# Context Exploration For Requirements Elicitation In Mobile Learning Application Development

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**Summary**
With the advent of context aware applications into the learning scenario, the context in which the application is being run becomes an inherent aspect of the learning activity carried out with the system. It is always a challenging aspect to identify and understand the contextual elements and their role in the underlying application. This demands the need to make more contextual elements' categorization with understanding of the properties and a procedure to capture the above ones while requirements elicitation for m-learning application is in progress. In this paper we try to explore the contextual elements that enhance the requirements elicitation for designing and developing context aware m-learning applications. Also, the various properties of these contextual elements is elaborated for the better understanding, followed by an elicitation process that brings the contextual elements and their structure in the m-learning applications to live.

***Key words:***
*Context, Context Awareness, Mobile Learning, Requirements Elicitation.*

## 1. Introduction

The capabilities that mobile learning has made it widespread, and learners are now able to learn at any time and any place with the support of mobile technologies. With context aware mobile learning, many different learning contexts emerge because of the dynamic and continuous change in the learning settings of the learner's mobile learning environment.

Context aware mobile learning (CAML) place emphasis on mobile learners who are carrying portable devices, such as personal digital assistant, that has been augmented with hardware sensors, such as GPS receivers, wireless LAN, camera, etc and software sensors, such as network congestion manager, web log analyzer, student behavior analyzer, etc. [1]. These sensors could detect location, activity, network connectivity, learner state and more. A CAML system examines the sensed learning contexts and reacts to changes in the learning environment.

Mobile learning can be distinguished "by rapid and continual changes of context, as the learner moves between locations and encounters localized resources, services and co-learners" [2]. Context is a key in the design of more adaptive mobile learning systems [3] and context awareness must be integrated within the systems in order for them to be truly effective [4]. The task of a context aware mobile learning applications is to sense the mobile environment and react to the changing context during a student's learning process [2].

The context aware applications are described as "more attentive, responsive and aware of their learner's identity and their learner's environment" [5] and hence can derive the learner's needs implicitly in the context which surrounds him/her at any point in time. There are many proposed definitions and taxonomies of context. Shilit [6] divided context into three categories: Computing Context, User Context and Physical Context. Chen and Kotz [7] extended it by adding a time context. Dey, Abowd and Salber [8] gave four categories: identity, location, status and time. The importance of obtaining the *actual location* of the learner helps to identify the contextual features surrounding the location that affect/support the learner's ability to study. Schmidt et al. also found that location is the most often used context parameter and assert that mobile applications could benefit from a broader notion of context. This work investigates the use of multiple sensors to gather a wider range of context information[9]. Dey & Abowd found that the most often used context parameter was location while the most common application feature was the presentation of context aware information to users. The systems [10] also includes two location-specific features which their activities adapt to accordingly, namely the *concentration level* of the learner and the *frequency of interruption* at a specific location.

There exists various views on context: context as conceptual drift (a context engine), context as a layer above application, context as an implicit input to an application, context as a medium for the representation of knowledge and reasoning, context as what surrounds the focus of attention, etc [11]. In Human - Computer Interaction, a context feature is any information that can be used to characterize and interpret the situation in which a user interacts with an application at a certain time. In AI, Brezillon [12] defines context as what does not intervene explicitly in a problem solving but constrains it.

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From an informational perspective context aims to provide an information space that can be "adapted according to the user's context", and complemented by tools/processes that promote the socially situated construction and sharing of context [11]. Wang's six dimensions of the M-learning context: 1) Identity 2) Learner 3) Activity 4) Collaboration 5) Spatio-temporal and 6) Facility [13]. The first four of these would establish the situational context of M-learning, and the last two would be associated with the environmental context.

It seems very likely the future context aware applications will capture a rich variety of context information and also exhibit a richer variety of context-aware features than the present situation. Providing support for mobile learning application designers in the integration of a wider range of context into the applications will encourage the development of useful and compelling mobile learning applications for mobile devices of the mobile learners and tutors.

As the role context and different forms of it in the context aware mobile learning applications is on the high, there is a need for context exploration that can bridge the gap between the application users and the requirements eliciting personnel resulting in the improvement of the design outcome. This paper explores the context which aims to draw together different kinds of issues relevant for proper understanding of contexts and its representation in the requirements elicitation process of context aware mobile learning application development. In this paper, authors propose different forms of context and a process for requirements elicitation for CAML applications dealing with different contextual information to carryout learning activities by the mobile learners with their mobile devices.

The paper is organized in the following manner. Section 2 explores different forms of context and their understanding for an m-learning application development. Section 3 concentrates on the various properties of these explored contextual elements possess, and affect/motivate the requirements that drive the design and development of m-learning applications. Finally Section 4 throws light on a process for requirements elicitation of context aware m-learning applications, followed by section 5 that concludes the paper.

## 2. Context Exploration

Given the diversity of context information, it is useful to attempt to categorize it to make it easier to understand in a systematic fashion. The context categories we have identified can be utilized in a number of forms by context aware mobile learning applications. Context can be said to be as comprising of various components that are interdependent in different ways. To understand and identify its relevance for mobile learning we need to scrutinize it in different perspectives and ways in which mobile technologies can usefully support it. One way to do this is we take as many forms of it which we call context exploration and make the stakeholders aware of them when they are involved in the development of context aware mobile learning application.

The following forms of context is explored to atomic levels and serve as a starting point for eliciting contextual requirements in a different manner that can help in focusing the design and development process for CAML applications in more effective fashion.

### 2.1. Learner Context

In any context aware mobile learning scenario, learner plays the primary role by carrying out the learning activity through his/her device. There by he himself becomes a contextual factor leading to various adaptations by the m-learning application. While eliciting requirements for various contextual elements related to learner as context, the following can be used as a checklist:

- *Preferences*
- *Profile*
- *Calendar*
- *Learner's Goals*
- *Contacts*
- *Competences*
- *Experience & Practices*
- *Cognitive Abilities*
- *social Abilities*
- *Emotions & Feeling*
- *Intentions*
- *Tasks*
- *Results & Achievements*
- *Restrictions*
- *Objectives*
- *Current Needs of the learner*

The *history* of the particular learner in terms of their current level of understanding also provides a context for learning. In most of the cases, the learner context has wider implications for the design of the learning activity and other contextual information.

### 2.2. Activity Context

The ability to be aware of learner is often not enough as the contexts of the activity is/are undertaken by the learner(s), can differ enormously. The learning activity in particular creates the context within which certain

interactions, tasks, etc need to be identified and defined. The following checklist comes to help while eliciting the requirements regarding the learning activities:

- *Subject*
- *Purpose (Agenda)*
- *Objectives*
- *Expected Outcomes*
- *Pedagogical Theory*
- *Participants*
- *Teams*
- *Achievements & Results*

Another important factor need to be identified is whether the learning activity is individual or is it a part of collaboration carried out by a group or team of learners together.

### 2.3. Content as Context

As the learner carries out learning activity, next is content to play vital role in the process. Contextualizing content is major part of the application development. The question is to which relevant information it has to be contextualized? The elicitation of requirements in this regard must highlight the following aspects of content:

- *Content Type*
- *Size*
- *Presentation*
- *Delivery Mode*
- *Storage Options*
- *Content Structure*
- *Content Sequence*

Course materials (content) presented to learners properly reflect learning context and provide more relevant information to meet their dynamically changing contextual requirements [1].

### 2.4. Place/Location Context

As the mobile learner moves over different places or locations with his device, he carries out the learning activity on the move there by giving rise to location as another context that influences his/her learning activity. The requirements for the implementation of location as context in the m-learning application must be elicited and represented in more clear fashion.

a) One way is to represent this in the application is naming every location of his/her movement such as: *Home, Library, Museum, Lab, Class Room, Canteen, Hostel, e.t.c.*
b) The other way is to represent this in the application as: *Private, Public, Physical, and Social.*
c) One more form of representation for the m-learning application could be as: *On campus, Off Campus.*

For services regarding location as context can be in terms of *Absolute or Proximity.* Some learning applications may need more accurate resolution for the location categories. Identify the current application's requirement for processing location as context with respect to the type of representation it envisions fulfilling the stake holder's aspirations.

### 2.5. Time Context

Time context enables the m-learning applications to utilize temporal information. It can be used as a timestamp indicating an instant or period during which some contextual information is known or relevant [1]. Knowledge of time is easily obtained through the mobile devices. The factor that needs to be considered while eliciting requirements for a context aware m-learning application is the representation and processing of time in the format that is most suitable for the situation or activity of the learner.

a) One form of making time context more meaningful is to set *Exact Time* for the activities of the mobile learner in relation to other contextual information.
b) The other form of utilizing or structuring time context is to identify different *sessions* of the day like *early morning, morning, forenoon, afternoon, early evening, evening, before midnight, night,* likewise. And configuring learning activities and the contextual information in the most appropriate and result oriented fashion.
c) Another form of structuring the time context is to identify *time intervals* or *time latencies* or *time differences* relative to some other contextual elements that are configured in the m-learning application for providing adaptive learning situations and environments to the learner.

### 2.6. Environment Context

The basic idea of *any where & any time* learning of mobile learner naturally bring the environment as a contextual factor that has influence on the learner and/or learning activity in an m-learning scenario/situation/application. The environment context can be considered of having some more sub-contexts that prove worth of considering in the requirements elicitation for designing a CAML application.

#### 2.6.1 Weather Context

For mobile learning applications that are different subjects (like Biology, Chemical, Geography …) require weather as contextual information for carrying out the learning activities. This contextual element can be set to values like:

- *Sunny*
- *Cloudy*
- *Rainy*
- *Snowfall*

and other configurable value if needed by the application for the learning purpose.

### 2.6.2 Temperature Context

The temperature has its influence on learner and/or learning activities of any/a mobile learning application/scenario. The possible flavors for this contextual element can be like:

- *Very Cold*
- *Cold*
- *Cool*
- *Tepid*
- *Warmish*
- *Warm*
- *Hot*
- *Custom built*

The range of values these take and the unit of measurement/representation for them has to be clearly elicited and represented in the requirements gathering process.

### 2.6.3 Noise/Sound Context

The sound or noise has more influence on the learner with which he/she may get affected/motivated when carrying out learning activity through his/her device. The different levels of it could be like:

- *No Sound*
- *Quiet (unnoticeable)*
- *Faint Sound*
- *Normal Sound*
- *Louder*
- *Loud*
- *Unhealthy*
- *Hurting Sound*

The values of these levels have to be identified and their unit of representation must be considered along with those learning activities that are affected and/or motivated in the elicitation process.

### 2.6.4 Lighting Context

Most of the learning activities through the mobile device in practical fields or real environmental settings get influenced by the lightness in the environment. The levels of this lightness like *dark, dim, bright* may be identified along with the learning activities relating to different levels of lightness must be thoroughly represented for better understanding by the developers of the m-learning application.

### 2.6.5 Custom Context

Depending on the domain of m-learning application, the environmental context elements may vary in forms like *traffic conditions, safety conditions, toxic conditions* and the like must be designed and customized to different levels to relate them to their respective learning activities that are affected or motivated by these factors.

## 2.7. Day Context

The mobile learning activities carried out by the learner can be flavored with the day as context in the application. As learning in mobility is more of informal, one of the following forms can be considered as day context:

a) The structuring of the day context can take a form as *Working, Holiday* based on the need.
b) The structuring of the day context may also take a form of *Weekdays, Weekends.*
c) Giving more scope for wider aspects to be adapted in the applications, the day context can also be structured as: *On Vacation, Expedition, Festival, Project period* and so on.
d) If the m-learning application requires the day context to incorporate regularity for the learning activities of the learner, in such a case the day context can be structured as the days of the week like: *Monday, Tuesday, …Sunday.*

The elicitation process should emphasis on the domain specific aspects while gathering requirements along with the agenda and goals of the activities and application that is under consideration for acceptance by the participants of the learning situation/scenario.

## 2.8. Movement Context

One of the features of mobile learning is said to be the ability of it to support when the learner is on the move. As part of it, movement will undoubtedly become the contextual factor for which adaptations might occur to support the learner in his/her learning activity.

a) A form of this movement context might be *Slow, Still, Fast…*
b) The other form of it could be like *Walking, Driving, Traveling, Riding…*

The category on which the requirements must concentrate is purely based on the participants' perceptions and convenience as they are the beneficiaries from the activity or application.

### 2.9. Computing Context

To design a good interactive context aware m-learning application, understanding the characteristics of the computing environment is vital; involving various devices with different features and capabilities along with the input and output devices that may lead to new forms of interaction.

The mobile devices possess various capabilities that need to be taken into consideration for providing proper contextual support during the learning activities by the learner with the application or device. These can be elicited and some of them are like:

- *Computing (CPU) power*
- *Display size*
- *Color resolution*
- *Input method,*
- *Memory available*
- *Battery power*
- *Learner settings*
-

and some more need to be considered for adaptation. The communication context is an element that is part of adaptation when supporting learner. This involves the devices communicating by *Wireless LAN, Bluetooth, Infrared, GPS* and more.

The points to ponder when placing the computing context into the application for adaptations are as follows:

- Avoiding too much scrolling requirements as screen size is constraint to the mobile devices.
- Selecting a reasonable protocol for communication with the service providers resulting in energy saving.
- Identify the varying bandwidth from the learners' device to device.
- Intermediate results/data generated by the application during the learning activities need to be to the lowest as memory available is limited and may vary from device to device.
- Learning activity should not be overloaded with more number of input activities due to input capability variations among the devices of the learners.

### 2.10. Usability Context

In addition to the above contexts that were explored, the other context that comes as major support to the learning scenario is Usability Context. The usage aspects of the device and the m-learning application by the learner; can be put into the context aware m-learning application for maximizing the adaptation support to various forms or levels depending upon the data/statistics generated or behavior exhibited by the learner in various other contextual elemental values. This context is achieved by incorporating some methods, tools and techniques together, and using it results in the data that serves the purpose for adaptation in m-learning application. These could be like: *Frequency of Access, Usage Statistics, Physical Abilities, Usage Patterns, Usage History and so on.*

To identify and gather such contexts' requirements, the elicitation process must give scope for the stakeholders' special interest/emphasis in achieving *usability aspects* of the m-learning application under consideration. This may bring some more people like Subject Matter Experts and Usability Engineering personnel into the picture.

### 2.11. History as Context

If the context aware m-learning application requires some activities and/or tasks to be influenced by previous results or operations and/or sequence of operations, for such a case the historical base (storage) is the support. The requirements elicitation should identify those aspects/activities of the system that gets influenced by previous results or actions and represent them with finer notation leading to consistent and clear learning scenario/situation. The notable step that needs to be carried out in the process is whether to store the *results of the previous activities* or *the activities themselves* or else the *settings and contexts* under which those activities occurred/carried out or *any combination of these above* aspects.

## 3. Properties of Contextual Elements

Brining more clarity to the requirements elicitation is to identify and represent the most comprehensible properties of the various contextual elements that are visualized for the context aware mobile learning application. This information makes the application designers more comfortable when designing the contextual elements implementation aspects of the application. The figure 1 gives a view of the various properties the contextual elements and the text following gives needed explanation.

For contextual element *position*, we can do it as *continuous* or *discrete.* In *continuous* positioning service, a learner's position is known at all times as he/she moves through the space/area covered by the location service. In this kind, application is provided with more information. In a *discrete* type, the learners must actively provide the system with the information about their position.

When the application uses a wider range of context inputs from various sources and sensors, the complexity for the application designers increases. With the higher-level context abstractions (formed by the low level context inputs) the handling of contexts gets ease to the designers and developers. Dey et al., assert that using higher-level context abstractions that sit on top of individual component abstractions should make it easier for application designers to use context; they reason that the higher the level of the context, the easier it should be to use, at the expense of some information hiding [14].

Given the diversity of context information, it is recommended to attempt to categorize and make it comprehensible in a systematic manner. In this way, another contextual element property is *shared* and *individual*. *Individual* context possess information relevant to the learning activity and interaction between the learner and the m-learning application. *Shared* context possess information relevant to collaborative learning activities or tasks where in a workgroup or a defined set of learners share common goals, interests and experiences.

Given the learning activity that is carried out by the learner with the application, there comes the contextual element in two variations in terms of their participation in the current activity. The set of contextual elements that are relevant to the current learning activity are said to be *Active* and those contextual elements even with value are not relevant to the learning activity currently executed by the learner are said to be *Passive.* Understanding and representing this variations guide the designers to be concentrated on the contexts that are needed in any given learning activity design and development.

The contextual element participation in any given learning activity or task is not sufficient unless their evolution is known. The contextual elements that are of interest to the current learning activity, if undergoes change during the activity execution, they are said to possess *Dynamic* behavior and the contextual elements which participate in the learning activity but remains unchanged are *Static* in their behavior.

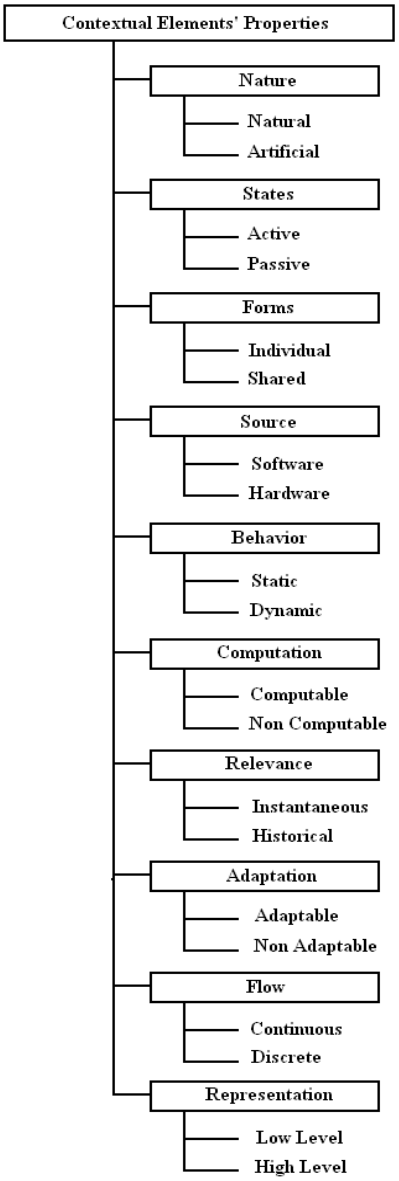


**Figure 1: Few Properties of Context**

The finer details of the contextual elements and their properties make the designers more comfortable in their task execution.

## 4. Process To Acquire Contextual Requirements

As context is the key in the context aware m-learning application, the requirements gathering for such a context should be carried out by following a defined process or method. Here, extending the inherited method for

requirements elicitation we give a simple process for the same.

1. Identify the various groups of learners that the mobile learning application is focusing on.
2. Determine or estimate the contexts all of the identified learner groups may be placed in, and more importantly those which may affect the application's interactions.
3. For each of the identified contexts, list out the requirements specific for the context, set defaults to them if needed.
4. Determine the learner's actions during the process of learning activity with the mobile learning application.
5. For each action, investigate how various contexts may affect on its interactions and with that information determine the required context aware elements to adapt to such contexts.
6. For each context aware element, list out the details of the expected capabilities.
7. If context aware capabilities are matching and satisfy all the elicited requirements then proceed to next step else some elements are not identified and redo from step 5 to identify those missing requirements.
8. Ask for learner's and/or tutor's control mechanism on the application and on some of the context features elicited in the requirements gathering process.
    a. Determine contextual elements of learning activities for which the facilitator or tutor configures the elements and/or values to them.
    b. Enlist the contextual elements of learning activities where in the learner is allowed to configure the elements and the values they take or given when he/she carries it out.
9. Prepare the document of the requirements elicited for contexts and pass it on to the designers after reviewing it by the stakeholders

Several attributes used frequently in context aware applications can be dependent on the person's subjective perceptions of the meaning of the attribute [15]. For successful application design, the developers of the application should have an understanding of user's perceptions (which may change over a period of time) related to the topic; which in our proposed process will guide the developers and the learners by giving a or various levels of control over the configuration of the contextual elements for the learning activities of the m-learning application.

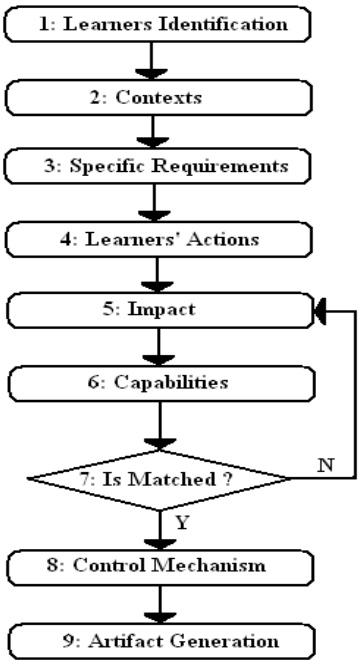


**Figure 2: Process Flow**

To take true advantage from the context information and to develop valuable applications for learners, we need knowledge of user's expectations, and acceptance on the issue [16]. To avoid crucial mistakes in application design, the concerns and criticism as well as positive feedback from mobile learners need to be studied. The possible approach is to place different levels of control mechanism in the m-learning application where in the learner is provided the options to configure and customize the allowable contextual elements and the values for which he/she believes in the most for a success in m-learning activities with the consent from the mentor/tutor.

At each or all steps of the above method, the following questions may bring more clarity or understanding to both the elicitation personnel and the users of the applications:

- Does this contextual element possess a default value? If yes, what is it?
- Does the change of value for this contextual element trigger any change in other contextual values or in the relationship among them?
- Are there any different states this contextual element can take?
- Which contexts/activities/tasks will consume the value of this contextual element?
- From where does this contextual element get its value?
- Do these contextual elemental values possess a range or else minimum and maximum values?

- Does this contextual information go into historical base of the contexts?
- In what forms of adaptations this contextual information is utilized?
- Does this contextual information exists alone or does it require other contextual value for usage in adaptation?
- Is there more than one source for this contextual element?
- Does the value of this contextual element gets updated continuously or only when there is a change in other contexts?
- Does the learner aware of this contextual information?
- Can the learner alter/change/update the value of this contextual element before/during/after the learning activity?
- Can this contextual element be used as performance indicator of activity/learner/application?
- How does this context change over a period of time or sequence of interactions?

## 5. Conclusion

When we concentrate on context to know what it really means, a much wider, complex picture with various properties and dependencies comes out. As the context seems much more complex when it is put into action, we tried to present the different colors and flavors of it for efficient support to be given to those who elicit the requirements for an m-learning application design and development. The process charted out along with the contextual elemental forms and various properties may be utilized as a means to bring more and more meaningful elements and procedure into the action that again may throw light on many more interesting research issues into the focus.

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