized by the absence of a global model for conduct of learning activities and the great freedom given to learners.

In this context, the learner may have a local view of all resources and activities. Therefore, it must work with the others to build his own knowledge.

For this, a decentralized orchestration resources and activities seem to be more adapted to this context of mobile learning.

In [3] the point of interest (POI) is defined as the smallest indivisible element of a learning path associated with location relative to a given reference. The POI may also be considered as Learning Object (LO) associated with a specific location such as, the address of a place, the geographical coordinates of a historical monument, etc.

Therefore, the POI may contain one or more resources such as text, images, web links, animations, videos and one or more activities such as questions, simulations, etc.

In this context of field trip, the design of mobile scenario for learners is based mainly on the selection of POIs in the learning process in terms of the objectives educational covered by the instructor.

However, each learner can choose their own path during the course of the visit. This path of POI reflects the running of this mobile scenario through the reading of resources and implementation of activities associated with each POI.

Many systems are based on the automatic recommendation of POIs and they may be proposed for facilitate learning during field trips. These systems are based on algorithms that allow doing an orchestration of mobile activities to provide a learning path adapted to the spatiotemporal context of each learner.

Thereafter we will be interested at different Technical recommendation of POIs well as the use of Multi Agent System (MAS) and the ontologies in the context of mobile learning scenario.

1) The collaborative filtering techniques

According to L. Candillier, methods for collaborative filtering usually give better results than the filtering of content [31]. For this, we present a review of major collaborative systems that recommend POIs as part of this mobile learning scenario.

a) Techniques of implicit collaborative filtering

According to G. Valigiani, ACO algorithm can be adapted to a learning environment organized in a graphic through hyperlinks. The structure of this graph can be optimized to facilitate the learning process for all users [32].

T. Wang proposes another approach based on ACO algorithm to help learners to progress in their visit using an adaptive learning path. This type of recommendation identifies the contents which are most likely to be chosen to form an optimal path based on different learning styles [33].

E. Kurilovas presents a new approach to recommend a learning path adapted to different groups of learners. The ACO algorithm is used for the selection and combination of Learning Objects in different sequences according to learner preferences. This recommendation allows rearranging the alignment of LOs using new pheromones to individualize and optimize the learning path [34].

The three previous works may be used as part of this mobile learning scenario because they optimize globally the learning path. However, these works take little interest in the management of the context of learner because they are based on the basis of implicit collaborative filtering of LOs.

b) The techniques of explicit collaborative filtering

In [35], the authors present a technique that allows to performing an explicit collaborative filtering to better customize the POI recommendation. This method is essentially based on all ratings made by the owner of the smartphone and on the evaluations assigned by the other users.

According to W.V. Zheng, the analysis of the historical of GPS traces concerning anterior visits also allows to make a recommendation of activity on POIs [36].

On the other hand, P.Phichayaanutarat proposes a technique of recommendation to assist the user in selecting appropriate POIs according to the preferences and the interests of old learners. This approach uses demographic techniques such as score of self-interest and user profiles available in the database [37].

These three works are based on collaborative filtering explicitly based on available historical after several visits to provide personalized recommendations. However, during the course of the field trip, learners remain implicit in their collaborations. So gathering relevant information from the traces of places visited and user profiles can be costly and complex.

For that, this recommendation is not adapted to the learning objectives because it uses the information in the database without worrying about the educational dimension of the mobile scenario.

c) The techniques of social collaborative filtering

As part of mobile learning scenarios, M. Ye has developed an algorithm based on naive Bayesian classification to recommend POIs based on user preferences and social influence well as geographical influences [38].

C. Biancalana describes a recommendation system based on social relationships able to identify preferences of users and their information needs. This system uses a process of filtering information to suggest a personalized recommendation of POIs related to the current location of the user [39].

These two works are within the scope of the recommendations made thanks to the social relationships that may exist between learners. However, the scenario of the field trip starts without historical data because it has no information on the different social interactions. For that, this kind of recommendation seems not well adapted to the spatiotemporal context of the visit.

2) The techniques of prediction of POI

J.Sang work goes further by recommending of a series of activities associated to relevant POIs in the user context (e.g., location, and hour), but also relative to its historic of visit. This approach allows users to schedule consecutive activities based on the probability of transition from one POI to another and the historical in a Markov chain [40].

On the other hand, the work of C. Cheng aims to explore preferences User, social influence and geographical influence to make recommendations of POIs using a collaborative filtering based on the social influence of friends and the spatial grouping. This approach offers a personalized Markov chain to predict the POIs to visit from the historical of a geographic region [41].

These two works may be used in the scenario of our field trip to enable a prediction of POIs to visit during the visit.

However, this type of recommendation is based only on the historical of learners and it neglects the point of view of the teacher.

3) Educational cooperation using MAS

The MAS is characterized by interaction, autonomy and distribution agents. This organization implies a distribution of knowledge and control: each agent has local knowledge and all cooperate to a global goal.

Thus, the MAS are well adapted to the design of mobile learning systems where the location and historical and knowledge evolve over time.

Another advantage of multi-agent systems which is very useful for our learning process is the ability to add new agents or change the behavior of some agents without affecting the entire structure of the device.

Indeed, in the context of a field trip and museum visits we can define new roles for teachers and learners in the context of collaborative learning [42].

4) Utilization of ontologies

Ontology is composed of concepts judged significant for the investigated domain. Among the possible structuration, the most common is taxonomic type where concepts are organized into sub-concepts. This organization allows to instantiate individuals and to build a hierarchical structure.

There are different types of ontologies: 1) ontologies of domain that are specific to a particular field, 2) ontologies of application that contain the elements necessary for a given application, 3) generic ontologies that cover several areas, and 4) the meta-ontologies that describe the primitive for languages of representation of knowledge [43].

In the context of m-learning, the process of adaptation concerns learning resources and activities associated with the specific needs of learners and environment. A context model can be seen as a system of concepts (entities) and relationships. It can form ontology for representing contextual knowledge.

This ontology must be able to capture all the features of the context of the learner and the learning environment. It is divided into three types of context:

1) Adaptation to the context of current location of the user through dimensions as the platform (hardware, software, bandwidth, etc.) and information such as country, city, etc.

2) The domain context which is used for both the user model ontology and resource models, it is composed of elements such as theme, language, etc.

3) The context of activity that helps the learner to better focus on their learning activities to obtain resources well adapted to their interests and objectives [44].

Thereafter, we made an overview of the work on using ontologies in the context of scenario of field trip.

HIPPIE project was one of the first projects that use an ontology capable of integrating the location context of the learner. Indeed, when a user is in front of an art piece, the system can submit the documents relating to his profile. This project is based on semantic annotation of works and Learning resources based on ICONCLASS taxonomy and user profile [45].

CHIP project aims to enable the recommendation of art works based on the browsing habits of learners based on direct links existing in the ontology [46].

However, in previous systems, the management of the context is limited to the work that considers the user and does not provide other types of activities such as self-assessment and quiz to fully customize the learning path for each user.

In [47], the authors are based on a semantic modeling of the learning domain and the context of the visit to adapt activities and interactions proposed based on interest and location visitor.

This adaptation mechanism allows to define semantic and contextual proximity that allow to generate learning aids (recommendations, self-assessment games) while assessing the adequacy context of these activities.

Table III summarizes the main characteristics related to different types of recommendation of POI as part of the decentralized approach related to orchestration of mobile learning activities:

TABLE III. CARACTERISTICS OF DECENTRALIZED APPROCH

Works	[32] [33] [34]	[35] [36] [37]	[38] [39]	[40] [41]	[42]	[45] [46] [47]
Support the spatiotemporal context	Yes	Yes	Yes	Yes	Yes	Yes
Interaction between participants	Clicks on hyperlinks	GPS tracks and Ratings	Social relationships	GPS tracks and Ratings	Message between agents	GPS tracks and Ratings
Enrichment scenario	Learner	Learner	Learner	Learner	Learner	Learner
Real-time collaboration	Implicit collaborative filtering	Explicit collaborative filtering	social collaborative filtering	Prediction of POIs	Cooperation of SMAs	Annotation of POIs
Integration of 3 phases of field trip	Only the visiting phase	Only the visiting phase	Only the visiting phase	Only the visiting phase	Only the visiting phase	Only the visiting phase
Support the unexpected Context	Yes	Yes	Yes	Yes	Yes	Yes

VI. CONCLUSION

In general, centralized orchestration of resources and activities do not allow teachers to anchor the activities and resources in the right places for the field trip.

Therefore, it is based on real-time collaboration of learners and the integration of the three phases of the visit in order to achieve the learning objectives.

However, this kind of orchestration does not support open or unexpected character of mobile learning scenario.

The difficulty is related to the learning environment which depends heavily on the user's profile and the historical of the field trip.

For this, the decentralized orchestration is in full swing with all its approaches and techniques to provide an adaptive learning according to the spatiotemporal context of the learner.

We hope in the near future define a general framework for the design of scenarios of field trip and a behavior model for the orchestration of mobile learning activities.

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