

A Design for a Notification and Recommender Mobile App for Educational Online Discussion

Research-in-Progress

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Abstract

This research presents an application design to integrate notification and recommendation systems (NARS) into online discussion forums (ODFs) on mobile devices. The integration is expected to overcome the issue of long delays in response that occurs in traditional ODFs. Notification increases participants' awareness of posts and recommendation reduces the effect of participants' information overload; as a result, the time between posts should be shortened and the pattern of the interaction should be altered. Specifically, the artifact is designed with respect to social constructivist theory as a kernel theory. In addition, the design includes an intuitive way to improve the accuracy of short-text clustering which is used to extract semantic topics from posts. Lastly, the paper describes a prototype of the design artifact.

Keywords

Online discussion, notification, recommender systems, awareness, information overload, social constructivist theory.

Introduction

Participation in online discussion forums (ODFs) can be improved by making the medium less passive. Giving students the ability to check discussion activity on mobile devices is one way to achieve this goal because ODF participation depends on the responsiveness of participants (Callum & Kinshuk, 2008). An ODF is a computer supported collaborative learning (CSCL) environment (De Wever, Schellens, Valchke & Van Keer, 2006), which is a specific type of groupware that adopts computer tools to foster online collaboration (Schellens & Valcke, 2005). With it, learners can exchange messages with one another through computers (De Wever et al., 2006). The medium is passive because it is designed for relatively large screens and keyboards so that participants typically check their forum(s) occasionally for new content (Hill & Roldan, 2005). Low participation has a negative effect on the enthusiasm of the participants. As a result, the participants will check the forums less often leading to decreased activity (Hill & Roldan, 2005). Mobile devices should be able to improve the effectiveness of ODFs for student learning which highly depends on "active participation and timely posting/response cycles" (Hill & Roldan, 2005, page 55).

In this research, we propose a design to integrate notification and recommender systems (NARS) into ODFs on mobile devices to address the above issues. Notification is a service that delivers messages to users instantly or at a specific time (Hornsby, Bouzazizi & Defee, 2010). In this case, it can be used to inform participants that there is a new activity on the forum. Recommender systems (RS) suggest relevant items for users based on various information filtering. Here, the system is used to recommend posts that might be relevant to the individual participants. Specifically, the current research focuses on ODFs that allow learners to have a discussion outside a classroom. Since the discussion is an addition to the classroom time, it is difficult for the learners to know when other learners are free to discuss.

Yukawa, Amarume, and Fukumura (2007) proposed a notification function on an ODF. The function notifies a learner when a new post containing words that are related to the learner's specified keywords is created. Guo, Tjondronegoro, and Roe (2012) explored mobile device features, including push

notification, as tools to enhance Q&A ODFs. They found that participants thought that the notification feature was the most useful. Loizou and Dimitrova (2013) thoroughly studied adaptive notification in virtual communities. They came up with a framework of the system and evaluated the effect of the system on learners. However, the research by Yukawa et al. (2007) and Loizou and Dimitrova (2013) are not based on mobile devices and the research by Guo et al. (2012) does not focus on learning outcomes. In addition, we could not find any research that shows how to design a NARS for ODFs.

Design Rationale

Making ODFs available on mobile devices allows learners to interact with each other anywhere and anytime; therefore, the learners can receive valuable and timely information (Callum & Kinshuk, 2008). Since participants can access the posts as soon as they are made, the time between the posts and their replies should decrease and the interaction should increase (Callum and Kinshuk, 2008). Nevertheless, they still retain the advantage as in traditional ODFs that participants have time to prepare their thoughts before they respond (Callum and Kinshuk, 2008). Moreover, enabling participants to check messages easily and frequently reduces the accumulation of unread messages. Participants do not need to go over the large volume of unread messages that might not be relevant to them anymore (Callum & Kinshuk, 2008). This also enhances users' perceptions of responsiveness, making the experience more like face-to-face interaction (Hill & Roldan, 2005).

With enhanced tools, ODF participants receive activity as it occurs and they may respond immediately (Hill & Roldan, 2005). If the participants are available at the same time, a critical mass can happen and the discussion can be synchronous. If not, the discussion remains asynchronous, but the time between posts is reduced (Hill & Roldan, 2005). The benefits of synchronous over asynchronous discussion are immediate feedback and motivation. Immediate feedback strengthens participants' learning by allowing them to immediately check their assumptions, which are required in group decision-making brainstorming, and analysis. In addition, synchronous discussion motivates participants to contribute when they see other participants' activities. As a result, the participants receive better learning experiences and can generate critical thinking (Callum & Kinshuk, 2008).

However, just making ODFs available on mobile devices might not yet yield all of the above-noted benefits. This is because the level of movement of the ODF still depends on participants' diligence to check their mobile devices for new posts. Moreover, one of the differences of using PCs compared to mobile devices is that users cannot focus on the mobile devices for a long time, especially while they are travelling (Wojciechowski, 2007). Besides, mobile collaboration at the cognitive level requires higher attention than when working on a laptop or desktop computer (Sapateiro, Baloian, Antunes & Zurita, 2011; Roda & Thomas, 2006). This is because in mobile collaboration users need to switch attention between their own work, the work of others, or other events in the environment (Sapateiro et al., 2011). These reasons impede the participants from checking their devices frequently; therefore, the mobile ODFs without NARS will not be different from the traditional ODFs.

Awareness

One of the premises of this research is that long response delay in ODF is caused by lack of awareness. Awareness in computer-supported cooperative work (CSCW) is referred to as an understanding of the activities of others in order to provide a context for one's own activity. This context makes sure that the individual's actions are relevant to the group's activities and contribute toward the group's goals (Dourish & Bellotti, 1992). In CSCL, awareness is very important to create effective collaborative learning. This is because it is difficult for learners to understand each other's situation in an online environment (Ogata & Yano, 2000). Moreover, the information about others regarding individual tasks influences the interaction; therefore, it might change the patterns of the interaction in a group (Gross, Stry & Totter, 2005). Finally, awareness encourages collaboration by increasing learner's curiosity and active learning (Ogata & Yano, 2000). Fortunately, awareness is commonly supported by various information generation mechanisms in CSCW systems (Dourish & Bellotti, 1992) and the number of those systems is increasing (Gross et al., 2005).

Notification

It is reasonable to eliminate the effect of long response delay by notifying users about what is going on in the system (Wojciechowski, 2007). Notification is a service that delivers messages to devices and users instantly or at a specific time (Hornsby et al., 2010). Specifically, a notification system is a lightweight display of information which is triggered by some specific events and delivered to a person with a current task-oriented concern. The service can also be used in an interactive way, such as asking for actions from the user (Hornsby et al., 2010).

Notification can be classified as push technology. Pull technology is a communication that delivers information to users upon their requests, while push technology delivers right messages to the right users based on predefined rules or triggers (Latif, Hassan & Hasan, 2008). The advantage of push technology is that the users are always aware when there is an update and they can respond immediately. However, push systems can cause overload since they potentially increase the amount of useless information that a participant must handle (Eppler & Mengis, 2004).

Information Overload

As noted above, several active awareness messages can cause information overload for the learners (Ogata & Yano, 1998). In general, information overload refers to the concept of receiving too much information (Eppler & Mengis, 2004). Specifically, it is a symptom when people can access, create and use more information than their information-processing capacity can handle (Roda & Thomas, 2006). It can also emerge when there is not enough time to process the information (Farhoomand & Drury 2002).

In the context of computer-mediated communication, communication can lead to information overload. In this case, information overload is a result of excessively high communication load, which translates to processing effort that participants need to handle a set of messages (Jones, Ravid & Rafaeli, 2004). Participants normally react to information overload in two ways to reduce its impact. First, participants change current communication behavior by increasing the effort or learning new information management techniques. Second, they drop their participation by failing to respond to some messages, producing simpler responses, responding as time permits, making more erroneous responses, or completely ending their participation (Jones et al., 2004). Therefore, a contribution can be made by finding ways to use technology to deal with information overload (Farhoomand & Drury, 2002).

Recommendation

RS can help users deal with information overload (Adomavicius & Tuzhilin, 2005). One problem is that users may not be able to find relevant information on an ODF. RS can solve such a problem by suggesting a set of relevant posts or threads to users (Abel et al., 2010). They not only mimic a person who is knowledgeable in a topic, but also take the person's tastes and preferences into account (Buder & Schwind, 2012). A recommendation system provides a service to users based on explicit feedback (e.g., ratings from other users) and implicit feedback (what the other users post) (Abel et al., 2010).

Recommendation systems can be classified into content-based, collaborative-based, and hybrid (Adomavicius & Tuzhilin, 2005). Content-based recommendation systems provide an item that is similar to the ones the user preferred in the past. Collaborative-based recommendation systems provide an item that people with similar preferences to the user liked in the past. A hybrid recommendation system is the combination of content-based and collaborative-based. It can provide more accuracy than the pure approaches (Adomavicius & Tuzhilin, 2005). This research adopts the content-based approach since there are not many participants in a class to create sufficient data for a collaborative-based system and content-based systems can also reduce the effect of a cold start.

Recommendation systems are commonly used in e-commerce to suggest products for customers (Buder & Schwind, 2012). However, the techniques used in commercial RS cannot be used in educational RS (Buder & Schwind, 2012). This is because the recommendation mechanism for learning should be pedagogically meaningful and it should consider learning goals, competence levels, specific interests, and intended application context (Manouselis, Drachler, Vuorikari, Hummel & Koper, 2011). Thus, RS for learning should be based on pedagogical theories; therefore, the next section describes the research's kernel theory for designing the artifact.

Social Constructivist Theory

The social constructivist theory (SCT) of learning focuses on the interdependence of social and individual processes in co-construction of knowledge (Palincsar, 1998). It argues that people learn and construct knowledge through social interaction (Pear & Crone-Todd, 2002; Pena-Shaff & Nicholls, 2004). In this case, learning is no longer a passive process; it requires active interaction with others within an environment (Pear & Crone-Todd, 2002).

SCT values the importance of feedback as reinforcement from society to construct individual knowledge (Pear & Crone-Todd, 2002). Moreover, the theory suggests that learning will be effective if the learners can share their ideas, experiences, and perceptions with their peers (Pena-Shaff & Nicholls, 2004). In addition, learning environments that encourage active participation, interaction, and dialogue allow learners to engage in a process of knowledge construction (Pena-Shaff & Nicholls, 2004).

Asynchronous ODF can facilitate the social construction of knowledge. That is, learners can collaborate together in an ODF to create knowledge (Hawkey, 2003). Knowledge construction processes in ODF are characterized by clarification, elaboration, and interpretation (Pena-Shaffa & Nicholls, 2004). Based on the SCT perspective, the outcomes created from ODF can be active learning, self-reflection, authentic learning, and collaborative learning (Schellens & Valcke, 2005).

The artifact (NARS) that is the outcome of the current research can enhance learning by improving the processes that are the basis of SCT. First of all, it brings immediate feedback to the learners. Learners can get reinforcement by replying to a post more quickly with notification than without. Secondly, it supports active participation in a discussion. The notifications keep bringing the learners back to the conversation when there is a new activity. If two or more learners are available at the same time, the conversation will be active. Finally, it can generate useful feedback. The recommendation messages are targeted to specific learners. Therefore, the system can bring only relevant learners to the conversation and the feedback can be more useful.

Architecture of NARS for Educational ODF

Most RS research focuses on recommendation methods; therefore, their frameworks specifically describe the methods and not the systems as a whole. Fortunately, the field of adaptive educational hypermedia systems (AEHS), which address the same issue as RS in learning (Manouselis et al., 2011), has very mature frameworks to explain the systems. Therefore, the current research adapts the generalized architecture of the AEHS model developed by Karampiperis and Sampson (2005) to describe the implementation of NARS (see Figure 1). The architecture is chosen because it depicts the main components of the systems and their structural interconnections. It contains a storage layer and a runtime layer. This research uses RS terminology to describe each sub-model.

AEHS is the most popular kind of adaptive hypermedia systems (AHS) (Brusilovsky, 2003) that deal with educational applications (Manouselis et al., 2011). AHS is a hypermedia system that adopts an alternative approach to the “one-size-fits-all” approach (Brusilovsky, 2003). The approach deals with the problem that learners with different goals and knowledge might need different information or treatment. That is, it adapts the presented information to an individual learner respective to his or her information in the user model (Brusilovsky, 2003) by using adaptive content selection, navigation support and presentation (Manouselis et al., 2011).

Storage Layer

User model: It is a representation of the user’s domain knowledge (Brusilovsky, 2003). The model contains information about posts that the participants have seen, their topic preferences, and their delivery preferences.

Item Model: It is a representation of recommending items. It keeps the following information: The structure of posts (post IDs, ordering, and parents), posts’ extracted topics from Latent Dirichlet Allocation (LDA) algorithms, tagging terms, and statistics (the number of people who like or read the post).

Domain model: It expresses how knowledge of the domain is linked together (De Bra et al., 1999). It is technically a network model connecting small independent knowledge concepts together to represent knowledge of the domain (Brusilovsky, 2003). It can be used as background knowledge to improve the topic discovery method described later. This can be an ontology acquired from a course’s syllabus, a book’s index, or external sources.

Goal model: It allows the individual learners to have their own goals (Brusilovsky, 2003). The goals can be adopted from the class’s objective acquired from a course’s syllabus or assigned by the instructor. For example, a goal could be to make a specific number of contributions in a day.

Recommending model: It defines how to utilize information in a user model, an item model, a domain model, and a goal model to perform adaptation (De Bra et al., 1999). The recommending model in the framework contains the six recommending rules defined later.

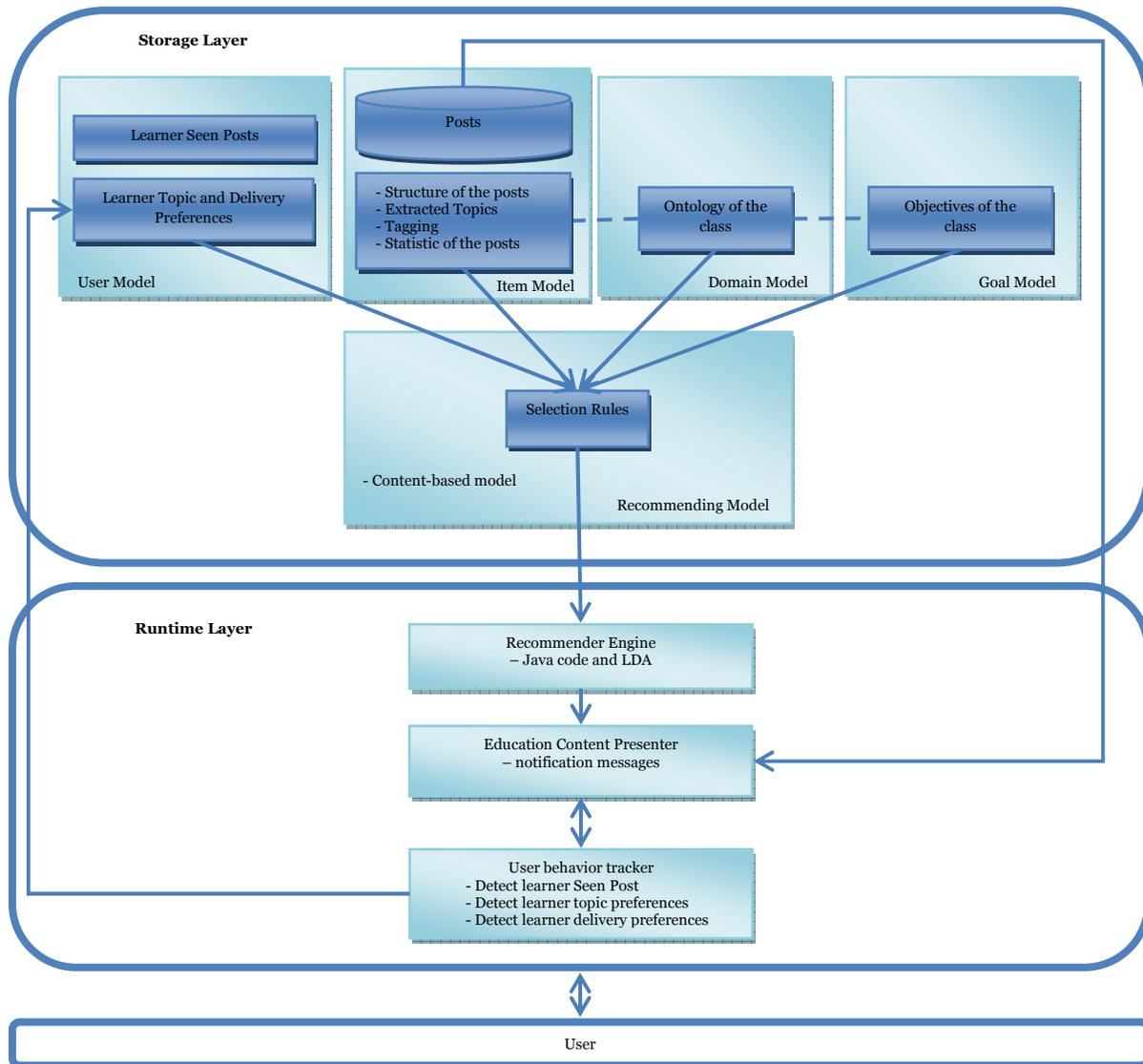


Figure 1. Architecture of NARS for educational ODF adapted from Generalized Architecture of Adaptive Educational Hypermedia Systems (Karampiperis & Sampson, 2005)

Runtime Layer

Recommender engine: It performs the actual adaptation by selecting the appropriate content (De Bra et al., 1999). The recommender engine implemented here is in Java and it adopts an LDA module to find topics from posts. In this research, LDA is enhanced with the method explained later.

Educational content presenter: It is a channel to deliver recommended items, which in this research is a notification message on a mobile device. If the participant is willing to see the post, the person can click on the message and it will lead to the post.

Behavior tracker: It tracks users' feedback to see whether users' preferences and other characteristics change, and updates the user models accordingly. First of all, the system updates the learners' seen posts model every time a post has been viewed by the learner. Secondly, users' topic preferences are detected based on both explicit feedback (a discussion thread the user wants to be notified about, a list of interesting keywords, or a post the user likes) and implicit feedback (a post the participant has interacted with). Finally, the participants can specify the time of the day they want to receive notification messages and notification frequency (i.e., the number of times per day that the participant prefers to receive a message).

Notification Rules

The goal of notification is to make users aware of posts and threads in which they might be interested. Table 1 describes rules to determine when the ODF should notify a discussion participant about new posts. Table 2 describes rules to determine when the ODF should notify a discussion participant about the existence of discussion threads. All the notifications will be limited to the number of messages and the time of the day that the user prefers.

Rationale	Rule
It can be inferred that participants are interested in the topic of the posts, on which they click "like".	If the topic of the newly created post is the same as the topic of the posts on which the participant clicks "like", a notification message will be sent to the participant.
Participants might want to follow up on a discussion thread that they created or in which they previously participated.	If participant A posts on a discussion thread and participant B makes a comment on that post, a notification message will be sent to participant A.
Participants might want to explicitly state that they are willing to follow the activity in a discussion thread.	If a participant states the desire to follow the activity in a discussion thread, a notification message will be sent to the participant when a post is made to that thread.
Participants might want to explicitly state keywords of topics in which they are interested.	If a participant indicates a set of keywords in which they are interested, a notification message will be sent to the participant when a post is made with one or more of those keywords.

Table 1. New post rules

Rationale	Rule
A discussion thread that has many participants involved or many users have indicated they “like” (popular discussion thread; calculated by percentage) might generate interesting knowledge.	If a specified percentage ¹ of participants have contributed to a discussion thread, participants who have not visited the thread will receive a notification message.
Some discussion threads have been created for a long time but do not have many people visit them. Perhaps this is because the thread title is not attractive although the thread is very interesting, or the author might be waiting for help. A discussion thread that is created for a long time, but doesn't have many people read it.	If a discussion thread has been created for a day but less than a specified percentage of participants have visited it, those who have not visited the thread will receive a notification message recommending that they visit the thread.

Table 2. Discussion thread rules

Discovering Topics from Posts

The current research adopts LDA to extract semantic topics from posts in order to identify a post that is in the topics that are relevant to particular participants. LDA is more powerful than other clustering methods since it can cluster words into topics and a document into mixtures of topics (Owe et al., 2011).

LDA represents texts based on a bag-of-words model, in which an attribute is created to represent each word in the corpus and each document is assigned those attributes with its value corresponding to the number of times the word occurs in the document (Petersen & Poon, 2011). However, the bag-of-words model has a limitation when it is used with short text documents due to sparseness of data (Xia Hu, Sun, Zhang & Chua, 2009; Petersen & Poon, 2011). That is, short texts do not have sufficient terms to make them appear in more than one document to measure similarity (Xia Hu et al., 2009). Moreover, synonymy – different words have the same meaning, and polysemy – a word that can have multiple meanings, make it even harder to analyze the texts (Petersen & Poon 2011). For example, if two different documents use different sets of terms to describe the same topic, the documents might be wrongly clustered into different groups; whereas the terms may be synonyms or related (Xiaohua Hu, Zhang, Lu, Park, & Zhou, 2009).

The length of ODF posts from mobile devices tend to be short because of the small size of the screen and the on-screen keyboard of mobile devices may impede participants from creating a long post.

Improving the Performance of Short Text Clustering

The proposed method is intuitive and does not require a modification of the LDA clustering algorithm. This method takes place in the preparation process that creates a representation of data before feeding it to the algorithm. First of all, Wu, Wang, Vu and Li (2010) suggest that important words that reflect the main topic of a document usually occur in the title, subject, keywords, etc. The proposed method identifies important words from a well-organized tree structure (Wang, Wang, Zhai, & Han, 2011) of an ODF as described below. Secondly, several studies enrich their representation of text documents with background knowledge from external repositories, such as WordNet (Hotho et al., 2003; Xia Hu et al., 2009), Wikipedia (Banerjee et al., 2007; Xia Hu et al., 2009; Xiaohua Hu et al., 2009), and Java ontology (Hotho et al., 2003). The background knowledge covers the synonyms and introduces general terms of the words (Hotho et al., 2003). This current research utilizes an ontology, for example, a book's index or a course syllabus, as background knowledge. Finally, Banerjee et al. (2007) find that doubling the weight of the terms in the title of a document yields better results. The current research follows this suggestion; however, it doubles the weight of all of the important words and terms in the ontology described previously. This approach can be used with any clustering methods that are based on a bag-of-words approach. Table 3 describes rules based on the structure of an ODF to identify important words.

¹ The discussion board administrator will specify such percentages.

Rationale	Rule
All of the posts in a thread are likely to talk about the title of that thread.	Important words should reside in the title of the thread.
All of the posts in a thread are very likely to reply to the root (first) post of that thread (Wang et al., 2011).	Important words should be in the root post.
Since a post is likely to implicitly reply to the post that is created consecutively before it (Wang et al., 2011), those two posts are likely to talk about the same topics.	The common words of two consecutive posts should be important words.
Most ODFs allow a participant to quote a statement from a previous post. In this case, the newly created post talks about the post from which the participant gets the quote.	The common words in the post and the quoted post might be important words.
Sometimes a post mentions the name of a participant in order to refer to the most recent post of that participant (Wang et al., 2011). Those two posts talk about the same topics.	Important words must be the common words in the post and the most recent post that its author is mentioned in.
Most ODFs allow a participant to explicitly reply to another post. Therefore, two posts talk about the same topic.	The common words in the post and the post that is replied to are important words.
A collaborative tagging system is used in an ODF to collaboratively indicate the topic of a thread.	The tagging terms should be important words.
The terms in the ontology of the class are the concepts discussed in the ODF.	The terms in the ontology are important words.

Table 3. Proposed rules to identify important words

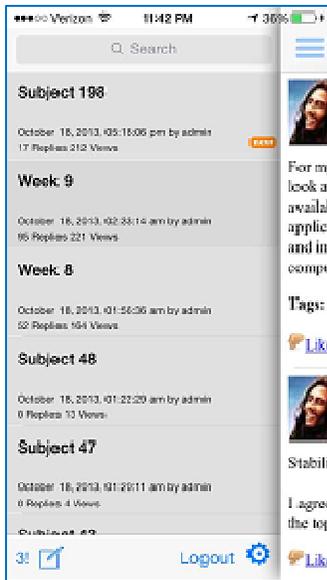
Prototype

The first author has developed a prototype of the design artifact as seen in the Figure 2. The prototype consists of a topic view (a) and a post view (b). Learners can switch between the views by sliding the post view or clicking on the  button.

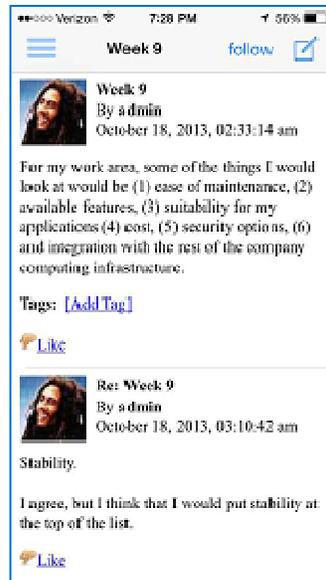
The topic view shows a list of topics, from which the learners can choose a topic to read. The setting button  leads the learners to the setting view (c) for them to specify the number of messages and the time of the day that they prefer to receive messages.  (lower left hand corner of the topic view) is a link to access the recommender view (d) which stores recommended posts and threads from notification messages. The number (3) indicates the number of recommended items in the view.

The post view shows all of the posts in the chosen topic. The learners can click on the [Like](#) button under the post if they like it. The learners can also add tags to the topic by clicking on the [\[Add tag\]](#) button and type in tagging words. The learners can also click on the [follow](#) button to have the system notify them if there is a new activity on the topic.

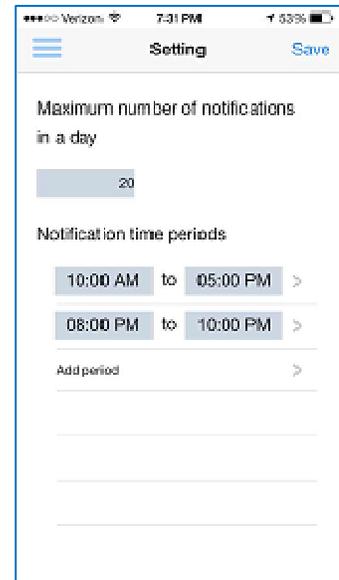
When one of the notification rules is met, a notification message is sent to the learner. For example, (e) is a notification message when a post that is relevant to the learner is created but the application is not running, while (f) is when someone posts on the discussion that the learner follows and the application is running. If the learner clicks on the message, the application will lead the learner to the post view of the topic. However, if the learner does not respond to the message, it will be kept with others messages in a notification center as seen in (g), which shows various kinds of notification messages.



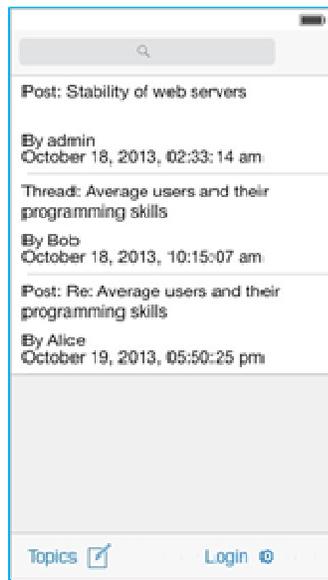
(a) Topic View



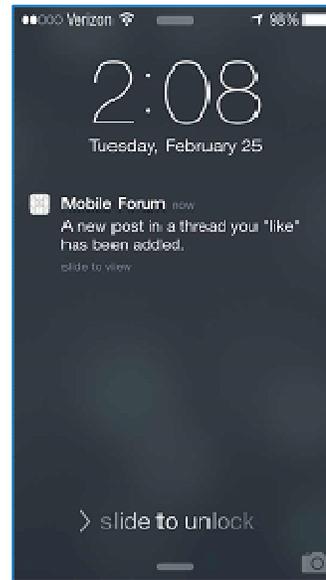
(b) Post View



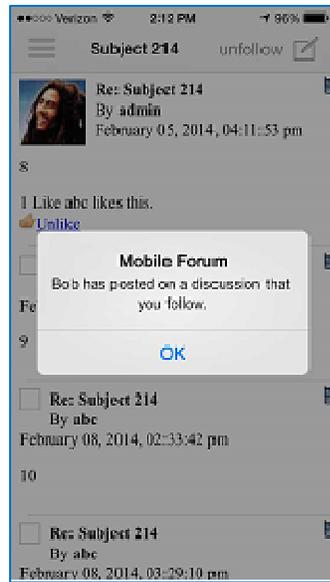
(c) Setting View



(d) Recommender View



(e) Notification (app is not running)



(f) Notification (the app is running)



(g) Notification Center

Figure 2. Screenshots of the application prototype

Discussion and Conclusion

This research presents a model that explains the potential effects of NARS on an ODF on mobile devices. As shown in Figure 3, notification gives the participants awareness of posts, and the awareness should improve the effectiveness of the ODF. In addition, recommendation reduces the effect of participants' information overload (Adomavicius & Tuzhilin, 2005). It is expected that recommendations will manage discussion participants' feelings of being overwhelmed, and therefore increase their confidence to contribute to the forum. Overall, the effectiveness of the discussion on the forum should be improved by NARS.

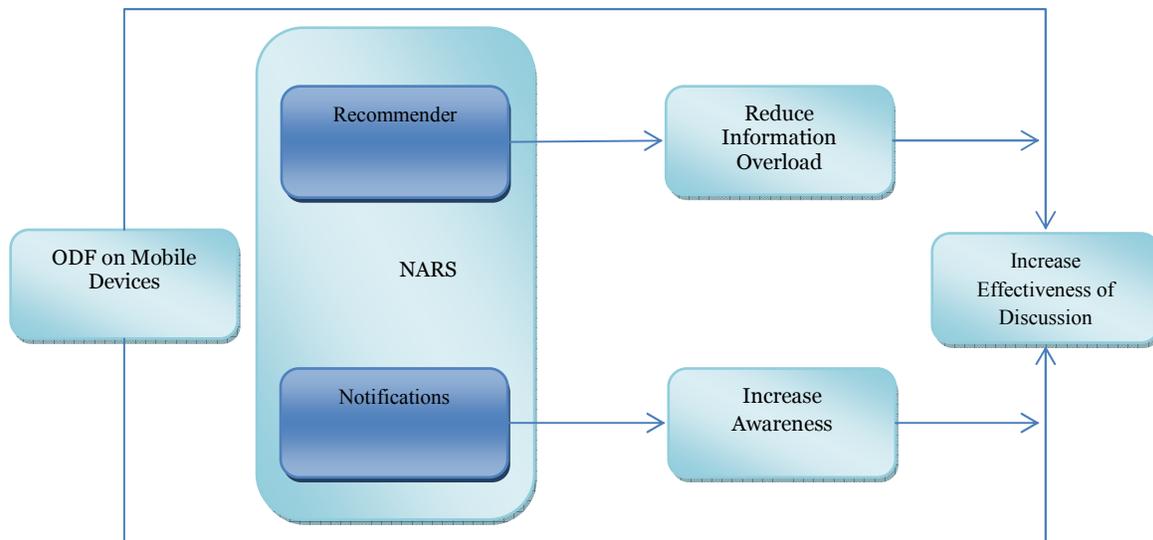


Figure 3. Model for the effects of NARS on ODF on Mobile Devices

Future research will evaluate the model and the prototype. An experiment will be conducted to evaluate the prototype. The experimental subjects will be asked to install the mobile application on their smart

phones and participate in an educational ODF. The experiment will be divided into a control phase and a treatment phase. NARS will be disabled in the control phase and will be enabled in the treatment phase. Outcome measures will include awareness, information overload, and pattern of discussion.

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