Designing the Content of a Social e-Learning Dashboard
The Study is based on Novel Key Performance Indicators

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Abstract: Scholastic institutions are increasing the use of social learning management systems (Social LMS) to reduce training costs, provide just-in-time skills instruction and classroom-based training, stimulate social collaborations, etc. In this paper we present a model to assess the use of a Social LMS by learners that could be applied to learning institutions. At the beginning we adapt the Kirkpatrick-Philips model (widely used in private companies) to the academic environment. Some metrics are also defined for each Kirkpatrick-Philips's level in order to evaluate the Social LMS. At the end we introduce modular dashboards to visualize the analytic report obtained by the social network.

1 INTRODUCTION

The integration of social aspects in a learning environment can be defined as an exchange of information and ideas, supplemented by interactions with a personal or professional network of users. A social learning program must provide users with immediate access to relevant content and to seasoned experts who can impart their wisdom (Kautz et al., 1997; Sakarya et al., 2012; Rössling et al., 2008). ICT social technology, for example, renders collaboration very natural. The core components of this technology are: social networks, wikis, chat rooms, forums, blogs, expert directories and expertize location, content libraries with content ranked for relevance, shared communities of interest, online coaching and mentoring, etc. By the addition of the gamification element, players can also develop and test their skills and learn complex subjects involving multiple roles and relationships. In the last decade, the goal of many researchers has been to define a Social LMS (Learning Management System) in order to built a complete "learning environment" that provides a support network, as well as the ability to collaborate, and share information to solve problems. In addition, in the modern world learning organizations (e.g, schools and academies) must go beyond the disciplines of building content for use in the classroom or online. They must provide context and pathways through which people can learn but also improve as learners and become bet-

ter creators of content. For this reason, social learning environments have to comprise both formal and informal learning elements in an augmented vision of the blended learning paradigm (Osguthorpe and Graham, 2003). While most formal training can be done in classes or in isolation, social learning systems may offer the ability to develop learning communities in which groups of learners and trainers share information and collaborate on their learning experience. Thus, a Social LMS integrates social networking, collaboration and knowledge sharing capabilities, as well as interactive elements that enable users to rate contents. In this paper, we propose a model for social network learning which is based on the idea that the act of learning should be an organic process comprising many subjects (students, teachers, specialists, families, etc.). The students remain the most important subjects of the e-learning environment since their development is the final goal of the school, however the interplay with the other subjects cannot be underestimated since a static world where only the students evolve while the school or the families do not change is clearly unrealistic. For a better insight of the process, all the subjects need analytical tools providing important information and automatic analysis (Buckingham Shum and Ferguson, 2012; Almosallam and Ouertani, 2014; Siemens and Baker, 2012). The information provided is not to be intended as a replacement of the specific capabilities of the teachers, specialists etc. At the contrary, it is thought as an additional tool

for these subjects which allows them to have a good understanding of the success or failure of their initiatives. With this information they are able to adopt measures which can improve the quality of the learning process. The platform must also include metrics which demonstrate real value for the learning organization.

Learning management systems are designed to measure the performance of a learner on assessments, but they are less efficient at measuring the effectiveness of content (Buckingham Shum and Ferguson, 2012; Nespereira et al., 2014). Since social learning is dependent on content generated from a variety of sources, a good social learning solution can measure who are the most reliable content providers and which content is not being accessed at all. As a result one can prioritize what is most effective. The goal is to connect users using social tools to accelerate learning.

The standard Kirkpatrick-Philips model, which is used as a benchmark for learning assessment in organizations, can be also adopted for a Social LMS with a different look. The Kirkpatrick-Philips model is defined by 5 levels that are: Reaction, Learning, Behavior, Results, and ROI. In this paper, novel key performance indicators for each Kirkpatrick-Philips's level are defined in order to evaluate the student's academic improvements through the Social LMS. It is important to take into account that each role is in need of different information in order to improve. A general model of interactions among these subjects is beyond the scope of this paper and pertains more to the social studies, however we want to provide tools which help to give quantitative assessments. At the moment, this paper focuses the work on students, but we are planning to extend our model on the other subjects.

The paper is organized as follows. Section 2 presents the revised Kirckpatrick-Philips models for Social LMS, Section 3 defines the metrics for each *new* Kirckpatrick-Philips's level, Section 4 introduces how the metrics can be applied to the forum and chat room social components, Section 5 gives an insight on how a dashboard for students can be defined that considers the *new* metrics. Finally, in Section 6 some conclusions and future works are stated.

2 THE KIRCKPATRICK-PHILIPS MODEL FOR A SOCIAL LMS

The classic Kirkpatrick-Philips model (KP) (Newstrom, 1995; Phillips and Phillips, 2003; Kirkpatrick and Kirkpatrick, 2010) is widely used to evaluate the quality of a training for companies as a benchmark

for learning assessment (Tour et al., 2014). According to the KP there are 5 levels which are used to evaluate the whole learning process: Reaction, Learning, Behavior, Results and Return on Investment (ROI), respectively. Summarizing, *Reaction* is an indicator which allows to understand how the training was received by the participants. It deals with impressions and tastes regarding the participants - Did they like it? How was the environment? Was the content relevant? Although a positive reaction does not guarantee learning, a negative reaction almost certainly reduces its possibility. *Learning* refers to the idea of assessing how much of the information which was presented has been understood and retained by the participants of the training. If possible, participants take the test or assessment before the training (pretest) and after training (post test) to determine the amount of learning that has occurred. In a company, however, the quality of the work after a training is expected to be better than before, this quantity is measured in the *Behavior* level. The evaluation issue, at this level, attempts to answer questions such as - Are the newly acquired skills, knowledge, or attitude being used in the everyday environment of the learner? How did the performance change due to the training provided? For many trainers this level represents the best assessment of a program's effectiveness. It is difficult to find a correct metric to measure the *Behavior* and its time evolution in a company, while in a school the time line is more strict and this can help. A final assessment on the training comprising all the parts just mentioned is necessary, in the KP model this is usually referred to as *Results*. Good results are achieved if some indicators are improved in the organization such as the increased efficiency, decreased costs, increase revenue, improved quality, etc. The *ROI* indicator clarifies if the training was beneficial to the company once its cost is taken into account, with the objective that the effect should be worth the cost. Are we achieving a reasonable return on investment? The ROI formula (Phillips and Phillips, 2003) is calculated as $ROI = (Benefit - Cost)/Cost * 100$.

Companies use the KP model to assess the investment in organizational learning and development although from the literature it emerges a clear difficulty in measuring with suited metrics the 5 levels just described. It is rarely possible to have data that allow to measure the effectiveness of each level by considering the evaluations of the tangible and intangible benefits in relation with the results of the investment as described in Section 1. Due to these problems, in (Tour et al., 2014) a complementary approach for enterprise training program management is proposed with the intent to overcome the barriers that companies can

have when adopting the KP model, that are: (1) isolation of the participant as a factor that has impact on corporate results, (2) lack of standard metrics within the adopted LMS, and (3) lack of standardized data to have benchmark to compare the defined training functions.

The difficulty in adopting the KP model is that the information from each prior level paves the way for the evaluation of the next level. Thus, each successive level represents a more precise measure of the effectiveness of the training program, but at the same time requires a more rigorous and time-consuming analysis. The idea is to determine which metric is more appropriate to understand whether the network of learners is performing well and whether the service supplied by the platform is useful for the network. The usage of the platform is a straightforward value which allows to understand the reception of the platform itself.

In this paper, we want to translate the KP model to a scholastic environment as such some modifications are needed because of the different purposes and means between a school and a company. For a company the aim of an internal training is to achieve a monetary/strategic gain, while for schools the overall growth of the learners is the final goal, and within it an increased education is of primary importance. In a social educational environment (as the one provided by a Social LMS), the KP model is properly suited as it guarantees the possibility to assess the educational path of the learner during his/her educative session for the whole set of levels. In an educational context, the problems presented in (Tour et al., 2014) could be overcome: (1) the social learning creates community discussions forums and group-based project work encourage collaboration by reducing the learner's isolation, (2) for learners: tangible values are achieved by considering standard grades, intangible values are obtained, for example, by monitoring the learner's activities in the Social LMS as explained in Section 3 and in Section 4, and (3) the data quality can be evaluated with standard evaluation metrics by teachers (e.g., tests, grades, . . .), and social evaluation metrics by peers (e.g., social grades on materials, comments, liking, . . .).

The novel interpretation of the KP model for the educational context is defined as follows (see Figure 1):

- The *Reaction*: "Did the learner enjoy the Social LMS?" The learner's satisfaction can be analyzed by two main techniques: explicit and implicit (Claypool et al., 2001; Teevan et al., 2005). With the explicit approach the user must explicitly specify his/her preferences to the system. This
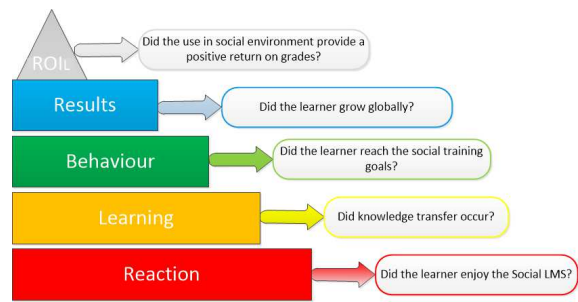

Figure 1: The Kirkpatrick-Phillips model for a Social LMS.

can be achieved by filling in questionnaires and/or by providing short textual descriptions in order to specify the topics of interests. With the implicit approach, the user's preferences are automatically gathered by monitoring the user's actions. To this regard, the defined techniques range from click-through data analysis to query and log analysis, sentiment analysis, etc. We prefer to use an implicit approach, where it would be possible to estimate the actual activity of an engaged learner, and use that as a target.

- *Learning*: "Did knowledge transfer occur?" *Learning* refers to the idea of assessing how much of the information which was presented has been understood and retained by the learners of the training. In a Social LMS for educational context, a formal assessment can be defined by the teacher's judgment or by official tests before and after the use of the system by analyzing if an improvement of the academic performance of the student is occurred; an informal assessment can be obtained by analyzing how peers and teachers have evaluated the learner's materials such as new multimedia documents added in the Social LMS, comments on specific subjects, messages from chat and forum, etc.

- *Behavior*: "Did the learner reach the social training goals?" Nowadays most of the schools have personalized learning programs, thus the percentage of completion of these programs can be thought as a measure of how the previous knowledge has changed the student's knowledge allowing her/him to take further steps forward. The gamification of the learning programs is an important aspect which helps to keep interest in the objectives.

The learner's attitude can be measured by specific behavior indicators: are learners increasing the creation and sharing of knowledge such as answers, documents, media, or interactive? The usage of collaborative tools, the new products produced, or less desirably, the circulation of updated

versions of materials for subjects would be metrics.

- *Results*: "Did the learner grow globally?" This level includes in a global statement if the learner's has improved his/her academic performance during the usage of the Social LMS. The data obtained from the indicators considered in the previous levels are gathered, elaborated, and then visualized in customized dashboards. The learning analytic uses data analysis to inform the progress related to teaching and learning. The global evaluation is a mush-up of data collected ranging from formal evaluations (e.g., tests, grades, etc.) to informal evaluations (e.g., social evaluations, judgment of peers, etc.). The heterogeneous types of data available allow to support more adaptive and personalized forms of learning enabling enhanced student performance.

- *ROI*: "Did the use in social environment provide a positive return on grades?" In an educational context, we define the ROI_L in order to evaluate whether the effort in the social interaction really affects also the scholastic performance of a learner, *L*. Is it true that a better social activity has returned better grades? Then, the ROI_L is calculated as:

$$ROI_L = \frac{\Delta G_L}{\Delta A_L}$$

where G_L is the average final grades (i.e., formal proofs, tests, etc.) and A_L is the key performance indicator that analyses the learner's activity from the *Results* level, while the Δ implies that we are using a temporal difference between the current values and the old values previously calculated. This time quantity is needed to ensure that the effect of an increased social activity can affect also the grades of the student for a given interval (e.g., weekly, monthly, bimonthly, etc.).

3 DEFINITION OF KPI FOR SOCIAL LMS

The failure or success of a student is determined by many factors. In the present paragraph we want to analyze key performance indicators which take into account various aspects of the student life associated with the levels of the KP model presented in Section 2. The students grades are an obvious starting point, in particular at the end of the academic year the average grade provides a good insight about the student quality. However grades do not provide the information regarding the general development of the stu-

dent. For example, social skills prove to be essential in modern life; for this reason we want make quantitative and qualitative assessments on them. The sources which provide the data needed for the indicators are the following:

- The "normal" student information (grades, absences, etc.) usually collected by the teachers, and in this case in digital format.

- The data inserted by the students in the social network (forum, chat, evaluations, comments...).

- Feedback from teachers, special instructors, families ...

- The multimedia material uploaded by teachers and students (for formal and informal learning).

There are many aspects which are important for determining the growth of a student and it is beyond the scope of this paper to take all of them into account. Since this study is devoted to social e-learning we will concentrate on criteria dealing with the learning and social parts of the platform. In particular, the novelty of this paper is to try to combine the social aspect of modern technology and learning.

The integration of social aspects in an educational learning environment can be defined as an exchange of information and ideas, supplemented by interactions with a personal or professional network of students. An educational social network (i.e., EduSN) is then created in a natural way by analyzing the interactions of students. The EduSN's effectiveness can be measured by adopting the revised KP model of Section 2 by providing metrics for each level as reported in this section.
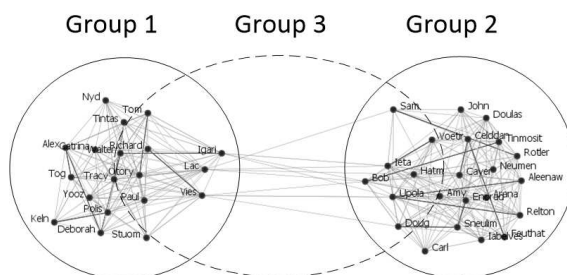

Figure 2: An example of an EduSN.

A prime model of an EduSN is given by a graph where users are vertexes and the links among them are the edges. In this case, we choose to restrict the network to the students; in future works, we plan to create more complex networks including teachers, parents, etc. In order to represent the network we need to establish how the students are connected. Grouping all the students of the same class is a simple idea which does not take into account all the possible scenario. Groups of students can be defined according

to several factors: classes, sharing of a same subject, organization of flipped classrooms across classes or institutions, sharing of a same scholastic interest, etc. For this reason, the concept of *learning groups* might be more appropriate than classes, so the definition of the network must be flexible. The network that we propose is an undirected graph where the edges convey the strength of the relationship between two students. With this model the visual representation of the graph can give insight about the compactness of the network itself. Figure 2 shows a portion of an EduSN where three groups are defined: (1) Group 1 identifies a class of 19 students, (2) Group 2 identifies a class of 23 students, and (3) Group 3 identifies a *virtual* class of 18 students defined by social interactions on the same topic. Formally, *EduSN* is the union of non-disjoint groups defined as $EduSN = \bigcup_i^g \mathbf{G}_i$, where:

- $\mathbf{G}_i = (V, L)$ is a group and g is the total number of groups presented in EduSN;

- V is a set of nodes, representing the students S;

- L is a set of links (or edges) between nodes in V.

Finally, we can define the metrics for each KP's level as follows:

Reaction. As indicated in Section 2, explicit and implicit methods can be used to establish the level of student's satisfaction in the usage of the Social LMS. At this level, we consider an implicit approach assuming that the usage of the Social LMS is related to the acceptance of the LMS. We define a quantity, called *connection*, which is a function of two students, and it represents the strength of the social bond between two students in a given day. At this level, we are not interested in the quality of the bond, but only to the amount of information in the academic time course.

Learning. The student's academic performance is evaluated according to formal and informal methods. The formal approach considers the standard evaluation obtained by grades (i.e., proof, tests, etc.), whereas the informal one considers social aspects based on the student's social behavior when she/he uses the Social LMS. In this last case, we define the *social contribution* indicator - which gives an idea of how the other participants of the network judge the interactions of the student with the social educational network. The social contribution of a student has to take into account two measures: appropriateness, and quality of the material added (by material, we also take into account the posts on the forum and on the chat room). Formally, the *social contribution* measure is defined by:

- *Appropriateness:* each material can be rated with four different levels of appropriateness (material which has no appropriateness rating counts as appropriate since we expect that normal material does not trigger the need for an appropriateness rating). For example, posting the timetables of the movie theater on the math forum would be considered inappropriate, while asking a clarification of a theorem would be appropriate. Highly inappropriate material adds -3 point to the appropriateness score of the student who posted it and also to the material itself (in such a way the teachers can easily ban particularly inappropriate material), inappropriate adds -1 points, appropriate adds 1 point and very appropriate adds 3 points. The average appropriateness score of a material is always visible to the other users in order to allow the instructors to ban any material which should not be visible.

- *Quality:* The quality of all the material published is divided in four different levels:
  - the material adds wrong content (-1 points)
  - the material adds no content to the discussion (for example if the material contains only information already present in the discussion) (0 points)
  - the material adds some content (a good question is also associated to this category) (1 point)
  - the material provides a complete answer to a problem (3 points)

At every point, the sum of all the points deriving by the *appropriateness* and the *quality* indicators of the published material is calculated. The *appropriateness* value and the *quality* value are transformed in a percentage by taking into account the best score of the school. The material is judged by peers (other students) and by teachers. Since we expect the ratings from the teachers to be more experienced than the ones of the students, teacher's rating will weigh three times more than that of the students.

For each learner L, to associate an overall score with the *social contribution* measure, SC_L, a linear combination of its two indicators is finally applied:

$$SC_L = \alpha * App_L + (1 - \alpha) * Q_L \qquad (1)$$

where $0 \leq \alpha \leq 1$. When α has a value of 0, the *appropriateness* value, App_L, is not considered, and the final weight is equivalent to the weight obtained by analyzing the *quality* value, Q_L. If α has a value of 1, the *quality* value is ignored and only the *appropriateness* value is considered. The importance of *appropriateness* value with respect to *quality* value can be balanced by varying the value of parameter α.

Behavior. At this phase (see Section 2 for more details), we take into account how the learner's attitude can be measured by specific indicators: are learners increasing the creation and sharing of knowledge (such as answers, documents, media, or interactive)? The *attitude* level is measured by analyzing the topological structure of EduSN, and by considering the *informal success* indicator. In the former case, once the EduSN graph is established we can calculate various centrality measures which allow to determine, for example, who are the reference students, who tend to connect participants, etc.; here, we will focus on the betweenness centrality since it perfectly reflects the social feature of the Social LMS. In the last case, *informal success* is associated with the awards attributed to: (1) the student about all the informal activities he/she was involved in, and (2) the achievements by a gamification approach to track the progresses of the student's academic path. In the former case, the idea is to also consider extra educational activities that are an indicator on how a student is socially active in the school; for example, a student can be a member of the: scholastic journal, soccer school team, etc.

Results. The two KPI we use to determine the student's final result are: (1) the *average final grade* obtained during the academic year to assess the formal performance for each subject (e.g., math, history, science, etc.), and (2) the *influence factor*. The *influence factor* represents the student's influence by considering his/her interactions with the EduSN's participants, his/her ability to drive discussions, to share materials, to attend to extra activities, etc. The more influential you are, the higher your *influence factor* is. The influence factor is a quantity we determine as the aggregation of three indicators previously described:

- betweenness centrality - which is a measure of the activity of the person in the network
- informal success - which takes into account how active a person is in the informal context
- social contribution - which gives an idea of how the other people of the network judge the interaction of the person with the social network.

Since these quantities are measured with different indicators, we first transform them in percentages, and then we calculate the average value for having the *influence factor* in percentage. In an environment with a large population we expect to have learners who excel in all of the three indicators whose scores can be used to calculate percentages.

- *Betweenness.* We first group the scores of all the students of a school in a list and we find the highest value. At this point we can re-evaluate the score of each learner as a percentage of the best result. Let us consider an example for the betweenness case, in a school where the highest value of betweenness is 0.88, a student has a betweenness equal to 0.72; this value is transformed into $82\% = 0.72/0.88 \times 100$.

- *Informal Success.* It is associated with the awards attributed to the the student about all the informal activities he/she was involved in. By associating a number to each activity (for example 50 points for being part of the soccer team who arrived second in the school tournament, etc.) each person will obtain a total number of points. Also in this case we can make an ordered list of results, where the percentage score of a single student is given by the ratio of his/her result and the best one (times 100).

- *Social Contribution.* Its value is transformed in percentage in the standard way (see Equation 1).

Then, the *influence factor*, *IF*, is calculated as the average value of *betweenness*, *informal success* and *social contribution*.

ROI. The ROI value is calculated, as defined in Section 2, $ROI_L = \frac{\Delta G_L}{\Delta A_L}$, where G_L is the average final grades (i.e., formal proofs, tests, etc.), and A_L is the *influence factor*. However, it is possible to calculate a ROI value for each subject by analyzing its own average grade.

4 EVALUATING FORUM AND CHAT

In this section, we analyze how the metrics defined in Section 3 can be used to assess the use of social modules on the Social LMS. In detail, we describe how can be formally analyzed the role of the forum and the role of the chat room when the EduSN's participants are interacting with them. In a Social LMS, chat room and forum play a key role, and they are some of the social modules most accessed by students. The idea is thus to inter-correlate the social aspect and the academic success by exploiting the natural tendency of human beings (and in particular of students) to be connected. Forum and chat room are different social elements: the forum is expected to be divided in topics to deepen the study subjects, whereas the chat room is intended as a more free space where informal topics can be discussed (such as sports, movies, vacations, etc.).

Reaction. A *connection* represents how many interactions between two students occur in a given time. At the beginning, the *connection C* is set equal to 0, i.e., $C(a,b;n) = 0$, where: $a,b \in S$, n is a time factor (e.g., a day). In the case of the forum, each time a person contributes to a conversation, a quantity "f" is added to all the participants of the conversation. Let us suppose that a student $a \in S$ asks a question about math on day 0, and a student $b \in S$ replies on day 1, then:

$$C_F(a,b;1) = C_F(a,b;1) + f$$

While student $d \in S$ replies on day 3:

$$C_F(a,d;3) = C_F(a,d;3) + f$$
$$C_F(a,b;3) = C_F(d,b;3) + f$$

Since this graph is undirected $C_F(a,b;n) = C_F(b,a;n)$, we also want a simple graph (Butts, 2008), that is $C_F(a,a;n) = 0$.

In a school environment there are also informal interests (friendships, feelings, sports, tournaments, etc.). These aspects are better represented by the chat room which does not have the same kind of moderation as the forum, and it allows for more freedom. Due to the synchronous nature of the chat room there is no obvious thread which allows to distinguish easily whether a student is talking to another, so we suggest to adopt a time approach, that is, if two students write messages in the chat room within a given time interval (Δt), then we can consider that those students are connected (for example because of a common interest or by personal reasons). At the beginning of each day the chat connection is zero. If a, b and d write on the chat room within "Δt" their chat-connections will be enhanced by a factor "c" (similar to the case of the forum).

$$C_C(a,b;1) = C_C(a,b;1) + c$$
$$C_C(a,d;1) = C_C(a,d;1) + c$$
$$C_C(d,b;1) = C_C(d,b;1) + c$$

Unfortunately time distance is not a very good form of correlation (and we plan to use better indicators in further publications), moreover we have to take into account that the bond between two people develops with time. We define a quantity called total forum (chat) connection which takes into account the history of connections. The total forum connection is a function of two students (for all the participants of the network) and of time, in the following definition we omit the student dependency for simplicity, and we keep only the time dependency starting from day 0:

$$K_0^F = C_F(0)$$
$$K_1^F = C_F(1) + \lambda_F C_F(0)$$
$$K_2^F = C_F(2) + \lambda_F C_F(1) + \lambda_F^2 C_F(0)$$
$$...$$
$$K_n^F = C_F(n) + \lambda_F K_{n-1}^F$$

In practice the total forum connection is an exponentially weighed average of the connections from a given day 0. The weights take into account the time dependency of the interpersonal relationships.

Similarly to the forum, the total chat connection is defined recursively based on the connection derived from the chat room as:

$$K_n^C = C_C(n) + \lambda_C K_{n-1}^C$$

Once we have the "total connection" value among two students we can define the length of the edge in the corresponding graph by aggregating forum and chat room values. The length of the edge between student a and student b $E(a,b)$ at time n is set to be a the inverse of the sum of the total forum and total chat connections, and it is defined as follows:

$$E(a,b;n) = \frac{1}{K_n^F(a,b) + K_n^C(a,b)} \qquad (2)$$

A proper choice of the parameters $(\lambda_F, \lambda_C, f, c)$ has to take into account that the connection established via the forum is less frequent but requires more effort than the frequent and more casual connections of the chat room. For this reason the quantity $f >> c$. The weights λ_F and λ_C give more importance to the most recent interaction in respect to the old ones, as an example we show the connection between two people in a 200 days period with two different lambda parameters: $\lambda_F = 0.99$ and $\lambda_F = 0.999$ (see Fig. 3).
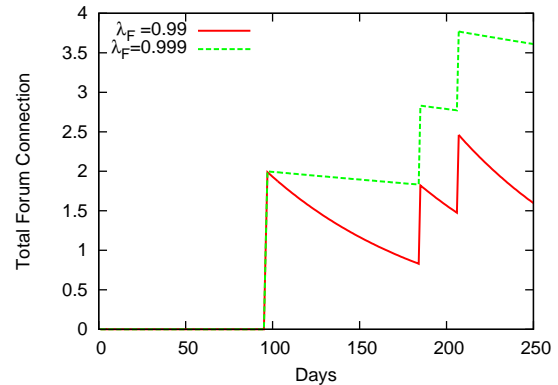
Figure 3: Simulated total forum connection according to different weights.

Learning. The *social contribution* indicator has to be used in a different way according to the usage of forum and/or chat room. The *appropriateness* is the metric used to evaluate posts on the chat room, whereas the *quality* metric is taken into account to evaluate the posts on the forum.

In the chat room informal topics can be discussed (such as sports, movies, vacations, etc.). For example posting the timetables of the movie theater on the math forum would be considered inappropriate, while asking a clarification of a theorem would be appropriate. In the case of the chat room the moderation is limited (due to the very nature of this form of communication), and thus more power is given to the students themselves. In particular all the people accessing the chat room can signal if a material is particularly inappropriate with a red flag which immediately sends a warning to the teachers who can connect and change/censor the material, and the value of inappropriateness of the poster increases (once a teacher confirms the bad quality of the content). A teacher is then a super-user having the possibility to censor particularly inappropriate content. Instead, the forum is expected to be divided in topics, and the teacher of the related subject can judge the quality of the students added material with the use of specific labels (i.e., *wrong, neutral, complete, comprehensive*). To each label a point is associated as defined in Section 3. In case of a wrong post, a teacher can ban the material in order to guarantee a high quality level of discussions. Peers can also judge the material added in the forum sessions. In case of a *wrong* indication, a warning is automatically sent to a teacher who can ban the uncorrected material.

Finally, the *social contribution* value is calculated by given the following balancing of its two indicators, i.e., $SC_L = 0.4 * App_L + 0.6 * Q_L$ with $\alpha = 0.4$. In this case, a greater importance is given to the *quality* indicator as the information from the forum are considered most significant than the ones obtained from the chat room where the information is only evaluated by the *appropriateness* indicator. This difference is given by the importance of the *formal* role of a forum with respect to the *informal* role of a chat room. In addition, the posts in a forum are less frequent than the ones of a chat room: a different score can reduce the possibility or overestimate the quantity of interactions obtained by the use of the chat room.

Behavior. Once the EduSN's graph is established we can calculate various centrality measures such (e.g., the betweenness as described in Section 3) which allow to determine for example who are the reference students, who tend to connect people, etc.

A non-secondary aspect of the graph representation is that we can have an idea of how a compact a group is. For example a graph where students share a lot of edges and these edges are short is expected to tell us that strong relationships have been established in the group. Collaboration is thus expected to be more present than in a group with looser bonds; this in turn has an impact on social learning (Bandura, 1963). A measure of this quantity is the sum of all the total connections between the students of a group, divided by the number of students of the group.

$$comp = \frac{1}{\left(\sum_{i \in group}\right)} \sum_{i < j \in group} \left(K_n^F(i, j) + K_n^C(i, j)\right)$$

(3)

A similar quantity can be obtained for the single student, but in this case it is enough to sum the total connections of a student to his/her "alters" (we will refer to this quantity as the *single compactness*). We emphasize that with this approach the graph associated to social network is based solely on the amount of interactions without taking into account its quality.

Results. For each student, the forum and chat room are overall evaluated by the *influence score* indicator that is calculated as the average values of: (1) the *single compactness* value (see Equation 3, and (2) the *social contribution* value as calculated in the *Learning* level. At the moment, the *informal success* indicator for the chat room module, is not analyzed as a semantic approach has to be considered in order to understand if posts of the chat room are related to topics on extra activities such as sports, theater, etc.

ROI. The ROI is then calculated as defined in Section 3 by subsuming to have the average final grades of the student's academic performance.

5 DASHBOARD

A dashboard representation is used to control the status of a learning process over a series of reports since the former has a strong visual and descriptive impact. Furthermore, evaluations have shown the importance of a dashboard when it is used by learners to get insight about their performances (Santos et al., 2012; Corrin and de Barba, 2015). Within a dashboard one can group a series of analytic tools in a single page and obtain a general overview of the desired study case (Santos et al., 2012). As described in (Verbert et al., 2014), learning dashboards are classified into three basic classes that are: (1) dashboards to support the traditional face-to-face lectures, (2) dashboards to

Figure 4: Student's dashboard.

support face-to-face group work and classroom orchestration, and (3) dashboards to support blended or online-learning settings. Our work refers to learning dashboard classified in the third group.

For a correct interpretation of the information of a dashboard, both a synchronous and a diachronous approach should be considered. In detail, how a KPI performs in respect with the others at a given time is a synchronous approach to understanding information. Let us consider a case of a student who has good grades in English. Is this student also a good communicator (i.e., he/she also has a very good social network) or not? In the former case, it means that good language skills are not only confined to the academic environment but also to the "real world", while sometimes people do not develop good interdisciplinary abilities.

One has to take into account that within a dashboard representation not only the time evolution of the indicators is automatically updated but it is one of its most important aspects. A diachronous approach to information allows a person accessing to the dashboard to grasp a more deep understanding of information. Knowing that student's grades are at the minimum sufficient level in a subject does not tell us whether this person is doing a good job by improving form very low grades or is in a difficult period dropping from very high performances.

The dashboard of this project is to be thought as modular. This means that we can associate to each different KPI a different module which can be interfaced with the dashboard. This approach allows for great flexibility. In fact, the data representation has to take into account the background of each person accessing it and a modular approach to the dashboard allows for simple re-ordination of the data in this sense. Students and teachers require many KPIs, some of them are common and some of them are dif-

ferent leading to dashboards differences. For example, the graph representation of the social network is more important for the teachers, who need to understand better the connections within groups. By using this graph it is immediate to have an idea of how the students are active on the network, if there are subgroups and how the groups are compact. This tool is fundamental since it gives to the instructor a global overview which is sometimes difficult without quantitative evaluations. On the other hand, providing the same tool to students might lead to unnecessary competition and unnatural modification of the network itself. The students' dashboard is thought to give a general overview to the student about his/her current status of achievements. We will focus on it in Figure 4 as an example. At the center of the dashboard there are two main indicators (see Section 3), that are the *influence factor* and the *average grade*. The smiley, which can have 4 possible results, gives a general idea of the student status. At the top center of the dashboard there is a picture of the student and his name, at its sides there are two buttons, one to access to the chat room and one to access to the forum. The absence days (divided by month and total) are reported at the top right of the dashboard. Right below it there is the indicator of the grades, where a label can be clicked to access each single subject. Multiple labels can be clicked (unclicked) at the same time in order to have comparative overview on subjects over time. On top of the subject name there is a smiley which reports how the student likes the subject, which can been obtained, for example, with a sentiment analysis of the comments of the students on the forum and chat room. At the bottom center there are the degrees of appropriateness and quality of the material posted by the student on the social network, these include the posts on the forum, the multimedia material attached, the comments on the chat. The assessments are divided by the students (peers) and teachers. At the top left of the dashboard there is in indicator of the *total connection* (see Section 3), this indicator is a box containing many small images of people and the actual value of total connection. The number of people not shaded increases proportionally with the value of the connection. Below the indicator of the total connection there is the list of the top 5 connection people. Below the top 5 connections there are the medals which include both formal and informal activities. These awards are assigned by the teachers. At the very bottom left we list the material published by the student and by clicking over it the student can access it and its ratings.

Although the dashboard here introduced is not yet functional it is a guideline for the implementation phase. The prototype aspect is a crucial preliminary

step in user interface design to obtain an immediate feedback with the goal to minimize costs in the software development (Santos et al., 2012). This has to take into account that our goal is to create interfaceable modules which allow to personalize the final dashboards according to the relevant needs of the considered LMS. In this respect our proposal is centered around the modules rather than a single instance of dashboard.

6 CONCLUSIONS

In this paper, we have introduced the structure of a platform for social e-learning. This model is a modified version of the KP model. In the standard KP model the evaluation of the learning procedure in a company is divided in levels which take into account the different aspects of a training, these levels are usually called: reaction, learning, behavior, results and ROI. The modifications that we introduced take into account the differences between a school and a company and we added a strong emphasis on the ICT social aspect. The proposed platform allows students, teachers, parents, etc. to be connected together, to add material and in general to interact. This generates information which can be used to make assessments and to help adjusting the training in order to obtain better academic performances. An important aspect is dedicated to the creation of an EduSN represented by a graph where the nodes are associated with the students and the links with the strength of the interaction between the students. The model of this paper is to create a graph depending only on the amount of interaction between people without considering the quality and directionality of the information transmitted. The graph created with this procedure is time dependent and takes into account the evolution of the social interactions of a school. This realization allows to have quantitative evaluations of some aspects of the school life which usually are considered only at a qualitative/intuitive level, such as the reference people or the presence of sub-groups. This work can be seen as a first step in the direction of a quantification of the complex structures which naturally arise in social learning environments; thus, going beyond the evaluation of single students. A complete model should include the social structures of all the different players in the learning environment (e.g., students, teachers, special instructors, families, etc.), and the effect of the interaction among the scholastic structures on the final outcome of the learning process.

This interplay between the bottom-up (from the student to the school) and top down visions (from the social structures revolving around the learning process to the student) are not thought to be limited to a single scholastic institution but can naturally be applied to include different schools in a town, region etc.; thus, providing useful metrics to manage the knowledge of schools at a more general level. For example, the evaluation of how compact are the school networks in a region in respect to another one compared with the respective performances, can provide deep understandings of the problems and excellences of the learning process.

The KPIs that we proposed range from the normal metrics usually employed in a school (grades, absences, etc.) to evaluations which take into account the social aspect of the student's life (e.g., centrality measures, connection, compactness of the graph). Once the information is analyzed it is presented to the main actors of the learning procedure by means of modular dashboards. These dashboards are designed to convey the relevant information and to be flexible to adjust to the changes which can naturally occur in a scholastic environment. As an example, we presented the dashboard associated with the students where both formal and informal aspects of the learning environment are taken into account.

A natural development of this work is the implementation and analysis of more sophisticated forms of connection among the students (taking into account the directionality and quality of the interaction) and other players. At a more general level, this work paves the way to a quantitative analysis of the interaction of the different social structures involved in the learning process and their effect on the success of the scholastic system.

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