Collective Intelligence Utilization in the Scope of Personal Learning Environment

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Abstract-Personal Learning Environment (PLE) is an emerging concept in the field of learning technology. PLE allows users to aggregate information from distributed Web 2.0 services and organize it in the way that it is convenient for learners. Despite the fact, that PLE uses distributed social services as information source and by the nature of its design, it is a type of virtual social community; the social component is used very poorly in the scope of PLE. A new model of "wisdom of the crowd" utilization is presented in this paper. **The exclusive feature of this method is both aggregated and generated information sources analysis, allowing developing more precise digital identity and its' further use for appropriate learning sources discovery.**

Keywords-virtual social communities; personal learning environment; social software; Web 2.0.

I. A CONCEPT OF PERSONAL LEARNING ENVIRONMENT

The notion of Personal Learning Environment (PLE) appeared as a result of discussion among experts in different fields regarding the future of Virtual Learning Environments [1]. Virtual Learning Environments were seen as a fenced garden without any connection with other virtual environments, which are used by students for information collection and results dissemination [2]. On the opposite, Personal Learning Environments were rather seen as platforms for content aggregation from different contexts were learning takes place, such as home, workplace or educational institution [2]. However, there is still no commonly accepted definition of what is a PLE.

Some researchers see a PLE as a predefined set of software tools, which are used by learners to organize their learning process. Thus, Mark van Harmelen from Manchester University defines PLE as a single learner's e-learning system, which provides access to different e-learning resources and/or personal or virtual learning environments used by students and teachers [3]. Other researchers use PLE as a metaphor to describe modern student's online activity and environment. Graham Attwell's definition of PLE refers not only to software tools, but also to peripheral devices, that could ensure learning continuity outside the institution boundaries, such as mobile phones, laptops or portable music players [4]. Despite the fact that explicit definition of PLE is still under consideration, still a common feature could be highlighted – personal learning environment passes the control of learning process to the learner himself.

PLE design and implementation is a topic of hot discussions as well. Nial Sclatter [5] distinguishes researchers to three groups with their own perspectives and functionality vision. According to the first group, PLE has to be implemented as a desktop application and serve as intermediate node between learner and online services [6]. In their perspective, PLE is a learner's owned software application, which communicates with distributed educational web services and databases on service oriented bases. The second initiative group's vision is that the PLE construction is based only on Internet browser, using either separate online services, or integrated online environments, that aggregates different kind of information from distributed, mostly Web 2.0, services, such as blogs, wiki, social bookmarking, multimedia sharing and others services, that enable students' collaboration and organizational activities. This group has most successors. Third group of researchers state that personal learning environment is not only a piece of software, but the complex infrastructure, which combines both software applications and distributed web services and technical equipment, and the main goal is to propose suitable teaching and learning methods for successful infrastructure exploitation and focus more on use cases and learning scenarios [4], [7].

A PLE is a self-directed and self-controlled learning environment with social media background, which aggregates information from distributed, mostly Web 2.0, services, and allows organizing received information in the way that matches the learner's needs in the most sensible way.

This paper presents a new approach on how to use Web 2.0-based collective intelligence in the scope of PLE. The definition of PLE has been introduced earlier on; next, a brief introduction to social media and hidden social structures in the background, types of relationships and their building principles. Section three introduces proposed method and explains its working principles in detail. Section four describes how the method was implemented in practice and shows the results that have been achieved. A case study finalizes the whole article.

II. SOCIAL MEDIA AND THE ROLE OF CONNECTIONS THERE

The previous analysis of PLE concept unveiled that due to its nature, PLE is a type of social media. In order to understand the nature of ongoing processes, an analysis on

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social media is required. There are two major types of social media [8]:

1. Social networks
2. Online communities

Everyone has their social networks (whether online or offline) (Fig. 1). Social networks consist of friends, family, co-workers and people they are acquainted with. Social networking sites are simply making these networks visible. The most important difference between social networks and online communities is how people are held together on these sites. People are held together by pre-established interpersonal relationships, such as classmates, friends, co-workers, etc., on social network sites. Connections as these are made to last. People join social networking sites to maintain old relationships and establish new connections as well [8].

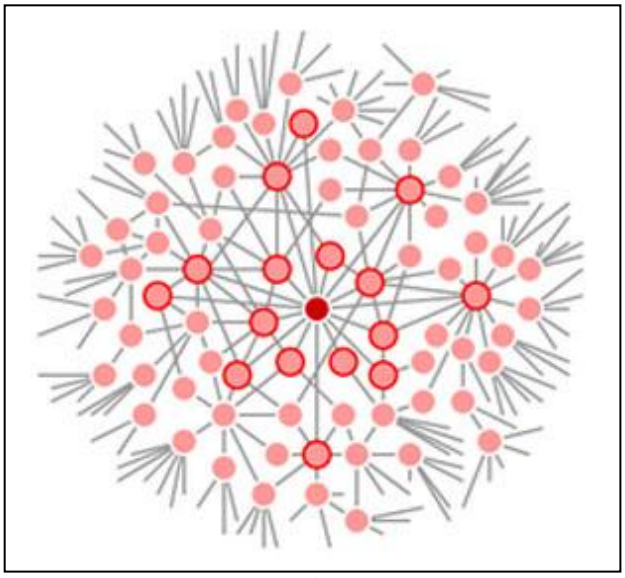

Figure 1. Structure of Social Network [8].

Unlike social networks, communities are held together by common interests (Fig. 2). It can be a mutual hobby, a common project or a goal, the way of life or a profession. People participate in online communities, because some members feel they can contribute to the community with their experience, while others feel they can benefit from being there. It is common for an individual to be a part of more than one community. Moreover, communities can overlap and are often nested [8].

Examples of the structure of social network and online community are presented in Fig. 1 and Fig. 2. Individuals are shown as red nodes in these pictures, and lines between those nodes represent relationships, that people establish between each other. However, the nature of these relationships is slightly different. A relationship in social network represents, that two people are members of the same social structure and have established connection there: it could be family, friends, co-workers, etc. However, it's hard to say without additional metrics, on how useful this relationship is to both sides, how strong it is, it is constant or happened only once. Relationships in online communities, on the other hand, are built in the same field and are related by the same interest. Relationships, of such type suite better, if there is an intension of using these connections for educational purposes.

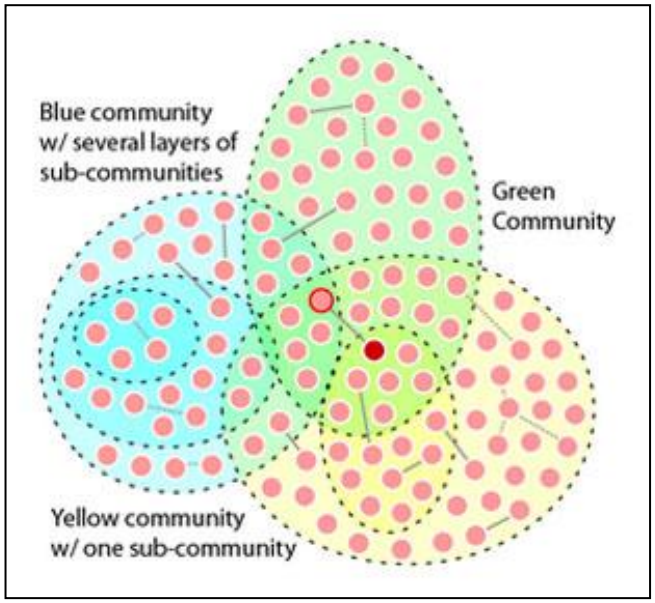

Figure 2. Structure of social community [8].

The lifecycle of every relationship consists of three stages (Fig. 3): 1) creating the weak tie: the first step of any relationship; 2) building up the tie strength: transformation of weak ties into strong relationships; 3) maintaining the relationship: preventing strong relationships from eroding and reverting back to weak ties [9].

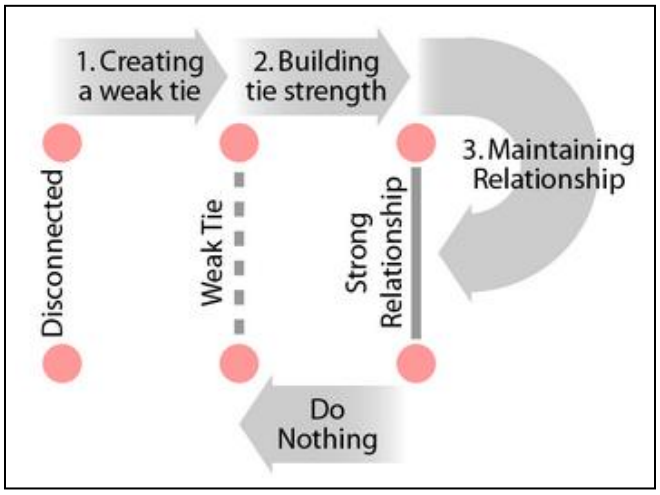

Figure 3. Lifecycle of Relationship [9].

A weak tie could be created both in social networks and in online community. The formation of weak ties between two people depends on their desire to connect, the amount of communities they share in common and the network distance between them. But tie strength predominantly is built in communities. What builds strong relationship within

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communities is the combination of frequent engagements, deep interactions, and the time spent together. If relationships are well developed, they become a part of person's social network. So, communities are needed for transforming weak ties into strong ones, and social networks are for maintaining and sustaining these relationships [10][11].

An approach of utilizing personal social network is proposed by Facebook social evangelist Eric Fisher and is called Social Design Strategy [12]. Social design consists of three core components: identity, conversation and community, in other words, the person himself, the other people and the conversations between the person and the other people. In the diagram (Fig. 4), identity is put to the center, conversation is in the middle and community is on the outside. Conversation is a media that serves as glue between the identity and the community. The conversation is the way people express their identities to the community and receives feedback from it.

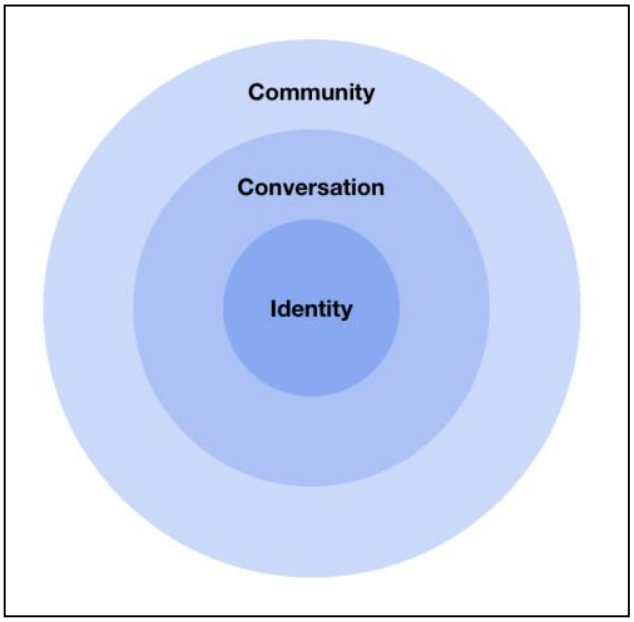

Figure 4. Social Design Diagram [12].

Fisher [12] proposes to start from the center and work the way out, during the process of designing a social product. That is, to allow people to create their identity, talk about it and build community over the time.

However, over the time, he proposes to take the reverse approach and work from the outside in. That is to utilize the community, define new types of conversations and to perform further identity updates.

III. "IDENTITY-NETWORK-PROPOSAL" MODEL

The analysis of relationship development in social networks and online communities, as well as analysis in social design strategy allows defining general a model of collective intelligence utilization. A general method is to construct digital identity, create weak ties with other members, turn weak ties to strong relationships and maintain these relationships. This section presents the potential of proposed method of PLE's collective intelligence for hidden network composition and its' further utilization for learning purposes.

The problem, in the scope of PLE, is weak ties establishment and their conversion into strong relationships, as PLE is a single persons' environment. Nevertheless, PLE by its design nature aggregates data mainly from distributed Web 2.0 services, meaning that social network or community could be established on distributed services side. Proposed model allows overcoming this shortage and using collective intelligence potential, accumulated in social software services, in a scope of single person's environment.

General model (Fig. 5) working principle is as following: the first step is to develop the digital identity of the person. In order to do that, the method proposes to separate and analyze 2 sources of information: users' aggregated content (source of knowledge) and users' generated content (reflection on learning process). Similar digital identities are created to all PLE platform users. The map of digital users' identities is created after the first step. The second step is finding users with similar digital identities and mapping them to each other. This step composes artificial communities that are based on users' interests, thus creating weak ties between users. The third step is turning weak ties into strong relationships. In order to do this, users are prompted with other users' operated content. A constant monitoring of user's activity is performed and logged. If users get interested in proposed content (clicks proposed data for further information, adds to favorites, etc.) the weak tie between these two users is labeled as strong relationship. At the same time, users' digital identities and connections between them are updated with new information.

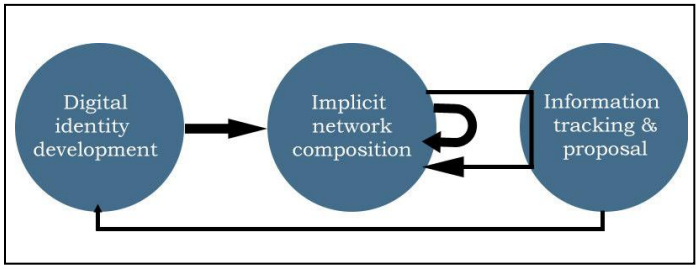

Figure 5. Identity-network-proposal model.

A more detailed model analysis is presented below.

A. *Step 1. Digital identity development.*

Main source of users' information is distributed Web 2.0 services, aggregated in the scope of PLE platform [13]. Every aggregated Web 2.0 service item usually comes with metadata that is called **tags**. Tagging is an inexpensive and easy way of using the wisdom of the crowd and making resources visible and sortable [16].

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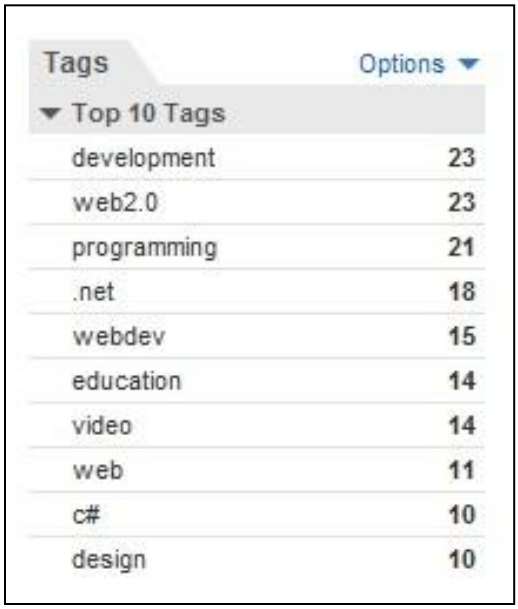

Figure 6. Tag list.

Tag is a metadata about the element that allows working with data in a more convenient way. A set of separate tags is called a tag cloud. Usually, tags in a tag cloud are visualized in different sizes, meaning that the tag with bigger size was used more often. The structured list view (Fig. 6) with tags and their usage density shows a clear picture of users' interests. At this stage, all platform users are merged to common matrix (Table I).

TABLE I. COMMON USERS' INTERESTS MATRIX

	User1	User2	User3	User4	User5	User6
web 2.0	6	5	1	2	6	3
education	3	4	9	5	3	2
technology	5	6	8		5	3
software	6			2		
.net	5					
learning		4	2			
python		4				
management			6			
hr				4		
programming					5	2

In order to develop a more explicit users' profile, the presented method proposes the usage of two types of metadata. The first type of the metadata comes in a form of tags pinned to Web 2.0 services elements. Generally, it is users' *aggregated* content: links from social bookmarking services, podcasts, vodcasts and "youtube" type videos, and other structured information. Second part of the metadata comes from users' *generated* content. At this stage, the method proposes to analyze and extract metadata from users' reflections on learning activities that they post in their blogs and wikis. The aggregated type of metadata corresponds to knowledge gained during the learning process. Another important part of learning process is reflection, which corresponds to users' generated data. As reflection information comes as a text (blogs, wiki, etc.) this information is analyzed and another set of metadata is generated.

Both types of metadata (aggregated and generated) are combined in a common user's interest matrix with the same weight (Table I). Such approach allowed defining more explicit user's profile, which not only combines consumed, but also created contents, that correspond the gained knowledge and reflection during the learning process.

B. Step 2. Implicit network composition.

This stage is responsible for the composition of weak ties. At the beginning there is no activity between users, thus there is no possibility to define these ties upon their actions. Therefore, weak ties between the users are defined using collective intelligence algorithms. In this case, an algorithm is used, that calculates Pearson correlation (1) [18] between all users.

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N})(\sum Y^2 - \frac{(\sum Y)^2}{N})}} \quad (1)$$

The result of calculations is shown in Table II.

TABLE II. PEARSON CORERLATION MATRIX

	User1	User2	User3	User4	User5	User6
User1	1	**0.6546**	**-0.826**	**-1.0**	**1.0**	**0.9449**
User2	0.6546	1	**0.1705**	**-1.0**	**0.6546**	**0.866**
User3	-0.826	0.1705	1	**1.0**	**-0.8260**	**-0.596**
User4	-1.0	-1.0	1.0	1	**-1.0**	**-1.0**
User5	1.0	0.6546	-0.8260	-1.0	1	**0.6882**
User6	0.9449	0.866	-0.596	-1.0	0.6882	1

The results of Pearson correlation algorithm illustrate that the biggest coefficient and, accordingly, biggest similarity have user pairs (*User4*, *User3*), (*User1*, *User6*), (*User2*, *User6*), (*User5*, *User6*) and (*User1*, *User2*), and the smallest similarity is between users (*User1*, *User4*), (*User2*, *User4*), (*User4*, *User5*), (*User4*, *User6*), (*User1*, *User3*) and (*User3*, *User6*).

Based on Pearson coefficient calculations, a set of users with similar preferences is made for every user. A set of similar users to *User1* is presented in Table III.

TABLE III. USERS SIMILAR TO *USER1*

User	Similarity coefficient
User5	1.0
User6	0.9449111825230654
User2	0.6546536707079769

Data on Table III show users with similar interests as *User1* are *User5* (1.0), *User6* (0.94) and *User2* (0.65). It means that there are weak ties between *User1* and *User5*, *User6* and *User2*.

Such matrixes are calculated for every platform user. After this step weak ties are established between all users with similar interests.

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C. Step 3. Information tracking and proposal.

The last step is responsible for converting weak ties into strong relationships. To do this, an appropriate user is prompted with information, operated by another user from similarity set. If the user responds to proposed information (clicks a link, saves to favorites, etc.), the weak tie get additional weight (gets +1 point) and is turned into strong relationship.

TABLE IV. *USER1* STRONG RELATIONSHIPS TABLE

	User5	User6	User2
User1	11	8	5

Relationships with bigger weight are considered more valuable. This weight affects information flow that is prompted for user later. Also, at this stage user's digital identity information is appended with new metadata according to his shown interests. This updated information is used to discover new weak ties.

IV. METHOD EVALUATION

Big players like Google, Facebook or eBay use collective intelligence utilization approach in their products. Nonetheless, their methods are not published and are held as commercial secrets. Such companies publish only general guidelines, like social design strategy, which was overviewed in the second chapter on this paper.

On the other hand, collective intelligence utilization methods are not applied in online education systems so far. That is why there are no legitimate numbers to compare with.

The proposed method could be implemented in any PLE platform. For the proof of the concept, method was implemented and tested in open source PLE platform "Dropthings" [17]. Principal schema of method implementation is illustrated in Fig. 7.

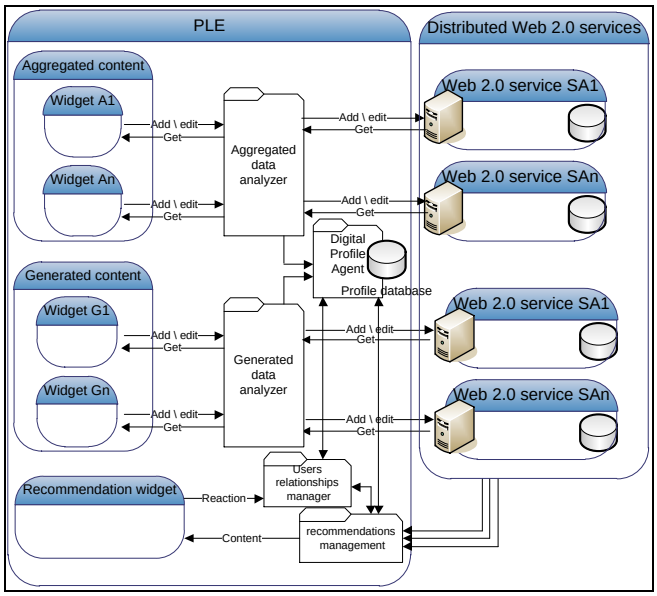

Figure 7. Method implementation in a scope of PLE.

As Fig. 7 illustrates, selected for the proof of the concept "*Dropthings*" PLE platform is a widget based aggregation platform. As the method suggests, widgets are divided to two groups: ones used to aggregate content (social bookmarking, YouTube videos, etc.), and those, which are used to reflection (blogs, wiki). Each group has separate analysers. Aggregated data analyser extracts tags from Web 2.0 items and passes them to the digital profile agent. Generated content analyser scans user's generated text information and extracts keywords from there, and passes them to the profile agent. The profile agent is responsible for digital identity storage. The relationships manager analyses profile information at the beginning and afterwards finds similar users according to theirs interests. That is how weak ties are established. The recommendation manager uses these ties to find potentially useful data and propose it to the user in recommendation widget. If proposed information is useful for the user, and he clicked proposed link, appropriate information is send to the relationships manager. The relationship manager adds addition weight to that relationship and turns it into strong connection, meaning, that from now on they will see more information from each other. Weak ties expire after predefined time, if they do not get additional weight.

In order to evaluate proposed approach, the survey was made among users, to find out, if this method allows students to discover useful information. Survey results revealed that 31% of users found such prompted help 'extremely useful', 57% stated that it was 'reasonably useful' and only 12% stated that it was 'useful occasionally or not useful at all'.

V. CASE STUDY IN CONNECT PROJECT

CONNECT [15] social learning and virtual community platform implements WEB-based social networking tools and it has been built by free Software applications (liferay). CONNECT is an international online community where everyone can find opportunities and stimulus to test oneself, to find chances of self-training either on one's own or with others, to increase own competencies in an informal way by exploiting the peer's experiences.

Project partners from Italy, Czech Republic, Spain, France, Germany, United Kingdom and Norway has their national communities but more than that they can connect to the transnational community which can be joined by anyone. The Connect project aim at creating a virtual environment is useful for all people who are at risk of exclusion from the labour market. Are they women in maternity leave, people over fifty, immigrants or whatever, the net may provide various chances to re-launch themselves. The Web 2.0 simplifies ways of creating own website at a low cost. It provides easy tools to promote oneself and own competencies in a very attractive and multimedia way. It offers applications to broadcast oneself easily on the net, contributing with opinions, discussions and products.

As Fig. 8 illustrates, there is a possibility of finding new ideas, as well as possibility of taking part in discussions and expressing oneself. There is also an opportunity to look up for relevant information which was placed in the website by other users.

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Figure 8. Social learning environment.

Connect Learning is organized in social network where users can create their profiles, post their ideas in different forums, create blogs, improve competences, explore resources, find people. Unlike for other similar websites there are no training courses, which usually are expected to be found and no teachers as well. It is just tutors and community members who find out together the most fruitful way to have the process as spontaneous as the informal requires. On the contrary, the direct experience made by people with similar problems may become an inestimable treasure. Surfing the net and its resources may become an unexpected way to learn content and train skills. Connect Learning could become the entrance to this world of opportunities and its members are to become the direct referents for increasing it.

VI. CONCLUSION AND FUTURE WORK

A new model of collective intelligence usage in the scope of personal learning environment is presented in this paper. The work has been implemented in the framework of Eureka ITEA2 project "Friends Family Colleagues Connect" [18] that is aiming to allow people to connect in natural and easy ways. An analysis of PLE concept allows defining common platform structure and the kind of data that is used in such environments. Following analysis of social media showed, what kind of ties and relationships are established there and how they can be used. Based on previous information, a general method of collective intelligence usage in the scope of PLE was proposed. Despite the fact, that PLE is designed for single persons' use, the proposed model allows defining weak ties, that are appropriate for online communities, and turning them to strong relationships that are specific to social networks, and using these connections for users learning. The exclusive feature of this method is both aggregated and generated information source analysis.

The proposed method was implemented in the scope of "Dropthings" PLE platform. Evaluation survey showed that the majority of users (88%) found such prompted help useful in their activities (31% - extremely useful, 57% - reasonably useful), and only 12% didn't gain any additional value.

The future work is maximizing usefulness of proposed material, which can be used for persons' learning. Next step is to change +1 (or like based) prompted content evaluation system to a grading system (it could be grades from 1 till 5), and thus enhance recommended content relevance.

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