A Design Methodology For Acceptability Analyzer in Context Aware Adaptive Mobile Learning Systems Development

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Summary
The use of mobile computing technologies supported by portable devices such as Mobile Phones, PDAs, and Smart Phones has contributed to the evolution of the concept of Mobile Learning or m-learning, which supports high degree of mobility for learning. Context aware adaptive content delivery in m-learning are delivering the right content to right learner in right time and at right place, but this doesn't necessarily mean that learners are interested in it or in any associated learning activity. In this paper we put forward a methodology for designing context aware adaptive m-learning applications/ systems that identifies the interest of the learner in which learner's own actions against the learning content with an m-learning application will become dominant indicators of his/her acceptability/interest to learn for that context.

Keywords: *Acceptability, Adaptive, Context aware, Mobile Learning.*

1. Introduction

The development and deployment of context aware applications is motivated due to the increased mobility of the learners and their activities. The nature of mobility urges the applications that are run in mobile phones to act situation dependent, in other way, to become aware of the learner's context and to adapt to it. In Human Computer Interaction, context feature is defined as 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 context aware applications area, Abowd & Dey [1] define context as any information that characterizes a situation related to the interaction between humans, applications and the surrounding environment.

Learner's needs are mostly intangible which in most of the cases affected by habit, self-image and even issues of motivation[2] (e.g., a person might be more active in the morning than in the evening). The design of a system must focus on reducing communication barriers by analyzing what can be known about a learner and how to support that information with task, learner and system models. As a rule learner must play an active role in the definition of the context about which the system must be aware of [2]. In addition to being able to obtain context information, applications need to have some "intelligent" component which functions as a predictor of a user's intentions. Developers can intelligently use context information in four primary ways [3]: 1) resolving references, 2) tailoring lists of options 3) triggering automatic behaviors and 4) tagging information for later retrieval.

Mobile learning has been defined as e-learning through mobile and handheld devices using wireless transmission [4]. The fact that different learners have distinct needs, preferences of personal features has been considered with adaptation [5] [7] and recommendation [6] purposes. In the context of mobile learning, the contents also need to be adapted to different devices [8]. A classification of the characteristics that can be used with adaptation purposes in mobile learning environments is presented in [9]. In [10], Yudelson, et al. used techniques for interpreting student behavior data and constructing student models can be classified into three categories: formal, semi-formal (heuristic) and informal (ad-hoc). Formal approaches use methods either from cognitive sciences or from artificial intelligence. Traditional symbolic AI techniques like semantic networks, rule-based reasoning tend to be replaced by non-symbolic techniques like machine learning, neural networks, genetic algorithms, Bayesian models; while symbolic AI techniques try to infer knowledge about the user based on each of his/her actions at click level, non-symbolic techniques have the advantage of extracting information about the user from his/her entire navigation path, viewed as a whole.

For MOBILearn project at the University of Birmingham, an interactional model of context has been developed, having advantages like [17]: it ensures that context is much more that location; it can be used to guide effective choices and propose future actions, rather than simply

acting as a filter on information. The University of Tampere for MOBILearn project has developed an adaptive user interface system [17] in relation with the context awareness subsystem. The adaptive user interface subsystem received data from the context awareness subsystem and this contextual, presence and device information was utilized to optimize the user interface for a mobile phone and a PDA.

The remainder of this paper is organized as follows. In section 2, the general schema of a context aware mobile learning (CAML) is explained. In section 3, we describe the acceptability analyzer which is of our interest. Section 4 discusses a typical application that utilizes the concept of acceptability analyzer in its design process. Section 5 concludes with a discussion of future research work.

2. General Schema

Mobile Learner is highly mobile in nature and this poses a major challenge in m-learning scenario where the learning content has to be delivered to the learner based on his/her current context. There are systems/architectures [11][12][13][14] that deliver learning content by adapting to the learner's context. All of them take the context (Physical, Device), the learner style, learner preferences, learner's knowledge, learner's experience or a combination of some of these as a means to adapt and deliver the appropriate content. So, an adaptive delivery of the learning content to the learner based on his place, time, device, physical activity is done; but this doesn't necessarily mean that they are interested in it or in any associated learning activity.

There is a need for identifying the interest of the learner on the delivered learning content by modeling and understanding the learner's actions against the learning content. In this work we have come up with a design methodology called Acceptability Analyzer for identifying learner's interest/acceptance level on the delivered learning content by modeling his/her actions against the learning content with an m-learning application supporting the learning content.

The design methodology is based on the notion that the learning content delivered to the learner has attributes specific to it and its type; the learning content is accessed by the learner with the support of an appropriate application that supports the learning content type and the application has its own specific Actions that are used by the learner to interact with the application in the learning activity process.

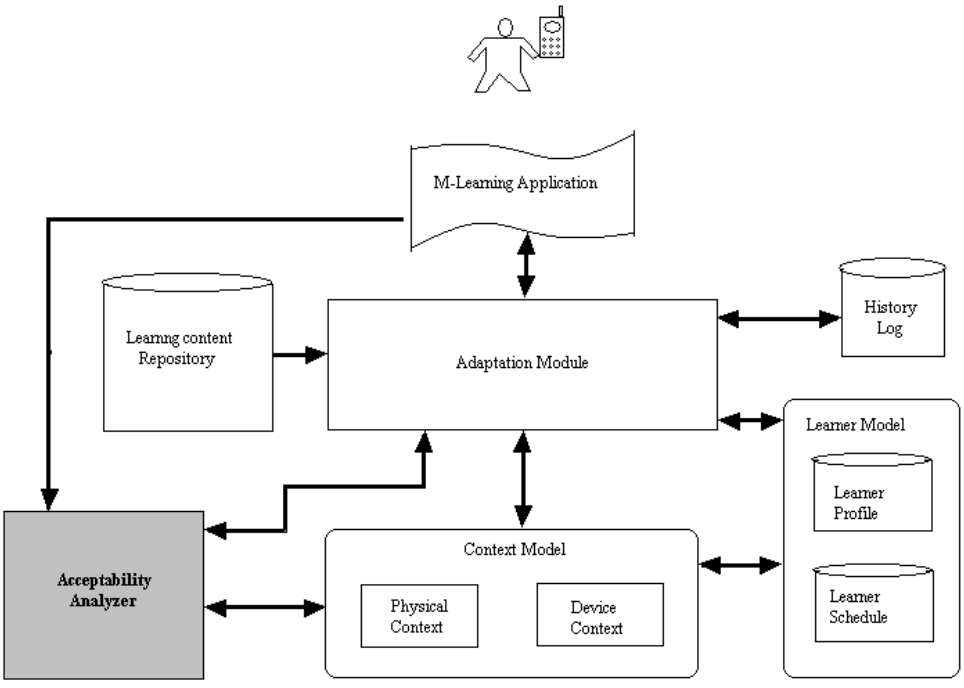

FIGURE 1: General Schema

The figure 1 shows a general schema for a context aware adaptive m-learning system which includes the Acceptability Analyzer module that supports the Adaptation module by sending the information regarding the learner's acceptability levels for the learning content delivered in a context; used by the Adaptation module for future decision making or evaluation purposes.

The learning content, to be delivered to the learner, is modeled and stored in a Learning Content Repository; is connected to the adaptation module for access in taking decisions to deliver appropriate learning content. The History Log, contains details about learner's experiences and interactions of the past, is also connected to the adaptation module for decision making purpose. The Learner Model consists of details about the learner profile which includes learner preferences, learning style and learner schedule that are accessed, used and updated by the adaptation module. By providing this (learner's) information initially, the system will be able to automatically determine the learning preferences and contextual features of the learner at a given place and time; this saves time and effort for the learner to have input this information while he/she is on the move. The learner can override a particular learning preference at any time and/or location. The learner model is consulted by the adaptation module to draw inferences and take decisions.

The M-Learning Application is a mobile software application that is used by the learner in his mobile device to carryout the learning activity with the learning content provided to him/her by the adaptation module taking into all the contextual elements in to the consideration.

3. Acceptability Analyzer

The *Acceptability Analyzer* in figure 2 is the centre of the methodology where in all the concentration regarding the learner's Action analysis is carried out. The sources of information for this component are the learner's actions against the m-learning application that is used for learning content presentation to the learner and the Action Specific Model which gives information about what to be understood or inferred for the Actions recorded by the Action Recorder module.

The factors that cause interruption in the leaning activity are termed as *Acceptability Affecting Factors* (AAFs) and they play major role in the learning activity's final state. The AAF Categorizer gives information about the factors that caused interruption and their impact on the learning activity flow to the Acceptability Engine. The Action Sequence Log stores all the sequence of actions against the application by the learner in a specific format which ensures the storage of corresponding contextual element values for the recorded actions.

The *Action Dimension Model* feeds information to the *Acceptability Engine* regarding what to infer for each action selected by the learner against the application in terms of *Learning Content Dimensions*, which are given by the *Learning Content Dimension Model*. These Learning Content Dimensions are used by the Acceptability Engine to infer how the Content Specific Attributes and Application Specific Actions are related to each other and their effect on the decision making process of acceptability level of the content by the learner. The Acceptability Engine can be implemented by using any intelligent techniques for inference available in the literature, which may be from a simple as rule based techniques to complex genetic algorithms.

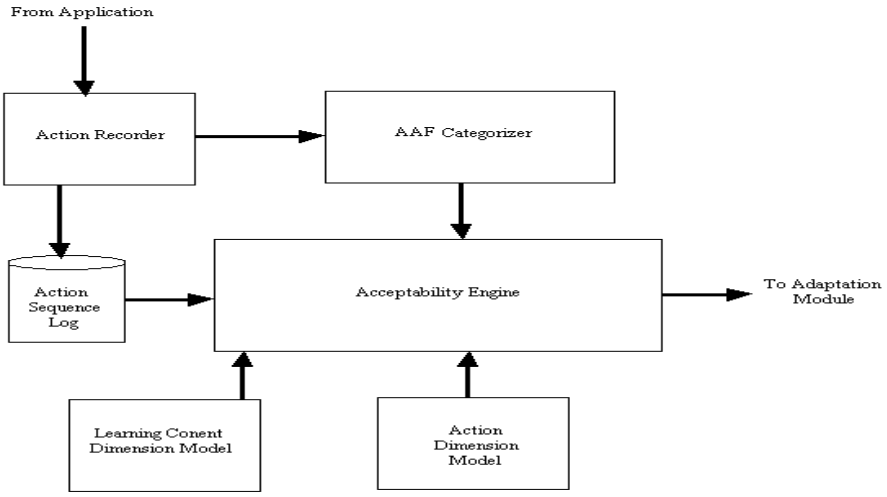

FIGURE 2: Acceptability Analyzer

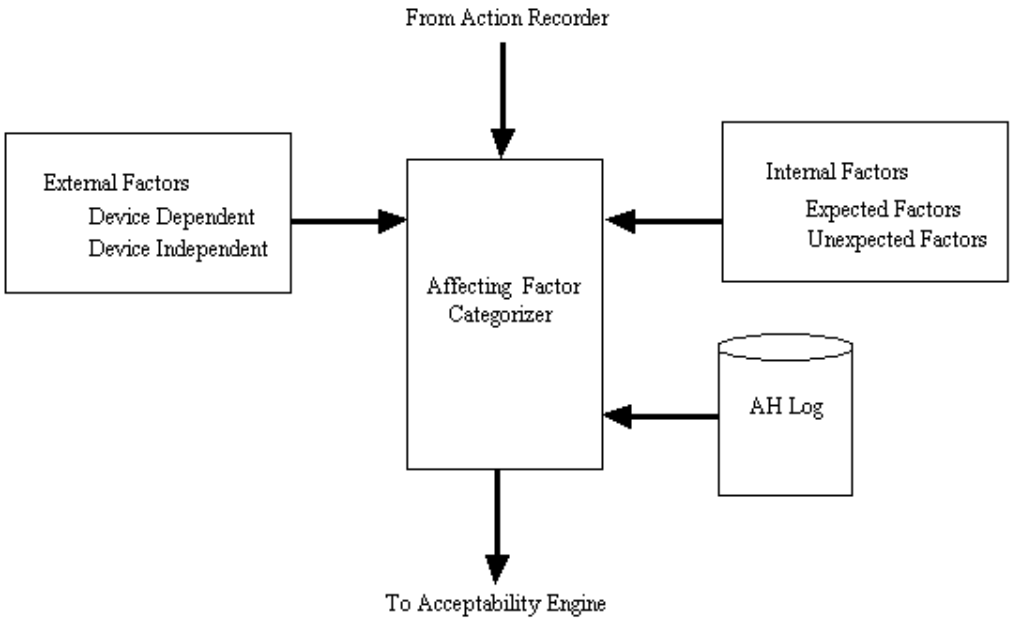

FIGURE 3: Acceptability Affecting Factor Categorizer

Acceptability Affecting Factor Categorizer

The factors that affect the learning activity flow in the form of interruptions must be understood and modeled as they have significant effect on the acceptability levels of the learner for the learning content delivered in a given context.

The input for this *Affecting Factor Categorizer* (AF Categorizer) is the *Actions* recorded during the learning activity flow given by the *Action Recorder*. When an interruption occurs in the learning activity flow, it is recorded by the Action Recorder and forwarded to the AF Categorizer which matches that cause for interruption against the possible Internal or External factors and AH Log to compute the amount of time that was spent by the learner away from learning activity due to the interruption, along with the contexts in which it happened. This information is updated in the AH- Log and also given to the Acceptability Engine for its decision making process.

Learning Content Dimension Model

In this model the *Application Specific Actions* and *Content Specific Attributes* come together, and there evolves the dimensions called *Learning Content Dimensions*; which relate both the Actions of the application and Attributes of the content by taking into consideration the device context.

The *Learning Content Dimensions* vary for different learning content types. They vary for different applications that are used for presenting the learning content to the learner. The learning content delivered to the learner may take any format/type, namely text type, audio type, vide type, picture type, slideshow type, e.t.c. For a given set of Learning Content Attributes and Application Specific Actions there exists a set of Learning Content Dimensions; And the values these dimension takes varies from learners device to device, as devices are not alike and their context (such as display screen size, processing power, memory,…) vary; which are utilized to present the content with an application.

The values to some of these dimensions are implicit in nature as they are device specific and application specific and for some other the values need to be set as per their usage. These dimensions play predominant role in identifying learner's progress/movement in a learning activity over a delivered learning content in the learning process.

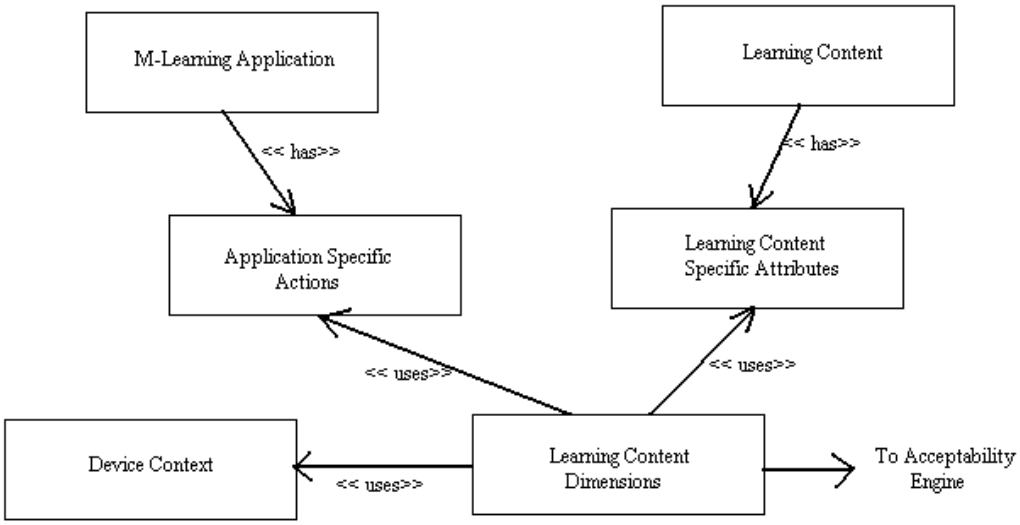

FIGURE 4: Learning Content Dimension Model

Action Dimension Model

The *Action Dimension Model* gives information to the Acceptability Engine regarding what to be understood or inferred by a particular Action selected by the learner against the application in the sense of his interest/acceptance of the learning content which he/she is currently using in the learning activity.

For each of the *Actions* of the application, there exist dimensions that need to be configured, which helps Acceptability Engine what to infer in the sense of learner acceptance or interest towards the content when he/she does select that Action. As these Actions are more in number and may repeat, occur any number of times and in any sequence; it requires a processing scheme that gives cumulative Action Dimensions which indicate the learner's interest or acceptance of the content as entire learning activity is carried out with possibly many Actions selected by the learner in it.

The Action Dimension Processing Policy is configured to make it process and relate Actions that are selected by the learner in a given learning activity against a particular learning content. The setting up of dimensions for Actions and Processing Policy design requires the design engineer to communicate with the Subject Matter Expert (SME) of the learning process who guides him how the relationship has to be established between the Action Dimensions and Actions to identify and calculate the learner's interest or acceptance in a particular method. The SME may use a learning style theory in guiding the designer in this process.

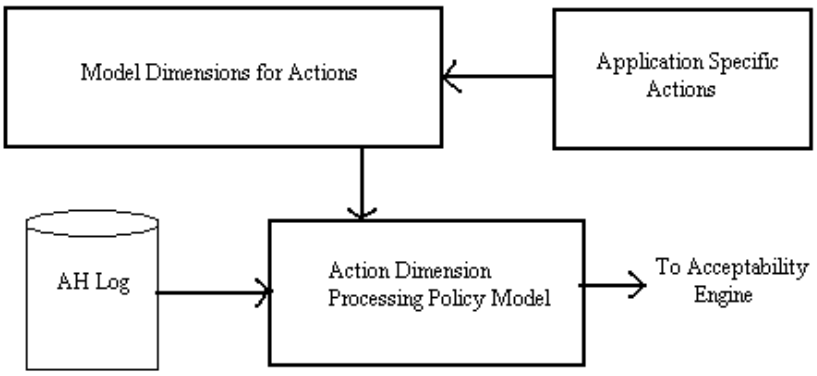

FIGURE 5: Action Dimension Model

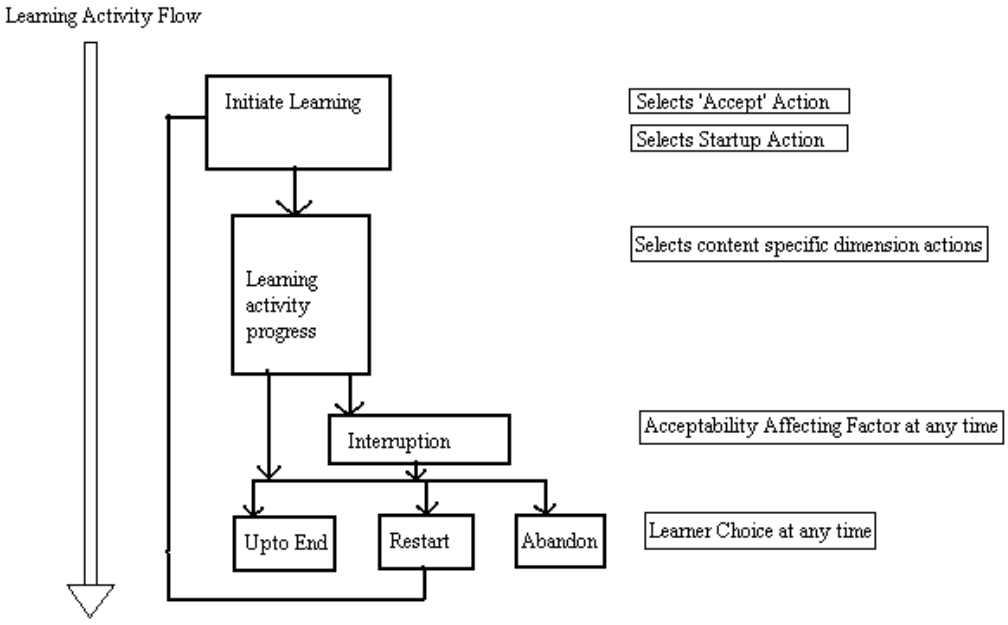

FIGURE 6: A Typical Learning Activity Flow

Action Recorder

The figure 6 shows a typical learning activity flow when the learner carries out the learning activity by interacting with the application using the Actions of the application. Here the main flow phases have been depicted along with their related Actions that are carried out by the learner.

As the learner receives the learning content he/she has to first decide on whether to accept the received content or not. If he/she doesn't accept, there is no further flow of activity for that learning process. If he/she is willing to initiate the learning activity, then the Startup Action of the application is selected by the learner to initiate the learning activity. By selecting Application Specific Actions the learner will further carries out learning activity; these actions help learner to move within the learning content to learn more about it.

At any point of time interruption may occur when the learner is involved in the learning activity. This interruption may be an internal device factor or an external environmental factor that has affected the learner's learning activity by distracting his attention from the learning activity. At this point, the next phase in the learning activity for the learner may be Abandoning the activity or Resume the activity or Restart the activity all again from the beginning of the learning content.

All the above learner's phase transitions that occur due to different actions selected by the learner or due to interruptions are recorded by the Action Recorder along with all possible contextual element values, as a unit of information action-wise in an Action Sequence Log.

4. A Typical Application

The above methodology has been adopted in designing a learning activity scenario for a learning content of type Text, by implementing passive context awareness [15]. It is being applied in a study that is being conducted to identify learner's attitude towards the usage of mobile technology in their learning process. The design details follow the discussion.

The learning content type considered is a plain *text* and the learner uses the message viewer to view/read the content. The *learning content repository* consists of the text in small nuggets that are sent to the learner using SMS technology. The learner model is considered and modeled, the learning style dimension considered is active/reflective [16] type. The *context model* is considered with emphasis on device context which has vital role in the Acceptability Analyzer Module. A simple rule based method is adopted for Adaptation Module.

The *Content Specific Attributes* for the text content type modeled and to utilize in the Acceptability Analyzer are like Number of Characters in the delivered text content, Number of Words in the delivered text content, Standard Time (Average Time) to read the delivered text content, Size in memory of the text content delivered.

The *Device Context* is employed and the context features considered in modeling are: Font Size set for textual characters in the device, Text Viewing Area dimensions, Screen Size.

The *Application Specific Actions* for the text content which is viewed using message viewing application are: Open, Cancel, Forward, Archive/Save, Delete, ScrollUp, and ScrollDown.

The *Learning Content Dimensions* evolve from the Learning Content Attributes, Application Specific Actions and the Device Contextual features are: Total number of Screen areas' consumed by the text content delivered, Total number of Scrolls required reaching end of the content, Total number of Scrolls made by the learner in a learning activity, Time between the Scrolls, Standard Time between the Scrolls.

The *Acceptability Affecting Factors* may lead to interruption during the learning activity; factors considered in the design are:

Table 1: Factor Types and considered factors

Affecting Factor Type	***Factor Considered***
External – Device Dependent	A phone call from a friend A message from a buddy
External – Device Independent	Any distraction from learner environment
Internal – Expected Factor	An alarm goes on A remainder pops up

The *Affecting Factor Categorizer* sub module identifies the time period or duration of time spent away from learning activity by taking the time difference between i) when the factor affected the learning activity and ii) the learner's focus shifted back to the application which holds the learning content. The information regarding a) Factor Type, b) Time of Occurrence and c) Duration of Time Spent on the factor, becomes a log record that is stored in Acceptability History Log (AH Log). The same results are forwarded to Acceptability Engine for its use in decision making process.

Two processing schemes are designed in Action Dimension Processing Policy to process actions selected by the learner with the designed Action Dimensions:

Weighting Scheme: This scheme ensures how weights are to be added up to get cumulative weight for all of the actions selected by the learner in a learning activity.

Polarity Scheme: This scheme ensures which type of weight is to be used for cumulative addition for a learner selected action, following the Weighting Scheme.

The results computed by this processing policy is forwarded to Acceptability Engine for inference about the learner's interest/acceptance levels over the delivered learning text content in all the possible contextual features.

4.1 Learning Activity Flow

A sample scenario of a learning activity flow for this application supporting text type learning content is depicted in the figure 7.

When the learner starts his/her learning activity, his/her selected actions are recorded by the Action Recorder component and forwarded to *Acceptability Affecting Factor Categorizer* , *Action Sequence Log* which stores these actions sequence details along with other contextual feature elements such as time, place, day in a structured format as one *ActionSequenceLogRecord*. The *Acceptability Engine* consults this Log for decision making purpose.

The *Acceptability Engine* consults *AAF Categorizer*, *Learning Content Dimension Model*, *Action Sequence Log* and *Action Dimension Model* to identify the learner's acceptability levels for various contextual features and gives the results to the Adaptation Engine which utilizes this information in adaptation process for delivering learning content to the learner.

The application whose design just explained is being utilized in one of the case studies that are being conducted in the department. The results of this study will prove the efficiency of the application in addition to the study's intended results.

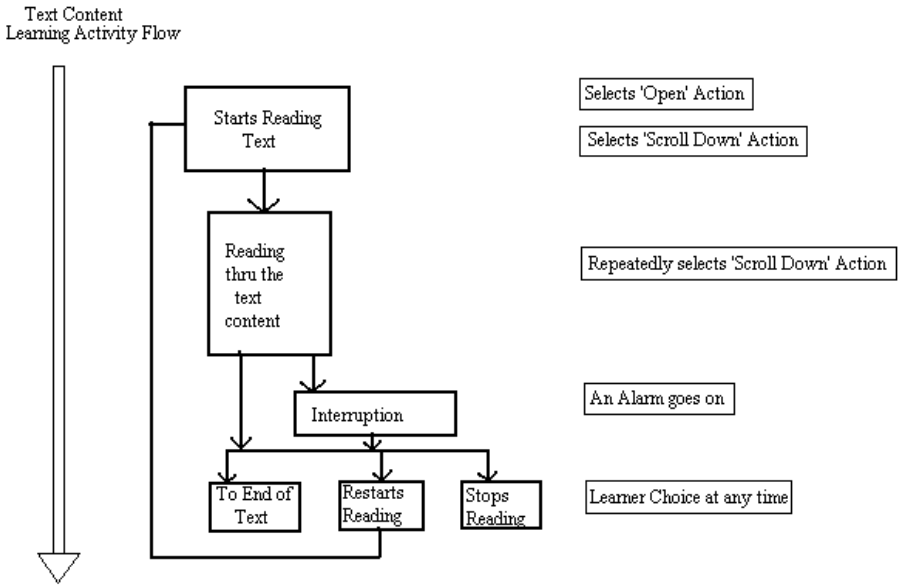

FIGURE 7: Learning Activity Flow for the application supporting *Text* type learning content

5. Conclusion & Future Work

The design methodology presented here is intended for designers interested in the developing m-learning applications that adapt to different contextual features by taking into consideration the learner's willingness to participate in the learning activity on observing his /her selected actions against the application that is presenting the learning content.

With the development in other fields such as image processing analysis, learner physical activity observation capturing technologies and psychological effect on the learner in learning environment supported by technology will enhance this methodology; as it starts to take into consideration more and more dimensions that will have impact on the learning process and acceptability or interest of the learner for that learning activity.

Further more, with the implementation of machine learning techniques and other AI techniques will make the methodology to help in designing the systems that are more intelligent in understanding the learner and may also predict future courses of actions that learner may take.

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