Toward a Visual Analytics Framework for Learning Communities in Industry 4.0

Peter Hasitschka
Know-Center GmbH
Inffeldgasse 13/6
8010 Graz, Austria
Email: phasitschka@know-center.at

Vedran Sabol
Know-Center GmbH
Inffeldgasse 13/6
8010 Graz, Austria
Email: vsabol@know-center.at

Stefan Thalmann
Know-Center GmbH
Inffeldgasse 13/6
8010 Graz, Austria
Email: sthalmann@know-center.at

***Keywords*—Visualization, Graph Visualization, Learning, Industry 4.0**

I. Introduction

Industry 4.0 describes the digitization and the interlinking of companies working together in a supply chain [1]. Thereby, the digitization and the interlinking does not only affects the machines and IT infrastructure, rather also the employees are affected [3]. The employees have to acquire more and more complex knowledge within a shorter period of time. To cope with this challenge, the learning needs to be integrated into the daily work practices, while the learning communities should map the organizational production networks [2]. Such learning networks support the knowledge exchange and joint problem solving together with all involved parties [4]. However, in such communities not all involved actors are known and hence support to find the right learning material and peers is needed.

Nowadays, many different learning environments are used in the industry. Their complexity makes it hard to understand whether the system provides an optimal learning environment. The large number of learning resources, learners and their activities makes it hard to identify potential problems inside a learning environment. Since the human visual system provides enormous power for discovering patterns from data displayed using a suitable visual representation [5], visualizing such a learning environment could provide deeper insights into its structure and activities of the learners.

Our goal is to provide a visual framework supporting the analysis of communities that arise in a learning environment. Such analysis may lead to discovery of information that helps to improve the learning environment and the users' learning success.

II. Analyzing Communities

Learning systems may contain different types of learner groups (communities). We define four types: **(1) Predefined communities (C_P)**, which may be set by a teacher. For example, different working areas of a company or different classes. **(2) Learning communities** (C_L) define groups of learners that learn and comment/rate a similar set of learning resources. **(3) Communication communities (C_C)** group learners depending on their communication exchange, auch as messaging or question answering. **(4) Similarity communities (C_S)** cluster learners by their properties (e.g. expertise, interests, job description, skills etc.). Note that (C_P) is explicitly specified in the learning system, while the other three – the Extracted communities (C_E) – are derived automatically from the learning behavior, communication exchange, and learner properties, respectively.

Community analysis can contribute to an improved learning environment. For instance, when (C_C) show little overlap with other community types, such as (C_P) or (C_L), then this might indicate a problem: in the first case the classes may need to be reorganized, while in the second case learning communities might profit from increased communication.

A. Use Case

An industrial enterprise periodically provides courses for its employees using a learning environment. The learners were divided into classes (C_P) according to their estimated knowledge. They can consume learning resources and communicate with each other. The platform administrators realize that the learning success is not as high as in the year before. They do not know what the exact cause is and how to improve the system, since the mass of activities, performed by hundreds of learners is too complex. They assume that possible causes may include either a wrong class allocation, incompatible learning goals, or communication problems between the employees.

In the following we demonstrate how our approach could help identify the problems using a visual comparison of its C_P (classes), and the three C_E community types. The outcome of such an analysis could be valuable for optimizing the environment by adapting the classes, motivating communication or adapting the learning resources.

B. Comparing Communities

In this section we describe an approach of identifying similarities and differences between the different community types. We use our framework to visualize and analyze the communities, where all communities of the same type are shown within a single *plane*. The user can select two of those planes to perform visual analysis and compare different community types.

1) Calculating the Community Comparison Graph: Whenever the user invokes the comparison between two community planes, the calculation of their *Community Comparison Graph*

(*CCG*) is performed first. Following the example of Figure 1, the plane containing C_P communities (left) is compared with the C_L plane (right). To make their analysis possible, the intersections between the two community types are calculated. Each overlap of learners of a single C_P and a single C_L community is stored as a new virtual group (bottom). For example, only three learners of the predefined community C_{P3} also appear in the extracted learning community C_{L3}. These three learners, who are in the same class and learn the same resources are thus gathered in the C_{P3}-C_{L3} group. The comparison between C_{P2} and C_{L2} results in a group (C_{P2}-C_{L2}), which contains all the learners from both communities since they overlap completely.

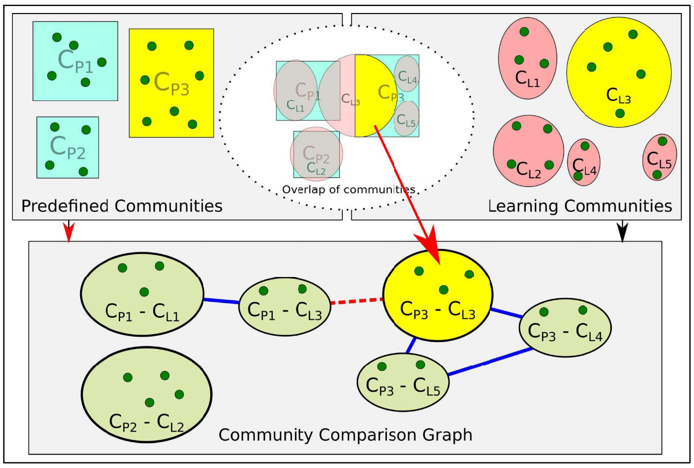

Fig. 1. Calculating the *CCG*: Comparing C_P and C_L calculates intersections between communities of different types, resulting in the *Community Comparison Graph*.

2) Visualizing the CCG: The example shown in Figure 2 visualizes C_P communities in the left plane and C_L communities in the right plane. After calculation, the *CCG* is visualized in a third plane which appears at the bottom.

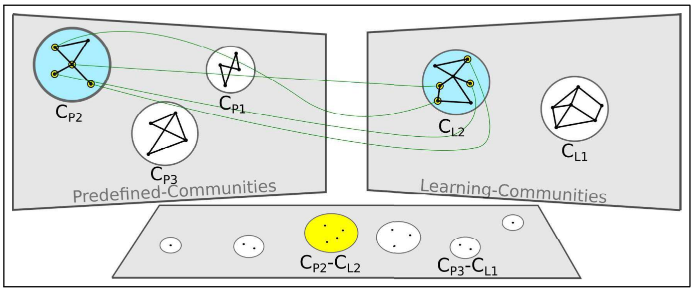

Fig. 2. Comparing predefined communities (left) with learning communities (right). A third plane (bottom) visualizes the *CCG*. Interactivity (clicking, hovering) allows further exploration of relationships between communities.

The size of the intersected groups in the third plane represents the number of learners they contain. Intersection between C_{P3} and C_{L1} results in a comparably small group, whereas the highlighted example (C_{P2}-C_{L2}) appears larger, since the intersection yielded a larger number of learners. The user can click on an intersection result to identify the two communities which where compared. Additionally, hovering over a single community in one of the upper planes, will show links to communities in the opposite plane. Each link represent the membership of a learner from the hovered community, in a community of a different type. Links connecting to a single community in the opposite plane indicate a high overlap between communities of different types (as shown in Figure 2). However, links spreading over multiple communities indicate a low overlap which may represent a problem.

3) Analyzing the Comparison: Let us assume that the administrator of a learning environment wants to analyze if learners in predefined classes also learn similar resources. Thus, the administrator compares the C_P and C_L communities (as shown in Figure 2). Since sharing the same resources within a class is beneficial, a bigger overlap between those community types would be advantageous. Considering the *CCG* plane, the number of groups and their size indicate how strong the overlap is. If only a small number of large groups exist, the C_P communities have a high overlap with the C_L communities, which indicates that the class members learn the same or similar resources. Then again, if a larger number of smaller groups exist in the *CCG* plane, the overlap between C_P and C_L is lower. If hardly any overlaps exist, it would indicate that class members use different resources for learning. This could be caused by different levels of previous knowledge, so that class restructuring might be necessary.

III. Conclusion & Future Work

We proposed an approach for visualizing and analyzing communities within a learning system with the focus on learning in Industry 4.0. An interactive comparison mechanism allows to identify overlaps in different types of communities, which may be either predefined or extracted depending on the learner behaviour and properties. Using a simple example, we demonstrated that such comparisons can be useful to identify problems within a learning environments, and to provide hints on which actions could be taken to improve the situation.

Within the *AFEL*-EU-project[1] we are currently doing further research to extend our approach, and to explore its usefulness. A prototype of the visualization framework is currently under development.

IV. Acknowledgement

This work is funded by the EU Horizon 2020 research projects *AFEL* (grant agreement nr. 687916) and *MOVING* (grant agreenemt nr. 693092). The Know-Center GmbH is funded within the Austrian COMET Program - managed by the Austrian Research Promotion Agency (FFG).

References

[1] H. Kagermann, W.-D. Lukas, and W. Wahlster. Industrie 4.0: Mit dem internet der dinge auf dem weg zur 4. industriellen revolution. *VDI nachrichten*, 13:2011, 2011.

[2] S. Schäper and S. Thalmann. Addressing challenges for informal learning in networks of organizations. In *ECIS*, 2015.

[3] D. Spath, O. Ganschar, S. Gerlach, M. Hämmerle, T. Krause, and S. Schlund. *Produktionsarbeit der Zukunft-Industrie 4.0.* Fraunhofer Verlag Stuttgart, 2013.

[4] L. Waizenegger, S. Thalmann, C. Sarigianni, A. Eckhardt, D. Kolb, R. Maier, and U. Remus. From isolation to collaboration-how the increasing diffusion of mobile devices has changed practices of knowledge sharing in non-office settings. In *ECIS*, 2016.

[5] C. Ware. *Information visualization: perception for design*. Elsevier, 2012.

[1] http://afel-project.eu/