

A Model-based Approach to Integrate e-Learning Platforms and Social Networks using a Service-Oriented Framework

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E-learning is moving beyond traditional Learning Management Systems and Social Networks are raising new ways of learning. This work proposes an approach to integrate social networks and e-learning platforms taking advantage of both kinds of tools. The approach is based on a method which enables the formal representation of social e-learning situations by means of models. A service-oriented framework is proposed to implement such approach in a two way direction between e-learning platforms and social networks. This framework has been prototyped using widespread Facebook social networking platform tools and adapting a learning management system called Coome. The developed prototype has been evaluated demonstrating how useful such integration can be.

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1. Introduction

In the last years, there has been a huge interest in incorporating social environments into e-learning environments to promote new ways of learning process. The widespread use of social networks (SN) and tools, significantly encouraged by mobile technologies such as smart phones and tablets, represents an important contribution in terms of providing additional channels and diverse learning modalities, particularly in e-learning settings.

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There are related works describing e-learning situations where social interactions can boost the learning process, such as Remote competition games (Atanasijević-Kunc, Logar, Karba, Papić and Kos, 2011) or Collaborative learning of electrochemotherapy (Čorović, Bešter and Miklavčič, 2009). However, most e-learning platforms, also known as Learning Management Systems (LMS) have been focused primarily on managing learning resources and tasks, usually disregarding the social interactions. The current work proposes an approach to improve the integration of SN and LMS by taking the advantages of both platforms and the respective tools in order to make the online instructional process more socially-aware.

SN are popular online tools with more than 800 million users worldwide, enabling various types of interaction among users (Social Economics, 2011). More than 20% of the users spend more than 20% of their online time using SN and more than 50% of SN users are using SN on a daily basis. The fact is that there is a pool of more than 400 million users that are familiar with SN concepts and their user interfaces. Moreover, SN users do not need any special instructions on how to interact among each other, enabling the learning processes to benefit from this natural interaction promoting a constructivist learning view (Dalsgaard, 2006). Learning requires prepared contents to be learned or activities to be completed; both need to be appropriately developed in order to be meaningful to the users and deliver appropriate knowledge. The LMS is usually the source or repository of instructional materials and can provide different mechanisms to implement learning activities. Therefore, LMS cannot be ignored as they represent an important element of the learning process. Given the potential of the SN phenomenon, LMS presence can be further enriched and complemented with SN tools, which represents a challenging concept, addressed and discussed in this paper.

There are many e-learning platforms providing support for different e-learning issues, often including additional internal or external tools such as forums and wikis that enable users' interaction and communication among them. Nevertheless, it is sometimes difficult to convince e-learning users to employ such tools or encourage their usage. Moreover, in existing LMS environments the relationship between communication tools and instructional materials (courses) is typically weak. The fact is that communication tools present in current e-learning platforms must be adapted or replaced by more efficient or alternative versions. Previous works are available that propose the integration between e-learning and student management systems (Fumana and Bertazzo, 2009) or platforms for SN applications integration (Garofalakis, 2010). In contrast these works do not provide a solution on how to systematically approach towards the LMS and SN integration. The contribution of this work is to introduce a software platform intended to integrate e-learning and SN tools in order to facilitate their connection through a service-oriented framework.

There is a growing interest in the so called Social LMS such as Topyx (Interactyx, 2010), Knoodle (2010) and Sclipo (2010); for the time being these actually represent simple LMS with incorporated social tools. There are also some initiatives to launch LMS applications for Facebook such as Uduu (2008) and AppFusion (Wing, 2011). Existing LMS applications for Facebook display the LMS inside the SN environment, while the LMS and SN are detached as well as the user experience of using two separate platforms. The solution proposed in this work differs in the way to integrate the LMS and SN enabling those cases where the use of independent platforms and the use of the integrated solution are required. Therefore, it is important to support users' actions taken in the integrated solution to have an impact in independent platforms and vice-versa.

To make possible such integration, targeted research is required in architecture domain to fix conceptually the problem and design the most appropriate architecture, taking advantage of the

benefits provided by both model-based approaches and service-oriented architectures. The current paper proposes a model-based approach as a first step to represent the pedagogical issues in a formal way through modeling methods. From this modeling stage it would be easier to design service-oriented accesses to LMS and SN platforms and implement them in a second step. The remainder of the work is structured as follows. The next section provides a general overview of the model-based approach formulated to represent social e-learning situations by modeling of social patterns. The third section presents a framework, implementing the modeled pattern entities, for designing appropriate services that would enable the integration of e-learning platforms with social networks. The fourth section describes the framework implementation in a specific context based on linking Facebook to a LMS example, followed by a case study to test and verify the implementation in the fifth section. Finally, conclusions are drawn and further work is discussed.

2. Model-based Approach

The approach introduced in this work allows instructors to detect whether learning issues are appropriate or require the interconnection of social networks and e-learning platforms. The proposal is based on the use of design patterns, which can be considered as a structured method of describing good design practices in different fields of expertise. When applied at the modeling stage, design patterns are essential to provide sound model-based tools: they connect in a precise way problem space and solution space, making feasible to implement correct model transformations.

Originally, design patterns were introduced into architecture disciplines by Alexander, Ishikawa and Silverstein (1977) as 'a careful description of a perennial solution to a recurring problem within a building context'. This pattern notion has been successfully adopted also in other disciplines, such as Software Engineering or Interaction designs. Furthermore, pedagogical patterns are recognized as efficient mechanisms to document good practices in teaching (PPP, 2005), including visual flow representation (Hernández, Asensio, Dimitriadis and Villasclaras, 2007). In addition, other design patterns have been proposed 'as conceptual tools to support educational design' (Goodyear, 2005). Rohse and Anderson (2006) also justify the use of design patterns recognizing learning as a complex process. Furthermore, some tools, such as E-Len (Avgeriou, Papasalouros, Retalis, Skordalakis, 2003) and PCeL (Frizell and Hubscher, 2002), were developed to model these patterns in e-learning contexts.

Patterns are powerful mechanisms to represent different learning issues related to items such as theoretical contents or laboratory activities in a certain technology-based educational context. This approach can be extended by representing social interaction activities in the e-learning contexts. Figure 1 shows the debate pattern, an example of e-learning patterns, which can be included in the social pattern category. The debate pattern describes the pattern components by means of text: the problem to be solved, the proposed solution and some related patterns E-Len (Avgeriou *et al.*, 2003).

However, this narrative description hampers a more rigorous representation that could be useful in a context where such social patterns should be implemented by means of a technological setting and using software engineering mechanisms. This work proposes to use the debate pattern as a presentation of social activities in a learning process as well as the use of modeling techniques to represent the debate pattern and other social design patterns in a formal way through models (Ballester, Panach, Buendía and Pastor, 2011). By doing this, real-case learning scenarios are

Problem space	<i>'The exploration of contradictory views can promote a deeper understanding of a subject. It can stimulate each participant to develop their own opinions and explore their reasons for them. However, students are sometimes reluctant to challenge each others' views.'</i>
Solution space	<i>'Identify two or more students to 'speak' to each side of a motion. Give them equal time/space to make a contribution setting out their views. Once they have made their contributions, open the discussion to everyone in the discussion group. At the end of the period defined as the lifetime for the debate, invite the proposing and opposing speakers to sum up. End the debate by taking a vote on the motion.'</i>
Related patterns	DISCUSSION ROLES, VOTES etc.

Figure 1: Debate pattern

converted to models that can be adapted for further changes in other domains using different entities. This simplifies the application of social patterns to multiple domains.

Figure 2 shows an example of an UML diagram that models the debate pattern where entities and actions were defined according to the debate pattern problem and its solution space and users' roles and tools available in e-learning domains:

- **Users.** Participate in the debate under different roles, such as students posting their contributions and messages or tutors and teachers that moderate it.
- **Topics.** Represent all types of resources (instructional materials) that could be used in the preparation and implementation of the debate such as documents, audio podcasts, video presentations or Uniform Resource Locator (URL) links.

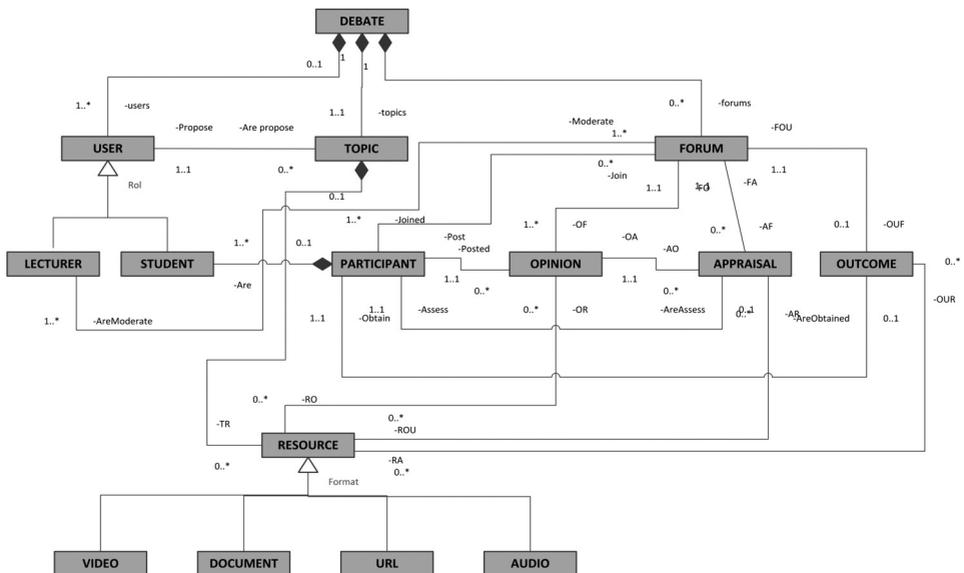


Figure 2: Debate pattern model

- **Tools (Forum).** Symbolize the area or virtual space where students' posts or teachers' comments and appraisals can be located.

A further step consists of implementing the debate pattern model in a context of integration among LMS and SN platforms.

Debate activities are frequent in educational environments and e-learning domains. There are multiple tools to implement them such as forums, messaging and chat. However, many of their implementations are bounded to message sequences about a topic without a direct interrelation with learning objects. The proposed debate model enables the representation of instructional resources, which can be used in the user discussion. Such feature permits to contextualize the debate allowing participants to have a direct reference to information items related to the commented topic.

3. Service-oriented Social e-Learning Framework

The proposed approach is used to design a Social e-learning Framework (SEF), a framework that integrates e-learning platforms and SN services to enable socially-aware e-learning environments. The framework provides a set of services and components to integrate the SN and the LMS environments into a concise SEF.

3.1 Social e-Learning Framework Fundamentals

The SEF reported in this work implements the previously proposed debate pattern model entities and relationships linking SN applications with LMS components. There are entities present in LMS that are not present in SN and vice-versa. Considering the entities of the two platforms, SEF assigns the debate pattern model entities to appropriate entities of the LMS and SN and it defines its relationships as services provided by both platforms.

SN applications are based on sets of interacting individuals who share common interests and are grouped according to their social activities and personal decisions (Kelsey, 2010). Individuals in SN are related in such a way that it is possible to follow the relations and start an activity with a non-related person. This mechanism enables the growth of SN relations and consequently the number of social activities and interactions. Software supporting online social networks includes a set of communication, collaboration and interaction tools, which can be used to fulfill the requirements of the SEF that deal with the activities of the debate pattern model.

LMS is the supportive software serving the e-learning process and providing simplified and controlled access to instructional materials and learning activities. SEF proposes to use LMS contents and user management tools to guide the social e-learning process where sharing of materials is identified with the resources involved in the debate pattern model.

SEF implements the debate pattern model relationships as services. This approach does not require a low level connection of LMS and SN. That supposes an advantage of such integration as both platforms act as independent platforms and they can always be detached. Moreover, the final user experience is expected to be deploying one single platform integrating all the social and e-learning solutions.

Figure 3 shows users' relationships in the SEF context that divides them in SN users and LMS users. Users that are present in SEF have accounts either in SP and LMS where the framework provides proper relations of users' accounts among the two systems. The framework does not

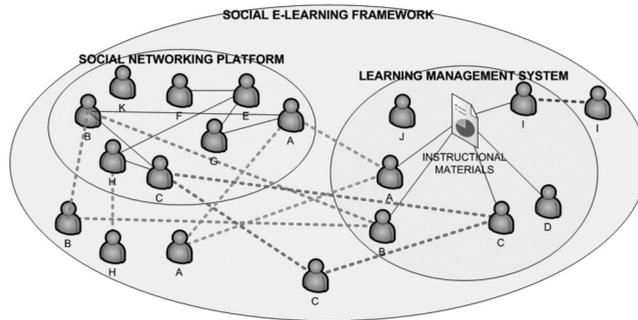


Figure 3: Social e-learning framework overview

restrict the creation of SN and LMS accounts to non related users. Furthermore, there are users accounts present in the LMS and in the SN, which are not related with the framework, and users in the framework, which are not related with a SN or LMS account.

The SEF integrates related social activities provided by SN and instructional resources provided by the LMS, and it assumes that users can do learning activities focused on e-learning materials and social events. Figure 4 shows the SEF services approach where learning activities are provided as external services of the LMS and social events are displayed as external services of the SN. Similarly, the access to the contents and the users' data is also provided via services. SEF proposes the integration of the SN and the LMS in a way where LMS learning materials and activities are introduced to the SN, and SN social tools and activities introduced to the LMS, which enables the social e-learning processes in both environments.

As shown in Figure 4 users present in the SEF do three different types of activities:

1. **Learning activities on instructional materials.** Are shown by label '1' on the figure and include the access to instructional materials and progress tracking. Activities are supported by the LMS.
2. **Social activities on instructional materials.** Label '2' shows the flow of the activities related to the debate pattern model. Social activities on instructional materials can cause new social

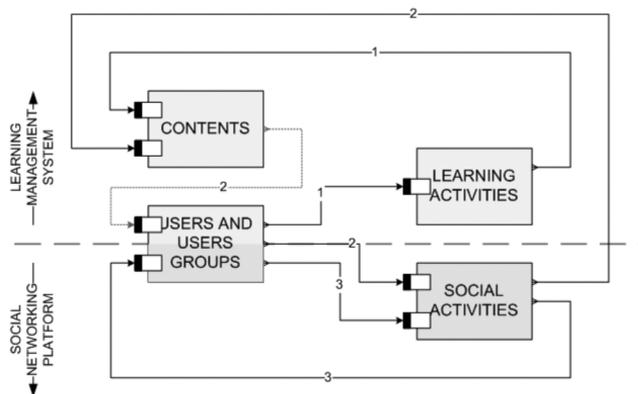


Figure 4: Social e-learning framework components

activities as marked with dotted line in the figure diagram. SEF services are required on both platforms, LMS and SN, to support these kind of activities.

3. **Social activities on users and groups.** Are social activities supported by the SN and are not necessarily related to instructional materials. On the figure are labeled with number '3' and they include messaging, chat and other social services.

3.2 Integrated Framework Activities and Services

The SEF proposes an integrated environment of e-learning and social activities where the support for learning activities is provided by a LMS and social activities are supported by a SN in both environments, respectively.

In this framework, the LMS is the entity in charge of data storage of all teaching materials, learning activities, users tracking and assessments, even though the SN tools provide services for users' social activities to promote the interaction among them. Users account data can be stored partially in both systems with a clear connection among single user data stored in the LMS and SN.

There are numerous social activities present in the SN. According to the debate pattern model previously introduced, suitable activities have been considered to be integrated with e-learning activities:

- **Chat.** It is a common live communication tool already present in various LMS. SN platforms typically have more sophisticated chat engines than e-learning platforms. There are needs to enable social network chat services interconnected with learning objects with integrated awareness of the relations among users.
- **Messaging.** Messaging is used for general communication and administrative purposes. While not being primarily used for real-time learning and communication, messaging must be present as an alternative communication tool in a general environment.
- **Commenting.** Comments are a featured social networking tool. In case of social e-learning processes, comments must be linked with learning objects encouraging users' communication focused on the target learning object.
- **Recommending.** This is a tool where users can flag a learning object as recommended and where all users have the review of others recommendations. Otherwise, a recommending tool can be used also for rating and assessment purposes.
- **Inviting.** Users can send an invitation to other users to use the selected learning object or report an event of interest.

While multiple learning activities are present in the LMS, not all are required to be available from the SN. The first version in the SEF considers two main activities to be available from the SN:

- **Access to learning objects.** It enables the integration of the LMS learning materials with the SN. Access to learning objects is the most important learning activity that gives meaning to other activities.
- **Progress and access tracking.** It is the activity, which needs to be integrated within the SN as the access to learning objects inside the SN and the LMS must be similarly tracked.

Figure 5 shows the framework model of the LMS and SN services, their mutual relationships and support for third-party tools. To support a two-way integration – from LMS to SN and vice-versa – services for data access need to be present in both systems including the option to integrate third-party tools.

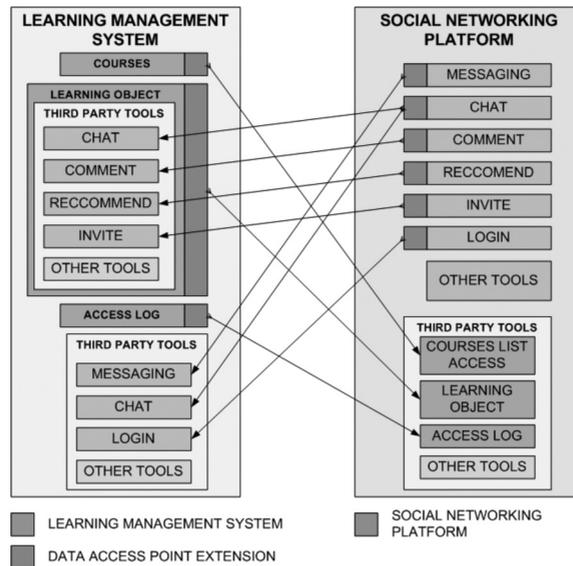


Figure 5: Social e-learning framework services

Based on the presented concepts and design considerations required for the implementation of the proposed SEF, the LMS has to implement services to access learning objects and to collect data about progress and access tracking. Also, the integration of third-party modules into the commonly used environments needs to be supported and systems for access to learning objects need to be appropriately upgraded. From the perspective of the SN, the use of third-party tools has to be supported from the main users' environments and services in order to enable access and use of SN tools.

4. Framework Implementation

The previously presented framework has been implemented in a specific learning context based on the use of Facebook as the SN and an e-learning product Coome as the LMS.

With more than 800 million users Facebook represents the world's most widely used SN. It already implements a mechanism to support the use of third-party services called Facebook applications. Also, services are available to access the platform data from external applications. Together with a large user database these characteristics justify the selection of Facebook as the SN for SEF application.

Coome is a LMS with a complete support for the production and distribution of multimedia-based lectures (LTFE, 2011). It primarily serves as a tool for synchronization of videos and presentations for multimedia-rich content production, as well as a basic LMS for faculties and institutes. Due to relatively simple implementation of the support for third-party services and development of data access services, Coome has been selected as the LMS for the framework application.

As the SEF proposes, framework application has been implemented in both directions – Facebook SN integrating Coome LMS learning activities and Coome LMS integrating Facebook SN social activities.

4.1 Facebook Application Mechanism

The Facebook application is a mechanism that allows the integration of third-party functionalities into Facebook as well as the access to Facebook data services. Registering the Facebook application on the Facebook Developers web site enables the access to Facebook services from third-party applications. Additionally, if a linked application is properly configured an integration of third-party functionalities is possible. A linked application is an external application serving Facebook requests to display third-party functionalities.

Access to Facebook data is provided by two mechanisms that are related with SEF services:

- **Facebook social plugins.** These are easily configurable modules, which can be quickly implemented into third-party applications and run directly from the Facebook SN. As the plugins are closed modules, modifications beyond the configuration limits are not possible.
- **Facebook graph API.** This is a representative state transfer (REST) web service that enables access to users' data in the way accessed data can be post-processed. With graph API custom social modules accessing Facebook data can be developed. When using Facebook graph API users have to confirm the data access to a registered Facebook application. Graph API can be identified with SEF services. Facebook platform offers software development kits (SDK) supporting different programming languages to access the graph API.

Facebook application registration optionally consists also in providing the URL address of an external application to be integrated into the Facebook environment. An application can be configured and used in either of the following two ways:

- **Standalone application.** This is an approach where users access the Facebook application directly inside the Facebook environment or from an external environment such as an external application accessing Facebook data. Before using a standalone application, users need to install the application inside their Facebook profile and permit the access of their data according to the application request.
- **Page tab application.** When used as a page, Facebook application is appended to a page tab. Users can use the application without installing it as the application is embedded inside the page tab. In this case, it is not possible to access user data using graph API.

Facebook application mechanism fulfills the SEF requirements. It provides services for data access and allows for third-party tools to be integrated within the Facebook SN.

4.2 Enhancements in the Coome Architecture

Coome is a Model View Controller (MVC) web application. To fulfill the SEF requirements Coome architecture was appropriately upgraded. Figure 6 shows the architecture enhancements wherein four main entities were added:

- **Routing filter.** It reroutes incoming requests to appropriate controllers. In case an invalid controller is requested, routing filter reroutes the request to custom modules proxy controller.
- **Custom modules proxy.** This is a controller that accepts requests, which are not identified by other controllers. Proxy reroutes the requests to appropriate modules deployed in the Custom modules container. In other cases it returns an error code.
- **Custom modules container.** This is a container where third-party modules processing the incoming request rerouted from Custom modules proxy or modules modifying the final rendering are deployed. Access to Coome data access models and use of public Coome

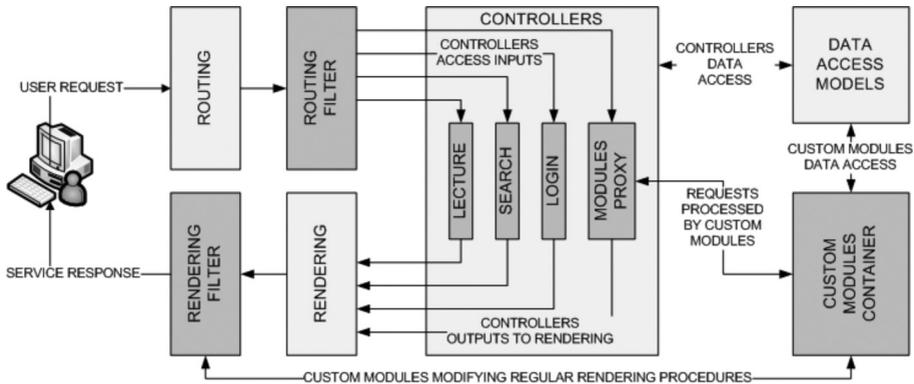


Figure 6: Upgraded Coome architecture

functions and objects are permitted for third-party modules.

- **Rendering filter.** This is a request final filter, which enables the modification of final data rendering. Filter looks up into the Custom modules container for appropriate modules filtering the displayed data.

To fulfill the SEF requirements for data access services the Open API module has been developed and deployed into the custom modules container. The Open API module acts as a representational state transfer (REST) web service with three main methods implemented:

- **Lectures search.** Enables the search of lectures present in the system. It returns a list of maximum 20 lectures with basic description data.
- **Lectures data.** Enables the retrieval of lecture-specific data such as video location, lecture presentation location and lecture presentation transitions. Lecture identification number must be provided as the API parameter.
- **Progress tracking.** This method enables on-demand changes to progress tracking log. Learning object identification string must be provided.

4.3 Integrating Social Activities into the Coome LMS

To enable the access to Facebook services a Facebook application has been registered on the Facebook Developers website. Following the SEF requirements three specific modules were developed and deployed in the Custom modules container:

- **Facebook login module.** It accepts rerouted requests and enables an integrated login into the Coome LMS with a Facebook account. At the first login with the Facebook account the user needs to allow Coome to access the basic data from the Facebook SN.
- **Facebook social plugins module.** It enables the integration of Facebook social plugins into the Coome LMS filtering the rendering of Coome LMS. From the viewpoint of the SEF, the use of plugins achieves the implementation of the SEF social activities into the learning objects. Appropriate Facebook social plugins were used in this case.
- **Social graph access module.** This module implements the general SEF communication tools into the Coome environment. Chat and users messaging were implemented by accessing the data through the Facebook Graph API. Users need to confirm the access of their messages to

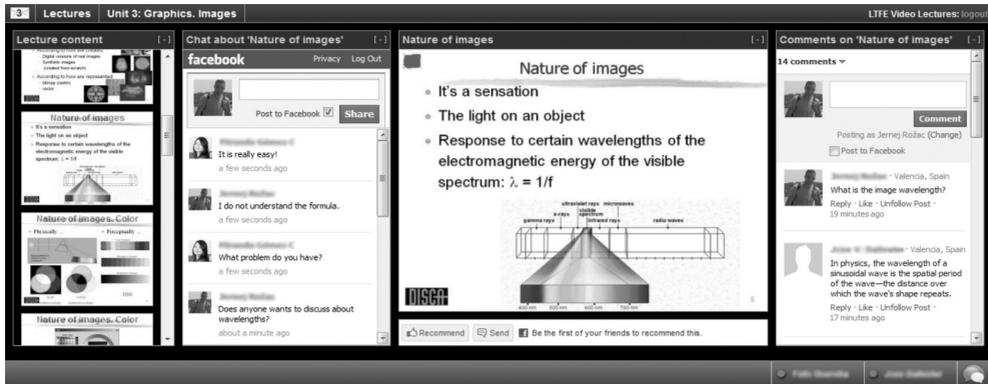


Figure 7: The Coome environment with the integrated Facebook components

a registered application, which represents the Coome LMS. This remains a challenge as currently the users' private messages are shared with an external application.

Figure 7 shows a screenshot displaying the Coome LMS with the integrated social activities offered by the Facebook SN. The figure displays the location of the lecture content, lecture chat, active learning object with 'recommend' and 'send to' functionalities, and comments related to the currently opened learning object.

4.4 Integrating Instructional Materials into Facebook

The settings of Facebook application registered in the previous section were adopted to enable the integration of instructional materials into Facebook. A linked application was developed and configured to work as a page-tab-application inside Facebook. The page tab approach was used for two reasons: i) to enable the use of other tools providing Facebook services for education purposes, and ii) given the fact that users do not need to install the application to gain access to the lectures.

While communication tools are provided by the Facebook environment, instructional materials were integrated into a Facebook page tab implementing the architecture shown in Figure 8. When a Facebook user accesses the page-tab-linked-application, Facebook renders the main layout and provides all the general social tools while the page tab content is returned by a linked application after accessing Coome data using Coome open API. Additionally, progress tracking data are sent to Coome via the Open API.

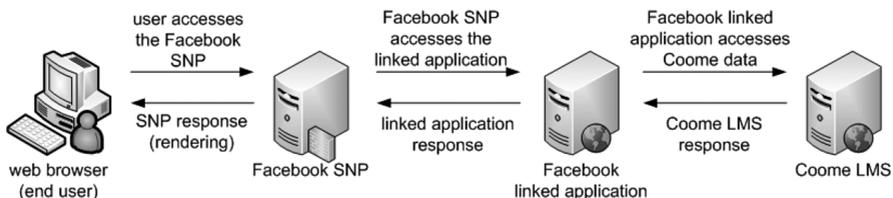


Figure 8: Integration architecture of Coome instructional materials into Facebook

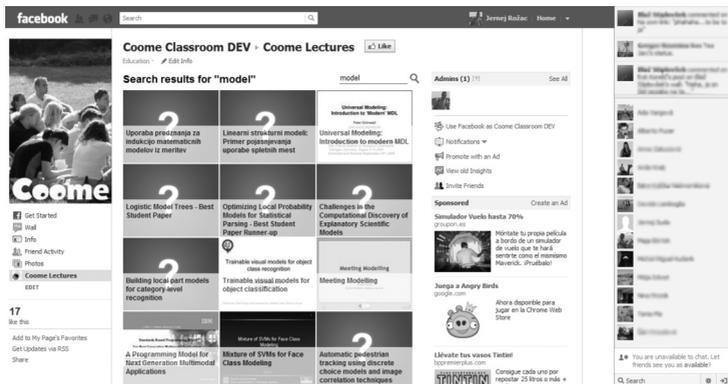


Figure 9: Facebook access to Coome LMS

The Facebook page-tab-linked application displays two main screens:

- **Lectures list.** This is the default home screen shown in Figure 9 where a list of all available lectures is displayed as a result of the search operation.
- **Lecture.** This represents the lecture screen where learning objects are displayed with all the required SEF social tools, for example, through a Facebook SN. For the implementation of the social tools related to the learning content inside the Facebook, social plugins were used in the same way as with the integration of social activities into the Coome environment.

5. Case Study

The presented SEF implementation was tested and verified through a real-world use case experiment involving real users. The use case was based on the previously presented debate model and incorporates an example of the Facebook social activity that serves to improve learning processes in higher education courses. This social activity is related with the instructional contents provided by the Coome LMS addressed in the SEF. The case study was completed with an evaluation of two non related student groups from different universities who were requested about the learning potential of the integrated LMS and SN.

As both implemented solutions (Facebook to Coome and Coome to Facebook) include the same functionalities, both could be used in the case study. Yet only the solution Coome to Facebook was considered as feedback received from the students using a new solution in a familiar environment (Facebook) is more representational. Furthermore, the main goal was to receive the students' feedback regarding the social e-learning solution only.

5.1 Debate Implementation

In the current case, a Facebook page was used to support the main debate area, exploiting the advantage of its widespread social impact and educational potential (Mazman and Usluel, 2010). The debate pattern was implemented through the SEF application installed to a Facebook page tab as shown in Figure 10. This scenario does not support the debate pattern topic related discussions. They can be supported by requesting the users to install the SEF application to their profile. As this is a drawback regarding users privacy, only the page tab scenario was imple-

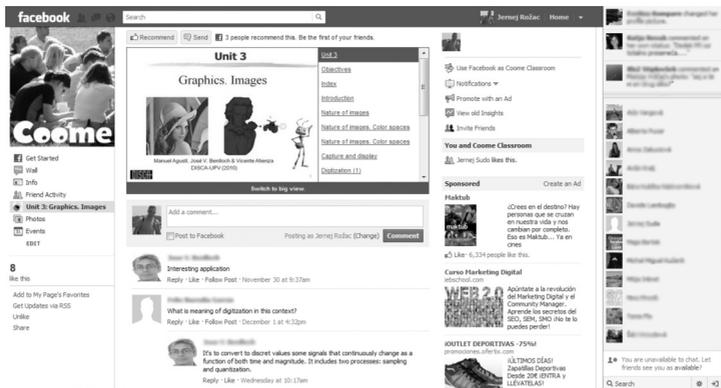


Figure 10: Connecting a Facebook page to multimedia contents stored in Coome

mented. In both cases, the access to topics resources is supported by the Coome LMS, while the discussions (public and private) are supported by Facebook.

5.2 Use Case Details and Evaluation of the Integrated Instructional Materials into Facebook

The selected use case was experimentally tested and evaluated for two independent student groups. The age range of students involved in the experiment was between 20 and 25 years, where 73% of them were male and 27% were female. Two user groups participated in the experiment, that is a group of 30 students from the University of Ljubljana (UL) taking the course of Radio and Television Systems of the Multimedia Communications degree, and a group of 25 students from the Universidad Politécnica de Valencia (UPV) taking the course of Digital Media Concepts. The UL students were selected and asked to learn interactive television basics using the implemented framework application while UPV students focused their learning on specific multimedia formats.

The experiment lasted one week, from the last in-class lecture to the next in-class lecture. Students were encouraged to deepen their knowledge of the topic of the last in-class lecture as well as to get familiar with the topic of the next in-class lecture. They were free to choose when, where and how to use the system. The session was not a real-time session. Although, it was partly guided by tutors as they were giving the online responses to students' requests by submitting additional explanations and answers to received questions.

According to the observed progress and access tracking, all users accessed the instructional materials where more than 40% of them accessed the materials more than once. Furthermore, more than 30% of the students participated in social activities related to learning objects. A questionnaire on general issues regarding the SN and the instructional potential of the SN was submitted to appropriately gather the students' point of view on the implemented Coome to Facebook solution.

Table 1 shows the questionnaire responses regarding general SN issues. In the UL case, it is possible to conclude that more than 74% of the students involved in the evaluation have a positive overall opinion on Facebook. Additionally, they are regular Facebook users using Facebook more than 30 minutes on a daily basis. Similar results were obtained from the UPV case in all categories

Question	Options	UL results	UPV results
I consider in general Facebook has a positive impact in my life:	Yes	74%	75%
	No	26%	25%
Besides Facebook I also use other social networks:	Yes	44%	75%
	No	56%	25%
I use Facebook:	several times a day	62%	86%
	once a day	16%	14%
	once a week	11%	0%
	occasionally	11%	0%
On average I daily use Facebook	less than 10 minutes	16%	14%
	between 11 and 30 minutes	12%	29%
	between 31 minutes and 1 hour	44%	43%
	more than 1 hour	28%	14%

Table 1: Questionnaire results regarding general social networking habits

except for the habits of using other SN, indicating that UPV students are more inclined to use other SN aside Facebook than UL students.

Table 2 shows the questionnaire results regarding the instructional potential of the SN. According to the obtained results of the access tracking both student groups included in the experiment confirmed that social activities related to learning objects are helpful learning tools and the SN has an instructional potential. However, UL and UPV students are not fully convinced of the assumed advantages achieved through the availability of learning resources within Facebook rather than inside the classical LMS. While the results have confirmed that the integration of the SN tools into the LMS environment provides firsthand usefulness, the evaluation of the usefulness of the instructional materials integrated inside the Facebook SN is itself useful but not entirely confirmed in terms of its usefulness to support learning processes. The finding can be explained in part with the fact that bringing instructional methods into the SN environments is a new concept that the users are not yet familiar with, but is identified with no doubt as an important consideration for the further stages of the SEF development.

Students in both groups had a generally positive feedback on the features provided by interconnecting the e-learning and the social network environments. However, a challenging aspect of the current implementation was identified regarding privacy of the users' activities as nearly 70% of the UL students and 60% of the UPV students were concerned about the privacy of their activities related to learning objects. This challenge can be resolved by limiting the access to learning content and activities using SN group memberships.

The results of the experiment have confirmed that the implemented SEF solution meets the requirements in terms of achieving an enhanced e-learning experience by exploiting the advantages of integrating the SN tools into the LMS environment.

Following the debate activities it was possible to determine that there were evolving centered discussions about topics students are not confident with. The discussions were more efficient if

Question	UL results		UPV results	
	Yes	No	Yes	No
I agree that instructional materials can be more useful when present inside Facebook rather than inside classical e-learning environments:	48%	52%	38%	62%
I agree that comments related with instructional material on Facebook can help me with my studies:	85%	15%	75%	25%
I agree that Facebook social networking and communication tools (comments, I like functionality, chat) can be useful for studying purposes:	78%	22%	75%	25%
I agree that learning in groups using Facebook can be more efficient:	67%	33%	70%	30%
I agree that public access to instructional materials on Facebook is appropriate:	70%	30%	75%	25%
I am concerned about my privacy regarding the use of social activities within the context of e-learning on Facebook:	67%	33%	60%	40%

Table 2: Questionnaire results regarding general social networking instructional potential

there was a tutor submitting additional explanations. In practice the discussions were continued and completed in next in-class lecture where online discussions were used as an indicator of leak of students understanding.

6. Conclusions

In this paper, a model-based approach was used in the design and implementation of an upgraded e-learning environment incorporating integrated social network tools and features of an e-learning solution to provide an enhanced Social e-learning Framework (SEF) featuring the novel instructional potential by introducing a socially-aware context into the learning processes. The implemented solution was evaluated in an experimental field study involving two independent user groups of students engaged in an e-learning process through the provided SEF environment incorporating integrated Facebook tools and Coome e-learning system.

A social e-learning concept was defined for the evaluation by modeling the well-known debate pattern. The design of the proposed SEF architecture integrating a SN and a LMS was demonstrated, as well the approach of defining the social e-learning concept as a representation of complex interaction processes involving a high number of considered entities was validated.

The results have shown that the SEF approach is appropriate as it provides a systematic, pattern-based and platform independent solution to support social e-learning scenarios based on data access services, where most suitable SN tools can be selected to enable social activities and the most appropriate LMS tools are used to support the learning activities. The SEF proposal provides a two-way integration, which allows independent and simultaneous use of both LMS and SN as a social e-learning platform.

A real-world SEF environment was designed, developed and implemented as a field trial by

integrating the Coome LMS and the Facebook SN to demonstrate the potential of the SEF as socially-aware e-learning framework. A framework evaluation experiment involving two independent groups of university students confirmed the usefulness of providing the social activities related to the instructional materials with more than 75% of students reporting a positive feedback on using the social tools for e-learning purposes. While the results have confirmed with no doubt that the integration of the SN tools into the LMS environment provides firsthand usefulness, the evaluation of the instructional materials inside the Facebook SN has indicated that further research work is required to understand why students do not support clearly the idea that instructional materials can be more useful when present inside Facebook rather than inside classical e-learning environments.

Many challenges arise from the provided results and findings that are subject to further research, development, implementation and experimental work. The main topics to be addressed in the future are the issue of privacy when using a public social network and enhanced evaluations of the effects of providing social activities inside the Coome environment. Mixed case studies including integration of social activities inside Coome and learning activities inside Facebook must be conducted to achieve the detailed feedback and derive future design and development requirements for the SEF. Additionally, social action tracking needs to be investigated and supported to provide contextualized monitoring of the access to the instructional materials taking into consideration the relevant social activities that promote the learning processes. Evaluating users have not considered the presence of instructional materials inside SN without social activities as more useful. Finally, in order to improve the SEF in terms of providing efficient e-learning environment inside a social network, additional mechanisms need to be investigated and developed to appropriately accelerate and guide the social activities in the context of learning and novel social learning scenarios need to be tackled that guide, support and promote the adoption of this novel learning paradigm.

By modeling the debate pattern it was shown that it is possible to convert a basic pattern model to SEF and implement the SEF using a service-oriented architecture. Further research should focus also on other social learning patterns, trying to extend the SEF to these patterns. In addition, Model-Driven Engineering (MDE) techniques should be considered in further works to automate the process of converting a custom learning pattern to SEF modules and to automate the SEF implementation. This would increase the possibility to try more social learning patterns in e-learning domains and test them with additional case studies.

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Appendix A

Questionnaire for evaluating the use of Social Networks.

G1-Personal data
<ol style="list-style-type: none">1. Gender: F / M.2. Age.
G2-Filling out the point of view about general issues regarding Social Networks
<ol style="list-style-type: none">1. I consider in general Facebook has a positive impact in my life: yes / no.2. Besides Facebook I also use other social networks: yes / no.3. I use Facebook: several times a day / once a day / once a week / occasionally.4. On average I daily use Facebook: less than 10 minutes / between 11 and 30 minutes / between 31 minutes and 1 hour / more than 1 hour.
G3-Filling out the point of view about the learning potential of Social Networks
<ol style="list-style-type: none">1. I agree that instructional materials can be more useful when present inside Facebook rather than inside classical e-learning environments: yes / no.2. I agree that comments related with instructional material on Facebook can help me with my studies: yes / no.3. I agree that Facebook social networking and communication tools (comments, I like functionality, chat) can be useful for studying purposes: yes / no.4. I agree that learning in groups using Facebook can be more efficient: yes / no.5. I agree that public access to instructional materials on Facebook is appropriate: yes / no.6. I am concerned about my privacy regarding the use of social activities within the context of e-learning on Facebook: yes / no.

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