Multi-Purpose Proactive m-Artifacts

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ABSTRACT
Paper-based artifacts (e.g., forms, manuals, questionnaires) are used ubiquitously and pervasively to support a wide set of activities. Education and Health Care are major examples of such endeavors. However, given the passiveness of the medium itself, several problems (e.g., communication, adjustment, lack of interactivity) are usually encountered within these activities which hinder human efficiency or prevent users from achieving desired goals. This paper presents a framework that provides common users with tools to create interactive and adjustable digital artifacts for mobile devices. The artifacts can be adjusted to the users’ needs, introducing different configurations regarding their look, interaction and behavior, providing support to various purposes by coping with and enhancing different procedures. The framework has been validated through two case studies by providing support to mobile learning, and within psychotherapy, by offering means to achieve ubiquitous cognitive behavioral therapy.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – Evaluation/Methodology, Graphical User Interface.
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Psychotherapy, Active Applications, PDAs, m-learning, assessment, questionnaires, mobility, usability.

1. INTRODUCTION
Mobile devices possess outstanding capabilities that set them apart from fixed technologies. They present excellent characteristics (e.g., size, autonomy, portability, multimedia capabilities, short usage learning periods, low-intrusiveness) and adequateness to a wide variety of ubiquitous activities that can benefit from computational support. This support can be, among other alternatives, easily offered by replacing the traditionally used paper artifacts with a technological or digital medium [13].

In general, paper-based procedures lack multiple communication modalities, customization and configuration possibilities as well as introducing the usual archiving and search difficulties. Moreover, given their passiveness, paper-based artifacts are unable to (co)respond to users’ activities while interaction is taking place which might compromise their use in certain critical scenarios.

Mobile devices in particular can greatly enhance the underlying processes without changing paper-based procedures since they can be easily carried along with, still offering some similar interaction possibilities (e.g., touch-screen, cursive writing). Accordingly, concepts such as m-health or m-learning are currently gaining momentum and offering users ways to achieve specific tasks ubiquitously [5],[11].

However, current existing applications that focus this type of activities are generally pre-defined and focus particular domains. Most importantly, most are either too generic, and fail to grasp important user details, or too specific to certain subjects offering low-flexibility levels. On the contrary, in many of these domains, there is the constant need to update, re-use and improve existing artifacts on a daily basis. Generally, power users (e.g., therapists, teachers) are not given the ability to quickly and easily modify and create their digital items and artifacts according to specific requirements.

These problems, together with a couple of on-going projects, that focused psychotherapy [15] and education [14], were the base motivation for the design of an m-artifact (m stands for mobile) development framework. The framework offers end-users the possibility of creating interactive artifacts and adjusting their content, interaction and presentation to their needs, including ubiquity and mobility requirements. Moreover, the system offers means to exchange and transfer existing artifacts to other users (e.g., students, patients) supporting cooperation and team work. Given the digital support, the framework also allows users to include behavior in the resulting artifacts. This permits the creation of proactive tools that facilitate users’ tasks and daily activities, reacting to usage behavior, time triggers and interaction patterns.

This paper presents the mobile-artifact developing tool and the contribution that it has provided to the creation of effective tools that support multi-disciplinary activities. It focuses the specification of the artifacts’ behavior capabilities and explains how end-users, without programming or design knowledge, were able to map their needs into psychotherapy and educational tools. We start by addressing the current state-of-the-art within the aforementioned domains, stressing the features and problems that characterize most of the existing tools. Afterwards, the
framework’s architecture, components and features are detailed. The following sections present the case studies and the several steps that were taken to validate the framework and the resulting artifacts. Finally, results are discussed and future work is drawn.

2. RELATED WORK

Mobile computer applications directed to psychotherapy have been gaining some momentum in recent years. As in many other areas on the health care domain, they often focus on data gathering or visualization, analysis and especially organizational tasks [8]. Specific software, directed to the psychiatric and psychological use, allows patients to follow particular methods of therapy and even diagnosis [10]. Excluding patient solutions that, relying on expedite approaches of diagnosis, have revealed strong human rejection [7], studies have demonstrated the effectiveness of the computer role in the process of anxiety and depression therapy [12].

However, most of these systems provide either isolated therapist solutions or isolated patient solutions with no therapist control. Moreover, they only cover partial steps of the therapy process and do not allow the customization of the patients’ tasks or artifacts. The majority is rather simple and allows simple measurements of the severity of pathologies, indicates drug dosage or provides therapists with reference information about diseases or drugs [9]. On the patients’ side, some self-control or relaxation procedures are available on handheld devices [11]. Still, they are generic and offer no adjustment options that suit patients’ needs and problems or even the therapy stage.

Within education, mobile devices are also generating some buzz and conquering the e-learning domain [16]. For instance, experiences in schools show that, when PDAs are used by children, besides lightening up their enthusiasm, they allow them to play games, read e-books, communicate and collaborate with each other in safety [3]. Since PDAs are lightweight and generally peripheral device free, they are particularly suited to be used by children [4]. Their use in higher education has been tested as well. A group of computer science majors used PDAs as an adjunct to their student lives [1]. Results proved that most of the students frequently used their PDAs for lesson preparation, information sharing and even programming [1].

However, despite the abovementioned cases, their application on educational contexts is far from what it could be. Among others, the main reason for this low use, by teachers and students, is the limited number of relevant educational software for handheld devices [5]. The existing software is mostly non-collaborative, which contrasts with researches that show that the learning process is more successful where there is strong collaboration [2]. Their use is generally limited to the assessment and evaluation of students. Nevertheless, results from previous studies [6] show that PDA-based artifacts used by students, provide efficacy and efficiency levels that are identical or superior to paper-based ones. Moreover, advantages such as real-time scoring, for students, or less time spent on grading, for teachers, also promote the use of PDAs within schools and universities. However, some relevant issues regarding the variety of items and artifact customization, the chosen subjects and courses or even the information exchange between users still retract from a more common use of such devices within or outside classes.

Overall, users within these domains (e.g., therapists-patients, teachers-students), given their pervasive activities, share the need to carry artifacts with them, the need to extend their presence to ubiquitous locations and adjust their usage to specific requirements. Contrastingly, none of the existing applications offers ways to introduce behavior within the artifacts, easily programming them to react to students’ behavior or usage problems, extending teachers’ or therapists’ presence ubiquitously. Furthermore, the possibility of reviewing such behavior and analyzing the users’ activities through online or deferred tools is never available retraacting from possible improvements and innovations both on the applications and on the teaching and therapy processes.

3. ARTIFACT FRAMEWORK

The main component of the framework is a wizard-based user interface which allows users to easily compose interactive and proactive artifacts that suit their or other users’ needs. These artifacts are then exported to a runtime environment which recreates it according to the used device (e.g., PDA, cellphone, TabletPC). This exchange is supported through a synchronization tool that facilitates dissemination and data transfer between users and devices. The last component of the framework is a log player which re-enacts users’ activities while using their artifacts, providing a powerful analysis tool. All the components are available for desktop/Tablet PCs and PDAs (Pocket/PalmOS). The following subsections provide a detailed description of each of the framework’s components.

3.1 The Artifact Wizard - ScWiz

The artifact wizard (Figure 1) is the application that allows users to arrange artifacts, customizing their content and presentation, their interaction and behavior. Overall, the process of creating artifacts/applications is driven by a simple to use interface that comprises three steps: (1) creating items by selecting their content and respective presentation (e.g., typing a question’s text for a questionnaire, inserting a picture for a book); (2) customizing the items’ interactions components and modalities (a set of standard types is always available) and; (3) organizing the sequence between items. A special remark goes to the enforced usability guidelines (e.g., type and amount of content, location of buttons, adjustment to the device’s screen) that are included in each artifact, preventing users from creating poor applications/artifacts regarding their interactivity and usability.

Content/Presentation: Regarding the content and presentation modalities, users are allowed to compose items that show content using various text formats (e.g., different sized fonts or highlighted words) and images. This provides a certain flexibility regarding the presentation of the m-artifact. For instance, users can create pictorial-based artifacts that contain items that are mostly composed by images; or include reading material through items that contain texts and information about a specific subject. These items can later be interconnected to each other according to a sequence or certain criteria, much alike pages within a book. This metaphor is used in order to demonstrate the framework’s modular nature and easy creation process.
Interaction: Several interaction possibilities are also available, allowing users to configure the way in which artifacts will be used. Overall, there are four main interaction modalities available to select.

Multiple-choice/lists – allow users to choose one or more answers, sentences or images from an array of possible options. They can also be used on artifacts to display different types or information on a specific item (e.g., when used in conjunction with an image they can display captions of it’s various areas).

Gauge/Track bar – are generally used to quantify information or manipulate the item’s values.

Text/Open-ended questions – require users to write text on their own words, possibly following available hints, or to easily create and store structured annotations.

Point/Touch-screen – interaction is normally used with images where users can point on the screen and interact directly with images or drawings.

These four modalities can be used in conjunction with each other composing fairly elaborated items and highly interactive artifacts such as navigational questionnaires, manuals, role play games, etc. Still, the simple construction process is straightforward and wizard-based, allowing users with no programming or design experience to build and adjust the mobile-artifacts, easily and quickly materializing their vision into a specific tool.

3.1.1 Behavior and proactive artifacts

In order to create proactive digital documents/artifacts that offer hints and aids to users, manuals that omit or show new information according to the user’s performance while completing it, ScWiz also includes the customization of the artifacts’ behavior. The applications’ behavior can be configured through the definition of rules. Rules are composed by time, interaction and content triggers and a consequent behavior. They can be attached to a specific item or to the entire artifact. On the former, depending on the interaction or usage within a specific item, a certain behavior can take place. On the latter, the interaction within various items of the artifact (e.g., sequence of navigation or time to browse through various items) defines the entire artifact’s behavior.

Time-based triggers: can be configured to prompt warnings or change items according to the time the user is taking to review/complete it. They can also be used to define alarms that alert users to use or complete an artifact at a given time.

Interaction triggers: analyze the user’s interaction with the device by counting clicks or detecting where on the screen the user has interacted.

Content based triggers: activate behavior depending on the content of the items. For example, if the user chooses a correct value or a specific option from a list or a value within a defined threshold, a certain behavior can be triggered.

Behavior: In concert with the rules that are defined for each item or artifact, two different types of behavior can be selected. The first one prompts a message that is composed by the user while the second jumps from the current item to another item within the artifact (e.g., first item, end of the artifact, drawing, previous item).

3.1.2 Example of customized tools/applications

With these dimensions and corresponding functionalities, users can customize artifacts according to the users’ context. Using different presentations; different interactions; different navigations and behaviors the artifacts can be modeled to whatever is needed according to the requirements of a specific content, user, situation or available equipment. Overall, the artifacts can be adapted to:

(1) Content – different types of media (e.g. images, text) can be easily inserted, composing content or fetching information from several sources and compiling it into specific artifacts. These can contain various subjects (e.g., pain therapy, depression assessment, geometry, English). Together with the possibility of adjusting the content with different interaction types (e.g. touching the device’s screen and pointing at a picture; selecting an option from a list of choices or writing free text), our system allows users to create a varied set of tools for multiple disciplines and purposes.

(2) Location and time – using the same mechanisms mentioned above, users might compose artifacts according to the predicted location and time in which the tasks will be completed. For instance, if the user isn’t restrained by time, the artifact may be composed by open-ended questions. However, if the artifact must be completed while walking through a specific setting or similar context, lists and choice groups are better suited.

(3) User requirements – different users (e.g., students/patients) have different requirements. Therefore, the system allows teachers or therapists to personalize the studying/therapeutic material, including help and warnings, rewarding sentences, etc, according to the user and to his/her behavior while completing the task. Furthermore, the inclusion of different media types and content might also enhance the usage process for users with different ages (e.g. pictorial content for younger ages and textual or both for older students).

These capabilities allow end-users to configure their artifacts to specific situations (e.g., free-text interaction when user has time to write, multiple-choice when user is walking); specific users (e.g., images for infants, text for adults, both for teenagers); critical scenarios (e.g., pop a warning when user needs to take his/her medicine).

3.2 Synchronizer
The toolset also offers means for users to transfer all the information and artifacts to and between devices as needed. It also includes real-time browsers that facilitate the visualization and selection of artifacts and usage logs, automatically detecting the connection type, the device or exporting possibilities (e.g., to device, to XML file).

### 3.3 Running Environment

The artifact running environment is a simple software module that is installed on a mobile device and is responsible for re-creating all the artifact/applications' descriptions, stored within XML files and built using the artifact editor. The environment is driven by a simple to use user interface which allows users to select which artifact to use as well as to review previously completed artifacts and results. The runtime environment application also includes a logging mechanism that, if switched on, gathers information about artifact usage for posterior analysis. Gathered data can be composed by the amount of clicks, location of the clicks, chosen values, typed characters, time to complete each question, etc. Currently, there are runtime environments for PocketPCs, PalmOS based PDAs and desktop computers.

### 3.4 Log Player

All the information generated by the runtime environment and use of every artifact can be analyzed by the logging module’s counterpart. This counterpart is embodied by a player which reenacts every action taken by the user while using the artifacts on the mobile device. The player analyzes the logs and generates all the events stored on the log, creating a “movie” that pictures the user’s interaction with the artifact. This provides detail on the user’s navigation through items/questions, the number of times he/she presses each button, selects an option from a list, etc. Furthermore, as on the recording, the revision of the usage behavior can be modeled according to several granularities, browsing through high-level interaction events (e.g. selecting an option from a list) or low-level events (e.g. every tap on the screen). Search mechanisms and index navigation are also included. The log player is available on a desktop version where users can analyze and compare several logs at the same time and on a mobile stand-alone version.

### 4. CASE STUDIES

Throughout the development stage, several domains were experimented and a wide set of artifacts was created using the framework (e.g., short interactive tutorials, organized diaries, etc). However, to fully evaluate its potential, assess its usability and flexibility, the entire system was used on to real domains for real-life case studies. The first domain was psychotherapy and the second was education.

#### 4.1 Psychotherapy

Cognitive-Behavioral Therapy for the treatment of depression, anxiety or associated disorders relies heavily on the completion of paper questionnaires and thought registries, by the patients, throughout their daily lives. Accordingly, the introduction of a mobile-artifact developing framework was particularly suited to this scenario. Furthermore, the introduction of behavior and pro-activeness without disregarding ubiquity was greatly needed in order to react to the patients’ needs while away from therapy. The artifact development framework has been used by psychotherapists and cognitive behavioral therapy researchers to create a wide set of existing therapeutic tools aiming to enhance the therapy process and patient improvement [15]. Several specific data gathering artifacts (e.g., questionnaires, thought registering tables, pleasant activity records) have been emulated and adjusted to patients (Figure 2, left).

Moreover, new approaches were also experimented and new artifacts were created. Some examples include anxiety assessment forms, pain measurement questionnaires, and relaxation tutorials. For instance, Figure 2, on the right, depicts an innovating pain therapy artifact that was arranged by a therapist, using the framework. The artifact allows users to select the location of their pain through the image or the multiple-choice options. A similar artifact was created where users could point on an image their dislikes about their body and quantify them by using a track-bar. On thought registration forms, using the various interaction features, therapists included quantifying components that allowed users to catalog their thoughts and problems according to severity.

Using the log player to review how patients completed their questionnaires and registered their thoughts, therapists were able to identify problematic thoughts where patients felt more uncomfortable (e.g., thoughts that took more time to register or were frequently revisited) and those that required further intervention during therapy sessions. This feature was particularly appreciated by therapists.

**Figure 2. Cognitive Behavioral Therapy m-artifacts.**

#### 4.2 Education

The framework has also been used to create educational artifacts for students on a university setting, for a computer science course. Here, the main goal was to provide students with evaluation tests that could be answered on personal mobile devices (e.g., PocketPCs). Teachers also wanted to assess students’ difficulties while using the tests and to understand if those problems pertained to the selected configuration of the artifacts or to the subject and content itself. ScWiz was provided to teachers in order to create the evaluation tests. Tests included several questions with different presentation and interaction modes (Figure 3) and were distributed to a class through the synchronizer. This process was replicated at the university and at each student's home (e.g., tests sent to students through e-mail). All the results were gathered through the synchronizer or sent by mail and later reviewed by the teachers. The logging mechanisms allowed teachers to detect which questions took longer to respond, those that were revisited more frequently and those whose value was changed more than once. These three dimensions in conjunction allowed teachers to isolate questions...
that probably posed more difficulties to students. Moreover, it also provided some detail on which type of interaction components and presentation modes were more suited for that specific scenario [14].

On a qualitative analysis, students appreciated the fact of conveying within one device most of their annotations, exams and manuals provided by the teachers. Hints, the varied pictorial content and the visual appeal were also very well received. For teachers the major contributions were the ability to configure artifacts according to various dimensions and the groundbreaking analysis that the log player provided for both class and homework.

![Figure 3. Mobile Learning m-Artifacts with different presentation and interaction options.](image-url)

5. RESULTS AND DISCUSSION

The two case studies provided positive results regarding the functionalities and usability of the entire framework. The possibility of including rules and reactions within the artifacts allowed therapists to extend their presence outside of the therapy sessions, aiding patients whenever it was necessary. Patients also were able to complete their therapeutic artifacts more promptly, immediately after specific situations occurred and whenever alarms requested them to do so. Using the log player, therapists were also able to identify problematic issues and concentrate their efforts on the most relevant problems. Teachers were also able to isolate questions that posed more problems to their students thus focusing specific subjects or customizing their tests accordingly. For students, advantages emerged from the possibility of using several artifacts on the same device and even being able to carry on with their tasks (e.g., homework) wherever they were.

Overall, the framework’s adequateness to these two domains suggested that new boundaries can be found and other activities can be enhanced or supported by using mobile devices with proactive and customizable c-artifacts. Creating simple artifacts that serve the purpose of prototyping for complex applications can also be a possibility for ScWiz. Complementing this use, the log player and analysis tools can also be used within usability evaluation research, detecting when and how users have difficulties using certain components or the device itself.

6. FUTURE WORK

Given the positive results from the evaluation stage and the benefits found while using the framework on real-life scenarios, the main goal for the near future is to apply the framework on other fields and domains, namely other healthcare areas.

Secondly, a group version of the log player is being developed. Its main objective is to provide detailed insight of user interactions within a working group. The same mechanism used for the individual version will capture events for each user depicting their activities as well as their interaction with other users, showing with whom they exchanged information and what information was exchanged. An on-line, real time version, supporting the management of on-going sessions or classes, supported by large interaction displays and mobile devices is also being developed.

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8. REFERENCES