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Designing a Collaborative Group Project Recommender for an E-Learning System

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***Abstract*—Collaborative work on project aids students to combine their personal expertise, experience and ability to achieve a shared work goal. However, a collaborative working environment that is appropriate for some students may be not suitable for other students. Students tend to have different interests, preferences, backgrounds or even knowledge. There is limited support for them that satisfies individual student's needs in the collaborative process. In this paper, we investigated the needs of the students for the recommended project, group members and tools communication for group project, aiming at collecting the requirements for the implementation of the research environment. Additionally, we propose a framework for recommendation of collaborative project work to function within a social e-Learning System. Moreover, we are proposing the architecture of the system.**

Keywords—Recommend project; group members; task; and communication tools

I. Introduction

Working in teams can encourage students to engage in focussed learning activities with other students. It increases the students' motivation; students spend more time in studying and solving difficult problems and communication in collaborative project/coursework can lead to an increase in learning products [1]. However, various boundaries can prevent students from working together in the same team. These can be boundaries of location, as in the case of Saudi Arabia, the boundaries of rules and culture (such as female students being not allowed to stay in the university after 4 pm). With the aid of Web 2.0, collaborative tools have been applied to support virtual project teams in educational environments. Web 2.0 tools (e.g. message, chat, sharing resource) can motivate students to creating active learning/project environment with the collaboration and feedback from their peers [2].

Although research on collaborative learning has generally revealed that student interaction can improve team performance and individual learning, these positive outcomes do not always occur [3]. There are many problems with group collaboration, which ultimately impact on the effectiveness of collaborative learning or project work. The most critical problem is poor interaction, where some members may not contribute in a discussion at all, and others may contribute in a limited way; or members who are too active, making it hard for others to participate [4]; or members whose contribution is unrelated to the topic or work [5]. The interaction is a vital factor in collaborative learning. If the students become apathetic they tend to not participate on the required task [6]. Furthermore, the lack of clear personal responsibility is another problem that is limiting the advantages of group collaboration projects. Numerous related issues triggered by this are, for example, not meeting deadlines, not completing the given tasks, etc. [6].

The main reason for these problems is that collaborative systems do not offer the personalization features required to meet to the student needs. In fact, some students struggle with communication tools and interpersonal skills or have poor knowledge related to the topic of the project, and this influences on the outcome of a project. An environment that is appropriate for some students may be inappropriate for other students. For example, some students have little collaboration experience, thus they need a great deal of support. Students tend to have different interests, preferences, skill, experience, backgrounds or even knowledge. Therefore, allocating the topic of project, the group formation, the tasks and communication tools utilised during a group collaboration project should be considered as a personalization process. The aim is then to allocate individuals to a project, to a group and to specific tasks. A well-defined task structure influences positively the efficiency, effectiveness, and satisfaction level of global virtual teams [7]. Individual responsibility and commitment toward work is the vital factors for creating trust among group members [8].

Brusilovsky [9], in his review on adaptation technologies, also mentions among them technologies for *adaptive group formation and peer help and technologies for adaptive collaboration support*. Technologies for adaptive group formation and peer help "attempt to use knowledge about collaborating peers (most often represented in their student models) to form a matching group for different kinds of collaborative tasks". Technologies for adaptive collaboration support "attempt to provide an interactive support of a collaboration process just like interactive problem support systems assist an individual Patterns (provided by the system authors or mined from communication logs)".

Most researches about the adaptive systems for collaborative learning support (AICLS) systems focused on the group formation process, which is determined systematically based on the students' profile, and the

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information sharing process in groups. However, there have been few studies about adaption for project task management. Therefore, to address the gaps in prior research, *this study aims to propose an approach for using a student-centered method in project-based e-learning to support the student in decisions regarding project definition, based on students' knowledge and skills; group membership, based on student profile characteristics; project task, based on students' personality; and communication tools, by providing adaptive recommendations*.

In this paper, we investigate the needs of the students with respect to the project, group members, project task and communication tools for the group project, aiming at collecting the requirements for the implementation of the recommender environment. Additionally, we propose a framework for recommendation of collaborative projects within an e-Learning System. Based on this framework, we proceed to define the architecture of the Topolor 3 system.

The paper is organised as follows. Section II presents the developments related to adaptive collaborative learning environments. Section III presents design ideas for a collaborative recommender system for group projects online. Section IV introduces a model for the recommendation process. Section V presents the system architecture of Topolor 3. Section VI shows the system implemented. Outlines of further work are given in Section VII the system implemented.

II. Related Work

Although most traditional collaborative learning environments (Blackboard [10] Moodle [11] and LAMS[12]) offer a variety of supporting functionalities for online collaborative learning, the methods adopted for constructing groups do not tailor to individual students' characteristics, because students are usually assigned to groups manually by teachers, or randomly by the systems. Therefore, recently, research efforts have focused on adaptive collaborative learning environments that tailor to individual students' characteristics.

Several techniques were used for group formation. Spoelstra et al [13] presented a team formation process model to determine a fitness-value for a group of learners for a particular project. The model determined three types of variables that manage the team formation process: knowledge, personality and preferences. One major approach in group formation is to form groups based on students' learning styles. For example, in [14, 15], the Felder-Silverman learning style model (FSLSM) and its index of learning styles (ILSs) questionnaire are applied, in order to group students, based on their preferences of dimensions (active/reflective, sensing/intuitive, visual/verbal, and sequential/global). Another example, in [16], it also used one dimension (active/reflective) of the FSLSM in the iGLS system to form groups. They found that learning styles influence the performance of the learners, when working together. Other researchers have proposed forming groups based on a pre-defined ontology, based on information on an individual user. More specifically, ontologies could incorporate several features of a user's profile, like preferences, learning domain knowledge level, learning style and stereotypes. For example, Ounnas et al [17] proposed applying semantics to permit teachers to form different types of groups by differentiating between semantic student profiles. Other researchers investigated how to best group students, considering communication by observing user behaviour, in order to offer students feedback or recommendations if they do not contribute or do not participate enough, encouraging them to increase their level of participation and contribution [18, 19]. However, there have been few investigations about adaptation within project management. Sun and Shen [19] introduced a Teamwork-as-a-Service (TaaS) system that allocates students to specific tasks, based on learning styles and preferences, by using two heuristic algorithms: a genetic algorithm and a simulated annealing method.

These researches have been applied successfully in limited areas. Group formation process is determined systematically by student's profile. These methods force a student to join the recommended group and cannot be used to give students support on how to participate, which may eventually be more effective. Additionally, the algorithmic methods are complex for non-experts, and thus the link between cause and effect might be obstructed or impossible to extract and reuse diminished. Moreover, a pre-defined ontology about several traits of user profiles requires experts' effort on building the ontology and students' effort on clearly expressing their descriptions of interests. These systems do not automatically use characteristics of learning and collaborative behavior in an existing e-learning system to support students in decisions about project selection, group formation, etc. Instead, they use independent tools for supporting group formation environments.

In our study, we introduce an alternatively way, the *Topolor 3 approach* for providing adaptive recommendations to support students' decisions about project selection, based on students' knowledge and skills; group membership, based on student's profile characteristics; project tasks, based on students' personality; and communication tools. The users' characteristics are collected automatically from social networks and from a social adaptive e-learning system, which allows for frequent updates and includes collaborative aspects. The aim of these recommendations is to offer performance monitoring and dynamic support to the user, to increase the acceptance of virtual group project.

III. Design Ideas for a Collaborative Recommender System for Group Projects Online

Students are the central participants in the e-learning environment, so students' opinions should be considering in design e-learning. They can aid designer by exchange knowledge between them, which will lead to the development of more effectual learning environments. Therefore, one of the aims of this paper to *investigate the needs of the students in relation to the recommended project group members, task and the communication tools for the group project, aiming at collecting the requirements for the implementation of the recommendation environment.*

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The hypotheses are:

H1: The student's knowledge level, skill, interests and personality parameters can be considered for recommending the project topic.

H2: The students' knowledge level , skill, collaborative behaviour, and gender can be considered for recommending group members.

H3: Communication tools are considered useful to be based on student personality and collaborative behaviour-level.

H4: The student's personality parameters can be considered for recommending project tasks.

H5: The student's self-defined virtual project group membership is preferable when compared to the system-organised virtual project group membership.

H6: Students are able to select which web 2.0 tools to activate in group project within e-learning

H7: Social networks are useful for building students' profiles.

A. Experimental setup

The experiment was carried out in October 2013. In this small-scale experimental study, six undergraduates and eleven undergraduates participated from the School of Computer Science at the University of Nottingham and the Department of Computer Science from the Nottingham Trent University, in the UK. All the students were asked to answer an optional questionnaire. The questions related to their opinions about the parameters that are relevant for the recommended group project, system-supported or system-defined virtual project group members' selection, and the type of toolset needed for social interaction related to the group project. The questionnaire provided also a list of suggestions of requirements, to aid the students in their choices. However, they had the option to express additional requirements, based on their previous experience of group projects.

Students were asked to rate the parameters considered for the recommended group project topic, the group members, the communication tools and the project task. Each question was answered on a 5-point Likert scale, where 1 = strongly disagree, 3 = neutral and 5 = strongly agree. When defining the 'Closest Interpretation' for each question, the mean is used. Hence, mean response of from 3.41 to 4.20, gives a closest interpretation of 'Agree' or 2.61 to 3.40 could be 'Neither', but if the mean is 2.60 then the interpretation is set to 'Not Agree'. The results indicated that parameters that were considered relevant for the project topic were: student knowledge level (M= 5, SD= 0.49), skill (M= 4, SD= 0.49), interests (M= 4, SD= 0.66) and personality (M= 4, SD= 0.49). All the means are larger than 3.41. Therefore, the H1 has been supported. Recommend group members was considered to be dependent on the student knowledge level (M= 5, SD= 0.51), skill (M= 4, SD= 0.43), collaborative behaviour (M= 5, SD= 0.49), and gender (M= 5, SD= 0.50). All the means are greater than 3.41. Hence, the H2 has been confirmed. Communication tools were considered to be useful to be based on student personality (M= 4, SD= 0.43) and collaborative behaviour-level (M= 4, SD= 0.49). All the means are higher than 3.41. Therefore, the H3 has been supported. Project task was suggested to be adapted to student personality (M= 5, SD= 0.49), project state progress (M= 5, SD= 0.51) and skill (M= 4, SD= 0.63). All the means are greater than 3.41. Therefore, the H4 has been supported.

Furthermore, T-test showed that the student *self-defined virtual project group membership* from learners' profiles (e.g., skills, interests, knowledge and gender) is *preferable* (M= 4.76, SD= 0.43), when compared to the system-organised virtual project group membership based on learners' profiles (M= 2, SD=0.61) $t(16) = 17{,}162$, $p \leq .05$. Therefore, the H5 has been supported. Moreover, students were asked to rate the usefulness of various features using a 5-point Likert scale from 1="Not useful at all" to 5="Very useful". When defining the 'Closest Interpretation' for each question, the mean is used. Hence, mean response of from 3.41 to 4.20, have as closest interpretation 'Useful'; 2.61 to 3.40 is 'Neither'; and if the mean is 2.60 or below then the interpretation is set to 'Not Useful'. The results from the questionnaire showed that the highest rated tools students desired were *resources* (M=5, SD=0.24,), *schedule* (project management) (M=4.88, SD=0.48,), *message* (4.88, SD=0.33,), *chat* (M=4.82, SD=0.39,) *forums* (M= 4.52, SD=0.62) *discussion* (4.23, SD=1.85). The lowest rated tool was *announcements* (M= 3.94, SD=1.29). All the means are greater than 3.41. Hence, the H6 has been confirmed. Moreover, we found that from the questionnaire all students daily use the Facebook and Twitter social network platforms. They can be used for a data collection tool. Hence, the H7 has been supported.

IV. A Model for the Recommendation Process

The proposed processing framework (Fig. 1) was established based on previous literature [13, 14] and the results reported. Hypotheses 1-7 require that several data are collected about the users: knowledge, skills, interests, preferences, gender, and collaborative behaviour. As a result, a *data collection* layer has been proposed, to unobtrusively obtain some of these student characteristics from social networks (SN) (e.g., first name, last name, email and gender) and the other relevant personal characteristics from an existing adaptive social e-learning system (e.g., students' collaborative behavior (asking, answering and commenting), students' knowledge (from prior learning achievements or test results) and skills). This user information is used to build the user model. The user model can be updated, according to the user's further activities. As students in the experiment preferred to have recommendations, instead of automatic processing, a *recommendation layer* was introduced, which represents a set of recommendation rules. It is the layer that performs the personalization and adaptation, by considering the information collected from both the adaptive social e-learning process and social networks. The *presentation layer* is responsible for displaying the recommended content to users or user groups.

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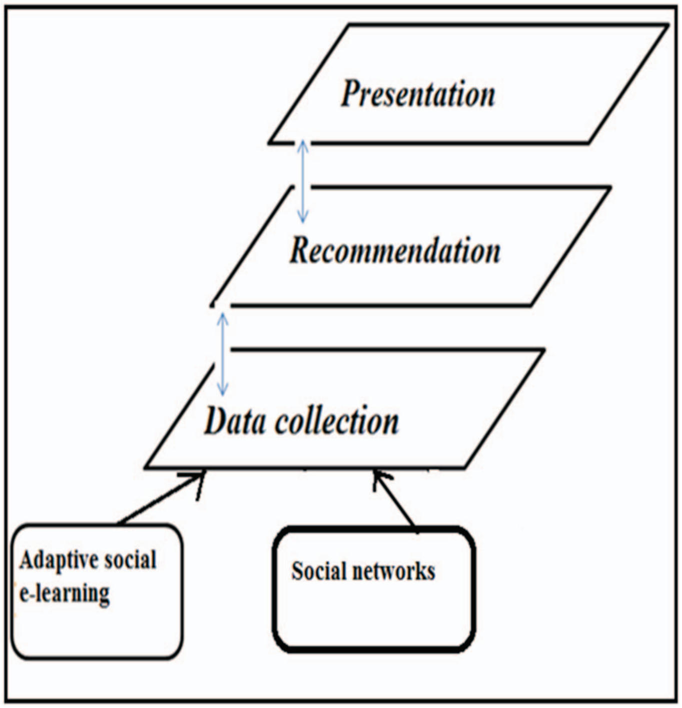

Fig. 1. Topolor 3 Framework

V. THE SYSTEM ARCHITECTURE OF TOPOLOR 3

Based on this framework, we proceeded to define the architecture of the Topolor 3 system (Fig. 2). The Topolor 2 system was selected as a basis for development, as it already supports some of the desired general features. Topolor 2 is an eLearning system, which allows for a modicum of adaptation, as well as social interaction. It has been developed at the University of Warwick. [20]. However, it does not support group formation, project recommendation, tasks recommendation and communication tools recommendation. Therefore, it was decided to extend its features to Topolor 3, so that it can allow the building of groups with appropriate membership, and allow for wider application to collaborative learning, specifically the type based on projects. Moreover, the Topolor 3 system has been additionally integrated with the Facebook system (the most popular social network worldwide), in order to obtain the student profile data. In this paper, we focus only on the features related to recommendations of project, group members, and task and communication tools in project-based e-learning.

The system architecture of Topolor 3 (Fig. 3) offers all the features for *the Recommendation of Project, Group members, tasks within project management, and communication tools,* supporting collaborative group project-based learning. The architecture of the Topolor 3 system is described in the following.

Project Model (PM): This describes the topic of the project. It is also linked to the course model (CM), to connect the learning process with the relevant projects (as below). Each project item in the project model contains some data about it.

User Model (UM): The user model retrieves students' information from Facebook and from the Topolor adaptive social e-learning environment.

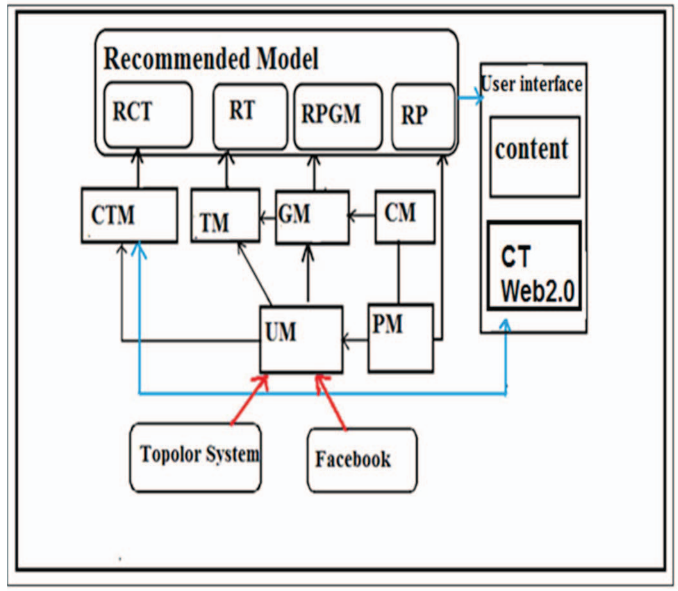

Fig. 2. The System Architecture of Topolor 3

Group Model (GM): This model represents a set of students having matching group characteristics and project goals. They have same skill knowledge and interest

Task Model (TM)*:* This describes activities that students have to perform, in order to fulfill the goals of the project. It is also linked to project model. Each task item of a project contains some data about it, such as student's name, start/end date task.

Communication Model (CM): This model is linked to a project model. It can be instantiated to chat, comments, and questions. This mechanism can help group learners easily interact with each other.

The recommendation model (RM): This is a set of recommendation rules for (what should be recommended, when a recommendation should be provided, how a recommendation should be presented) referring to projects (RP), tasks (RT), group members (RGM) and communication tools (RCT).

User interface: It contains presentation content and communication tools. Communication tools (CT) allow students to communicate with each other about the project.

VI. IMPLEMENTATION

Topolor 3 is implemented by applying PHP, HTML, CSS, SQL and JavaScript and is built on the Yii Framework (http://yiiframework.com). Topolor 3 has been implemented in order to meet the system requirements proposed by the learners, as defined in section II.

As shown in Fig. 3, a ***Project*** instance is composed of multiple ideas for projects related to Java Script, with defined

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skills for each idea that enable personalised matching between students and ideas.

Each project idea has one or more resources, to help in improving the students' knowledge about the project. A project is recommended to students according to their skills, knowledge level and interested.

Taking a Test: Each project has a quiz to assess students' knowledge, in order to recommend a project topic according to the student's knowledge level. If a student's knowledge is less than 40%, it is recommended to them to study the resources related to the project and repeat the quiz afterwards, to ensure that the knowledge has been updated, prior to joining the group or selecting another project that has different skills (Fig. 3).

Recommended Students: Group members are recommended according to registered students in the same project with their profile (e.g., first name, last name, email, gender, question asked, question answered, and comment). Student can easily select his members group that relevant to characteristics by learner's profile (Fig. 4).

Start Group: Students self-define group membership based on recommendations about the students' characteristics from the learners' profiles. Group members can be added by inviting them with a description related to the project and then the invitee can accept or reject the invite (Fig. 5).

Task Project Management: It contains different featured tasks that allow for students to create tasks, edit, delete and view list of students' tasks. Tasks are recommended to students according to the *task style*: whether the students are verbal or visual - as obtained from a personality Test. There are many measures of learning styles, but the one applied here is the Felder and Soloman's "Index of Learning Styles" (ILS) [21] . FSLSM has been named the most suitable for learning styles model in technology-enhanced learning [10, 11]. Moreover, it is freely provided, and has been integrated in Topoloe 3 as an external link that allows student to test their personality, to select appropriate tasks for them. Example tasks in a project are: creating the interface, coding, testing and fixing bugs, writing report and other tasks. Moreover, a task project management tool has been implemented, to help students plan and organize project groups. For example, it can give an overview about how long tasks will take to complete, early warnings of any risks to the project, recommended daily progress to complete the tasks before the deadline, and historical information on other projects.

Chat group: This is communication tool privately used by a group project and any member group can check the history of the discussions at any time. As it was earlier mentioned, one reason for problems with communication is that some students are struggling with communication skills, and that this can influence the outcome of a project. Therefore, recommendations for the communication tools are provided in Topolor 3.0, to improve communication among the group members and other groups. The system monitors user contribution and updates user models. Then, student participation can be identified.

Topolor 3 has also some other features, of social, personalisation and adaptation nature – that existed in the previous version, Topolor 2. For example, tools for sending private messages, for asking questions, for sharing text content, images and links, to further support students.

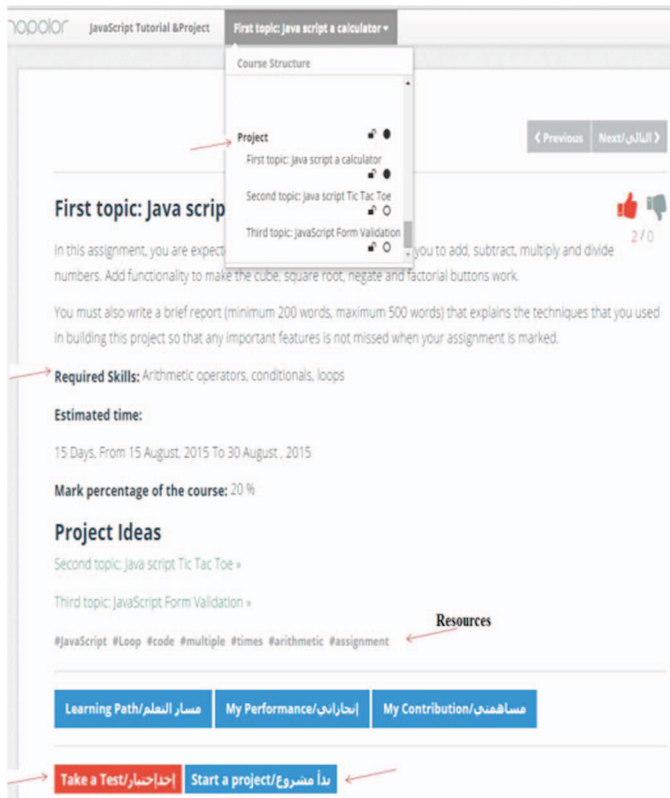

Fig. 3. Project Ideas and Taking a Test

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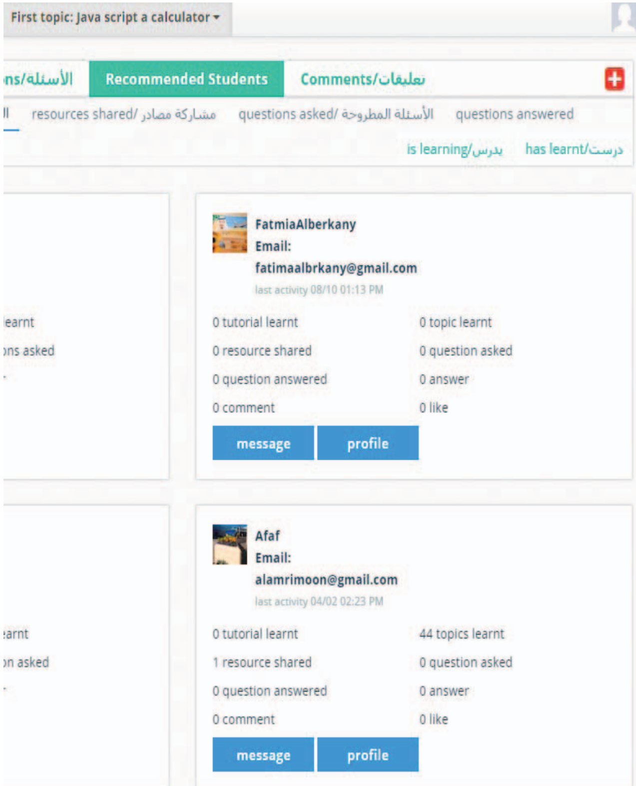

Fig. 4. Recommended Students

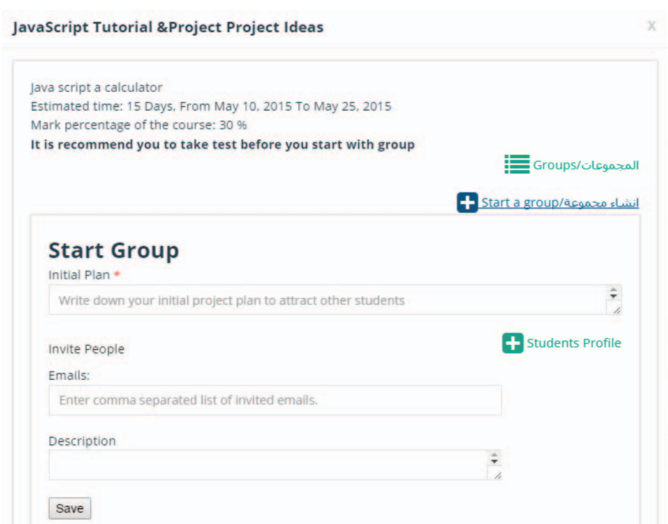

Fig. 5. Starting a Group

VII. DISSCUSIONS AND CONCLUSION

The main aim of the experiment was to investigating the needs of the students for the recommended project and tools communication for group project. The outcome showed the parameters which can be considered for recommendation of group project topic, group members, communication tools and project task. Recommendations of the project topic are according to student's knowledge level, skill, interests and personality. Recommendations of group members are according to student's knowledge level, skill, collaborative behaviour, and gender. Recommendation of communication tools are according to student's personality and collaborative behaviour-level. The recommendations of project tasks are according to student's personality, skill and project state progress. Moreover, although most researches used system-organised group formation, the results revealed that student self-defined virtual project group allocation based on system-recommendations from learners' profiles (e.g., skills, interests, knowledge and gender) is preferable, compared to system-organised virtual project group members allocation. Moreover, result showed that all participants use daily the Facebook and Twitter social network platforms. The main reasons for using Facebook and Twitter were that they are a place to share users' interests and discover the latest news. Also, Facebook provides users with a place to interact with their friends and family. This indicates that Facebook can be used to build the user model and profile. Additionally, the results from the questionnaire showed that the highest rated tools were resources, schedule, message, chat and forums discussion and that the lowest rated tools were announcements. Based on these results, we proceeded to establish a model for recommendation of group projects in and existing e-Learning system. We created thus the Topolor 3 system architecture. It is integrated with a Facebook system and social personalized adaptive E-Learning system, in order to build student profile data (e.g., students' skill, knowledge and students' collaborative behavior). The main contribution is combining group formation adaptation and project management recommendations with social learning domain adaptation.

In the future, it is planned to evaluate the system with students to investigate the learners' perceived acceptance of the recommended project, group membership, task, and communication tools.

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