**METHODOLOGY:**
Describe the methods you plan to use to achieve the proposed goals. For example: experimental techniques, sampling procedures justification, statistical analysis of results, etc.. **The maximum length for this section is 3 pages. (Arial or Verdana, font size 10).**

A) Analysis

We do not want to develop the framework from scratch but to use as much as possible already developed suitable components. Some of them might fit in as part of the framework directly; others might require some adaptation before being used while others can be used to inspire the development of our own solutions. The analysis of existing components must be done for the definition of the data format, the communication middleware and the interface. For this analysis we should bear in mind the operating systems of the various devices.

A.1) Analysis for the data Format

As already said, it seems to be natural to search for an XML-based standard platform-independent protocol for describing data. SOAP is a very popular protocol, extensively used to pass data between applications running on different platforms. However, it is a very “heavy” protocol: the description of the objects in SOAP requires much information, even if we want to describe a simple object having only one or two variables. This might be unpractical for the mobile devices. We will explore other protocols that generate shorter XML description of an object and we will evaluate the option of developing our own converter. This might have the drawback of not being compatible with the standards.

A.2) Analysis of the communication platform

This middleware has very strong requirements to fulfill: first, it has to run over different platforms. Even if the programming language that will be used might be the same for all platforms (which has still to be evaluated in the implementation phase), there are some libraries that work over one platform but they are not available for the version of the language for the other platform, which is the case of the libraries of classes Java used for WebServices: they are available for the Java Virtual machine of the PCs but not for the PDAs.

A.3) Analysis of the interface

Many of the devices being used nowadays to support learning use a touch screen for human-computer interaction (electronic board, Tablet-PC, PDAs and even smartphones). This is a very natural way to interact since it resembles the pen-and-paper situation. Therefore, we are going to develop applications implementing this type of interaction as far as possible. In the analysis phase we will explore the most important functionalities of an interface that can be implemented with gestures. We will also review the literature in order to find out which are the gestures that have been used successfully in other applications to check if it is worth to implement these functions. It is also important here to explore which gestures can be easily made in the various kinds of devices we intend to use.

A.4) Analysis of the applications

In this stage we will identify the requirements of a set of applications that will be developed with the framework. This set of applications should allow the teacher to present and/or collaboratively create learning material with the students during a lecture in the classroom (with the electronic board for the teacher and Tablet-PCs or PDAs for the students). In summary, it should allow to apply the integrated approach for using computers to support learning. It should also allow the students to use this material and go outside to gather data, working individually or collaboratively, then process this material at home in their PCs and finally present it on the electronic board in the classroom again.
B) Design

During the design phase the component of the platform as well as the applications should be designed.

B.1) Design of the data format

The format of the data that will be used in all applications will be defined. This means a formal and detailed explanation about how an object will be described in XML. Of course, this has to be done only for learning material and is thus going to be shared between the different applications. It is important to consider here that the objects should exist in various platforms. Therefore they should be able to contain variables which have a same meaning (representation) in all of them.

B.2) Design of the communication middleware

The product of this phase should be the description of all the services the middleware will implement and a detailed description of the API of the classes supporting the programming of communicating applications over this middleware. In this stage decisions must be made about whether are we going to use an existing platform, adapt it (for example, programming missing functionalities over it), or develop a new one from scratch. The design of the data format will necessarily impact the decisions that we will make.

B.3) Design of the user interface model

In this stage we are going to determine the common elements the interfaces of all applications will have. The design will include at least the following elements:

- A set of gestures which are both easy to remember and to perform over all kinds of devices. In this way the user will not need to learn new gestures when switching between the various applications.
- A set of icons that will have the same meaning in all situations, which means, they will trigger the same functionality, regardless of the device and/or application they are currently using.
- A layout pattern for distributing the elements of the interface. This will allow the users to find the functionalities in any application running in any device in more or less the same place.
- A set of awareness mechanisms that will be used when working collaboratively.

B.4) Design of the applications

Based on the requirements defined in the previous stage, each one of the applications will be designed in its functionality and its architecture. Here we will also decide the platform and hence the programming language for each application.

C) Implementation

The designed elements of the framework will be implemented in this stage.

C.1) Data Format

No implementation is necessary since the data format is a specification that will be used while implementing the applications.

C.2) Implementation of the communication Middleware

Depending on the decisions made in the previous stage, the middleware for the communications will be programmed or adapted. It will be programmed for each one of the platforms chosen where the various applications should run on. A TCP/IP based communication mechanism and the common data model will ensure that the applications running on different platforms will be able to exchange data and therefore synchronize with each other.

C.3) Implementation of the interface model

Having defined the set of gestures that we will use we are going to implement a library of classes for recognizing gestures. Since gesture recognizing has already been implemented for electronic boards (Henning et al., 2005), PDAs (Zurita et al., 2008), we are going to adapt and extend one
of the existing solutions to the required platforms. The layout pattern defined in the previous
stage will be used to diagram the applications’ interfaces. Icons containing similar images but in
different sizes will be implemented and added to the library in order to have a coherent set of
icons for the menus in the various applications.

C.4) Implementation of the applications
The applications will be implemented using the communication middleware and the gesture
recognition library. Therefore, the process of application development will also serve as a testing
for the suitability of the communication middleware API to support the development of these kinds
of distributed applications. We will mainly develop learning oriented but we will also use the
framework to implement other kind of applications. For example, this framework can be used to
implement Decision Support Systems (DSS) and Meeting Support Systems (MSS).

D) Testing

D.1) Testing the data model
Testing of the data model goes hand-by-hand with testing the communication middleware. We will
evaluate the suitability of the data model to describe all the necessary information (effectiveness)
and the length of the XML description required to code it (efficiency). The effectiveness will be
tested by checking if a data object residing in the memory of a certain application can be
converted to its XML representation as defined in the previous stage, sent to another application
with the communication middleware, and received and converted to the memory representation of
the receiver application without loss of information. The efficiency will be tested by measuring the
rate of information it is possible to send with the communication middleware in terms of number
of objects.

D.2) Testing the communication Middleware
Apart from the testing for the communication middleware already mentioned in the D.1 section,
here we will test the effectiveness of the middleware to establish the communications among the
applications in peer-to-peer as well as in client-server architectures and test how stable and free
of errors is this communication. In peer-to-peer architectures this means how well the
communication platform is able to localize other applications to which it has to establish
communication links with them. The effectiveness will be tested by measuring how long it takes to
recognize the applications and establish communication with them. Here we will also measure the
efficiency of the transmission by measuring the rate of information transmission in terms of bytes.
This and the test mentioned in the previous section will allow us to have a measure of bytes per
object transmitted among applications.

D.3) Testing of the user interface model
The interface model can be tested by a normal usability test in which the users work with the
various applications and they express their opinion about how easy or difficult is to use the
application by a survey. The questions in the survey should permit the users to express their
opinion on the selected gestures, the icons, and the layout of the elements in the interface.
The gestures selected in the previous stage should be tested for the different devices to evaluate
how the users learn the gestures. Of course, it should be considered that a gesture that can be
well performed in a certain device can be very difficult to perform in another one, so a tradeoff will
be necessary to select the best ones. Also the suitability of the awareness mechanisms should be
tested.

D.2) Testing of the applications
Testing of the applications will be the final stage of the project. This will be made in a real learning
setting. For this we will use students of first years in the university and students of the last school
years as subjects. Written surveys will be used to specifically gather information about the
suitability of the integrated approach as well as the usability of the interfaces developed following
the directives and using the tools of the framework.