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Comprehension and Learning of Social Goals Through Visualization

Jelena Jovanovic, Ebrahim Bagheri, and Dragan Gasevic

Abstract—The concept of social goals refers to organizational goals that are defined in an open and transparent manner; they serve as social objects that incite both formal and informal collaboration around shared interests/objectives. Our objective is to facilitate the comprehension of social goals and examine the role of social goals as scaffolds of social learning in an organization. To this end, we followed an approach based on the visualization of social goals and explored how different presentations of goals, specifically, faceted goal browsing, graph-based visualization, and timeline-based visualization, contribute to the realization of the stated objective. To assess this approach, we conducted a between subjects study where each participant performed a set of goal comprehension tasks with one of the examined presentations of goals. The study demonstrated that our visualizations of goals increase the accuracy of the overall comprehension of an organization's goals; this positive effect is also present when the comprehension of relationships—either explicit or implicit ties—among social goals is needed. The results also confirmed that our graph-based visualization of social goals could serve as a facilitator of social learning in an organization.

Index Terms—Goal management, organizational goals, social goals, social learning in organization, visualization of goals.

I. INTRODUCTION

THE trend of sharing content and activities in an open and transparent manner, as well as interacting and collaborating around shared content, is gradually spreading from open Web environments to the traditionally more closed organizational environments [24], [30]. This trend can probably be attributed to the role of social media that promotes collaboration in a less hierarchical (i.e., egalitarian) manner [6] and strongly relies on human weak-ties [18]. One of the core components of the organizational (workplace) context that is influenced by this trend are organizational goals which are evolving into social goals [41].

The concept of social goals refers to organizational goals that are defined in an open and transparent manner. They serve as social objects around which teams/communities are built and collaboration takes place. Besides traditional, formal

collaboration based on team membership, such goals set the scene for informal collaboration that allows one to contribute to the accomplishment of goal(s) they find interesting and/or relevant. Thus, social goals might be shared among people who do not necessarily belong to the same organizational unit or formal team. The perception of goals as being shared with other organizational members has proven to be important for both goal performance [37] and goal commitment [47], [48]. Previous research [29] has even shown that it is enough for people to believe that they have shared goals with others in the group in order to show higher commitment to the group's goals. In addition, the perception of shared goals is significantly related to some important organizational outcomes, namely goal commitment, job satisfaction, and communication satisfaction [19].

Being open and transparent, social goals lead to the development of social capital [30], which in turn leads to group identification, and thus to the commitment to the group goals [48]. In addition, the transparency of social goals increases the awareness of people's goal engagement and progress [14], [35], and thus allows for social comparison that, in turn, can motivate higher work commitment [25]. In addition, the increased awareness of how organization's goals are mutually related could facilitate harmonization of goals defined at different levels in an organization (personal, team, organizational), and thus help the organization deal with the well-known challenge of goal congruence [28].

Due to the aforementioned positive characteristics, the social goals construct has been adopted by an increasing number of companies, including Facebook, Mozilla, Zappos, and Spotify. Although the concept of social goals is underexplored, previous research on organizational goals (e.g., [31] and [28]), and collaboration and teamwork (e.g., [26], [40], [47], and [48]) demonstrated some of its benefits.

In this paper, we aim to address how to support people in adopting and pursuing social goals in an organization. More specifically, our aim is to explore how the comprehension of the overall structure of goals within an organization can be facilitated. This includes the comprehension of the relationship of one's personal goals to the personal goals of colleagues as well as to the upper level organizational goals.

The rationale for choosing this particular aspect of social goals is threefold. First, while there are many work management applications, developed as a part of the so-called Enterprise 2.0 trend [33], [12], support for goal comprehension is lacking. The available support typically takes the form of complex visual representations of the goals hierarchy. Such visualizations are neither easy to comprehend, nor consistent with the notion of social goals which is more about bottom-up than top-down hierarchical creation of goals [6]. On the other hand, emerging goal management platforms (e.g., Objectively.com, Work.com)

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typically rely on the faceted search metaphor [22] as a way of exploring social goals. While these solutions allow for efficient search of goals, they fail to provide insight into mutual relations of goals.

Second, one's personal goals are intertwined with the goals of affiliated social networks (e.g., team, organization) and are accomplished through interpersonal interaction [23]. The literature also confirms the relevance of having awareness of and insight into how one's goals are related to team/organizational goals for higher goal commitment [40] and important organizational outcomes (e.g., work satisfaction) [19].

Third, we hypothesize that the comprehension of social goals within an organization facilitates social learning on how to set up and pursue social goals, thus allowing for the concept of social goals to gradually become part of the organizational culture. This assumption is based on work in education. For instance, social cognitive theory states that people learn by observing what others have done [2]. This is further confirmed by research in social learning where people reach higher levels of learning through distributed cognition in computer-mediated communication [36]. Likewise, research in workplace learning demonstrated that knowledge develops through practice and sharing within relevant communities [4], [15].

To address the stated overall research objective, we focused on the visualization of organizational goals since visualizations can facilitate comprehension of complex structures [3], [7], [42]. Accordingly, we defined two research questions:

RQ1: Does a visualization of social goals enhance users' comprehension of those goals (including the characteristics of individual goals and goals mutual relations)?

RQ2: Is visualization of social goals perceived as a facilitator of social learning?

We explored these research questions in the context of the 7Geese social performance management software based on the notions of social goals, continuous feedback, and peer recognition. 7Geese had allowed for the exploration of goals in a faceted-browsing style only and offered no other form of goal presentation. In order to augment its goal exploration capabilities, we designed and developed prototypes of two types of interactive visualizations of organizational goals.

The remainder of this paper is organized as follows. Section II introduces our research model which provides the theoretical grounding for our work; Section III introduces the three kinds of presentations of social goals; in Section IV, the methods are presented; Section V presents the results; Section VI discusses these results, and presents the limitations of our study; Section VII concludes the paper.

II. THEORETICAL DEVELOPMENT AND RESEARCH HYPOTHESES

In this section, we develop our research hypotheses and the overall research model (see Fig. 1). We review different aspects of comprehension of organizational goals and social learning in an organization.

A. Facilitating the Comprehension of Social Goals Through Visualization

Information visualization enables one to get an insight into the information space, that is, to explore, analyze, and discover

relevant pieces of information [7]. This further empowers one to come to better conclusions/decisions and explain some phenomenon, or just to understand the considered phenomenon better [16]. In addition, visualizations allow for illustration and communication of ideas, concepts, and diverse kinds of data/information structures [42]. These features lead us to consider information visualization as a means of facilitating the comprehension of social goals in an organization.

Our visualization-based approach was also motivated by the use of visualization in enhancing comprehension of complex systems such as software systems (e.g., [38], [39], [43]). Park and Jensen [34] explored the potential benefits of information visualization in supporting newcomers to open source software projects. Teams collaborating on such projects bear some resemblance to teams gathered around social goals in an organizational setting. Park and Jensen demonstrated that visualization tools provided means for obtaining quality information, efficient handling of large amounts of data, and comprehension of dependences in source code; this in turn reduced the learning curve of newcomers, and the information overload experienced in the absence of these tools.

Visualization has also proved beneficial in: facilitating comprehension of the structure and dynamics of complex social networks [3]; assisting in the analysis of information and activity flows [45]; and serving as a community component in communication and collaboration activities [10].

From the perspective of social goal management, comprehension of the overall goals structure in an organization (i.e., how goals of different type are mutually related) is particularly important, since it facilitates harmonization/congruence of goals defined by different organizational members as well as goals defined at different levels in the organization (e.g., personal, team and organization-level goals). The benefits of harmonization of goals defined at different levels in an organization have been demonstrated in numerous studies (e.g., [26], [37], [46]).

Furthermore, according to Zhang and Chiu [47], by becoming aware of being committed to the same/similar goals as those pursued by team/organization members, an individual would more readily identify with the team/organization and perceive his/her personal goals to be aligned with the team/organization's goals. In addition, Haas *et al.* [19] found that increased communication and awareness of organizational goals might contribute to the increase in some important organizational outcomes, including goal commitment, job satisfaction, and communication satisfaction.

B. Facilitating Social Learning Through Visualization

According to social learning theory, organizational behavior is affecting and affected by the cognition of organizational members, the (organizational) environment, and the person–situation interactions [11]. This theory postulates that learning takes place vicariously through observing the behavior of other people and the effects it has on the social environment [2]. Theories of socially embedded self-regulated learning [20] argue that people rely and depend on the members of their social network to accomplish their learning goals. In other words, self-regulation is considered an interdependent, social process during which individuals exchange feedback, the feeling of connectedness, and support. Similarly, the situated learning theory sees learning as

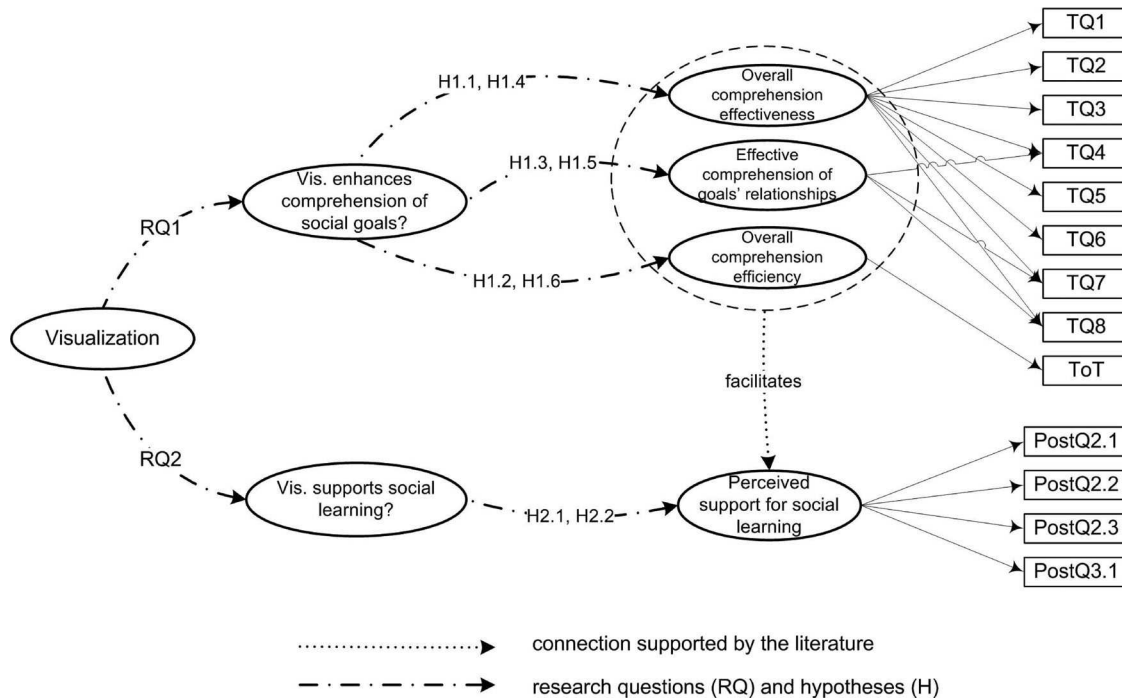


Fig. 1. Theoretical (research) model.

embedded in the shared practices, organizational culture, and professional activities [5]. It emphasizes participatory learning practices where learning is distributed over a community of people formed around shared work-related issues and/or professional interests.

Modeling or observing a model is a type of vicarious learning [2] relevant for the development and maintenance of general work patterns in organizational settings [11]. Learning through modeling occurs in organizations on a daily basis, even without people being aware of this process [32]. Since the creation and pursuit of goals in an open and transparent manner opens up opportunities for modeling, organizations driven by social goals are particularly suitable environments for this form of social learning.

C. Research Hypotheses

We aim to contribute to the domain of social goal management by exploring whether visualization of social goals can facilitate the comprehension of such goals. Hence, we introduce the following hypotheses to our research model (see Fig. 1):

H1.1: The availability/use of a visualization of social goals significantly affects the effectiveness of the overall comprehension of an organization's social goals.

H1.2: The availability/use of a visualization of social goals significantly affects the efficiency of the overall comprehension of an organization's social goals.

Here, *effectiveness* refers to the degree to which certain objective (comprehension of social goals) is attained, whereas *efficiency* is about the amount of resources that were used to reach the given objective [9].

Since today's solutions for presenting organization's goals do not provide adequate support for comprehension of goals'

mutual relationships (see Section I), we aim at examining if visualizations could close this gap. Hence, the following hypothesis is added to our research model:

H1.3: The availability/use of a visualization of social goals significantly affects the effectiveness of comprehending mutual relationships of the organization's social goals.

Visualizations tend to be very domain and task-specific [27], [44]. Whether and to what extent certain kinds of visualization prove beneficial depends upon the end users and the task at hand. To find a visualization that would facilitate the comprehension of social goals, we need to explore different kinds of visualization and assess how users perceive and understand those visualizations. Hence, we are interested in understanding whether the type of social goal visualization impacts effectiveness and efficiency of goal comprehension. Accordingly, we define the following research hypotheses:

H1.4: The type of visualization of social goals significantly affects the effectiveness of the overall comprehension of an organization's social goals.

H1.5: The type of visualization of social goals significantly affects the effectiveness of comprehending mutual relationships of an organization's social goals.

H1.6: The type of visualization of social goals significantly affects the efficiency of the overall comprehension of an organization's social goals.

Furthermore, by applying propositions of the theories of social learning, we hypothesize that a visualization of organizational goals would facilitate social learning in an organization. In particular, we hypothesize that by being able to observe social goals defined by others (e.g., team members), one would learn how social goals should be set and pursued, i.e., what are the expectations or even organizational norms for goal setting and goal pursuit in the given organizational context (e.g., team or

department). To test this assumption, we introduce the following hypotheses:

H2.1: The availability/use of visualization of social goals is perceived as a facilitator of social learning in an organization.

H2.2: The type of visualization of social goals significantly affects the perceived support for social learning in an organization.

III. PRESENTATION OF GOALS

We used the following presentations of goals: 1) Goal Explorer, a feature of the 7Geese platform that allowed for faceted browsing of social goals, and offered no visualization of goals; 2) the developed prototype for timeline-based visualization (TVis) of social goals; 3) the developed prototype for graph-based visualization (GVis) of social goals.

The 7Geese platform was representative of social performance/work management applications that, driven by the Enterprise 2.0 trend, have been emerging rapidly. Many of these applications are based on the notion of social goals, and have comparable features, such as goal management, quick feedback loops, and social recognition.¹ In addition, the company developing 7Geese was interested in exploring potential visualizations as means of facilitating the management of social goals. Therefore, it provided the required information and access to their code base.

At the time of this study, 7Geese was not offering visualization of organizational goals. However, it did provide faceted browsing of organizational goals through a feature called Goal Explorer (see Fig. 2). By using this feature, one could browse through the organizational goals based on the goals' deadline (i.e., see goals sorted based on goal due date and grouped on monthly bases), progress (i.e., see goals in progress and completed), and contributors (i.e., for each colleague, see to what goals he/she is contributing).

To reduce cognitive effort, information in a visualization should be appropriately mapped to the visual form [21]. For example, the best information representation depends on the task requirements [44]. Therefore, the design of our visualizations was driven by the objectives to be achieved with those visualizations, and the requirements derived from those objectives.

Social goals are connected via diverse kinds of relationships that needed to be visualized in different ways for comprehension. In particular, there was a need to support comprehension of explicitly declared relations (the relations defined by the users when creating/updating a goal) and implicit relations (i.e., relations inferred from the goals' properties). For the latter, we found particularly important relations based on the subject/topic of goals as well as those related to the goals' time properties (start/end date). To support comprehension of these kinds of goal relations, we introduced two kinds of visualizations:

- 1) GVis (see Fig. 3): presents goals as (graph) nodes that can be connected through explicit (user-defined) connections and/or implicit connections inferred from the subject/topic of goals; to make these two kinds of connections visually distinctive, different line patterns and colors were used; to

avoid the clutter, we enabled users to selectively turn the display of connections ON/OFF.

- 2) TVis (see Fig. 4): presents goals (as stripes) on a timeline; it supports scrolling in time and thus allows a user to see goals (all or of selected type) at any point of time. The objective was to simplify diverse kinds of potentially useful observations such as time periods with unusually high/low goal load, competing goals (i.e., goals with the same or very close due dates).

Besides these distinct features, the two visualizations have a number of common features, such as filtering of displayed goals based on the goal type, goal owner, urgency (i.e., number of days till the deadline) and tags (keywords).

The two visualizations were developed as Web-based prototypes. Further details about the two visualizations, including the design process undertaken, the design decisions being made, screenshots, and links to visualization demos and demo videos explaining their features, are available at <http://goo.gl/Fhh142>.

IV. METHODS

A. Study Design

The study design was a between subjects experiment in which each participant used one way of presenting social goals: 1) Faceted goal browsing (FGB) with no visualization of goals; 2) TVis, and 3) GVis.

The study tasks were related to the stated purpose of enabling users to comprehend the overall social goals structure, to see how their goals fit into the overall organizational goals, as well as to perceive and comprehend the urgency, completeness, and other relevant aspects of individual goals. Accordingly, these tasks were aimed at assessing whether and to what extent different kinds of goal visualization assist users in comprehending goals and their interrelations.

B. Participants

For the recruitment process, we relied on the Snowball sampling technique [1]. Specifically, we aimed at recruiting knowledge workers who had a solid degree of computing literacy, regularly use technology for their work, and were familiar with social networking platforms. To avoid bias or confounding results, we needed participants who had no previous experience in using 7Geese or any other social goal/work management software. Invitations were sent (via email) to researchers studying/working at the authors' affiliated universities. Subsequently, we asked the initial participants to recommend additional people who might be interested in participating.

A total of 39 participants (17 male and 22 female) were recruited and retained for the study. Seven (21.2%) received Ph.D. as the highest degree, 22 (56.4%) a Master degree, and ten (25.6%) a Bachelor degree (either B.Sc. or BBA). Their professional positions included: 1) research and development (R&D) with 31 (79.5%) participants working as a research/teaching assistant, programmer, software developer, or postgraduate student; 2) senior R&D with eight (20.5%) participants who specified their position as being either Post-doctoral fellow or Assistant Professor.

¹An overview of these applications and their features is available at <http://goo.gl/0gFct8>

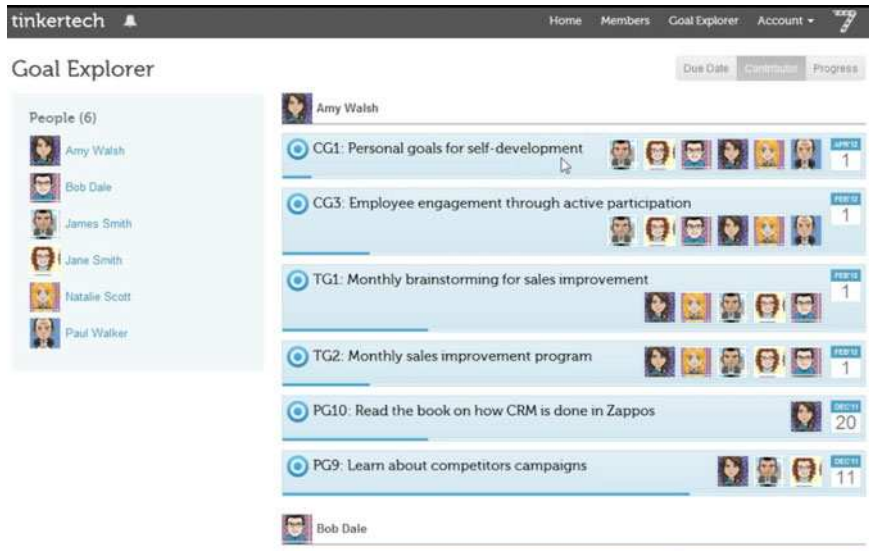


Fig. 2. Faceted browsing of social goals in the 7Geese application, using its Goal Explorer feature; the figure shows exploration using the Contributors facet.

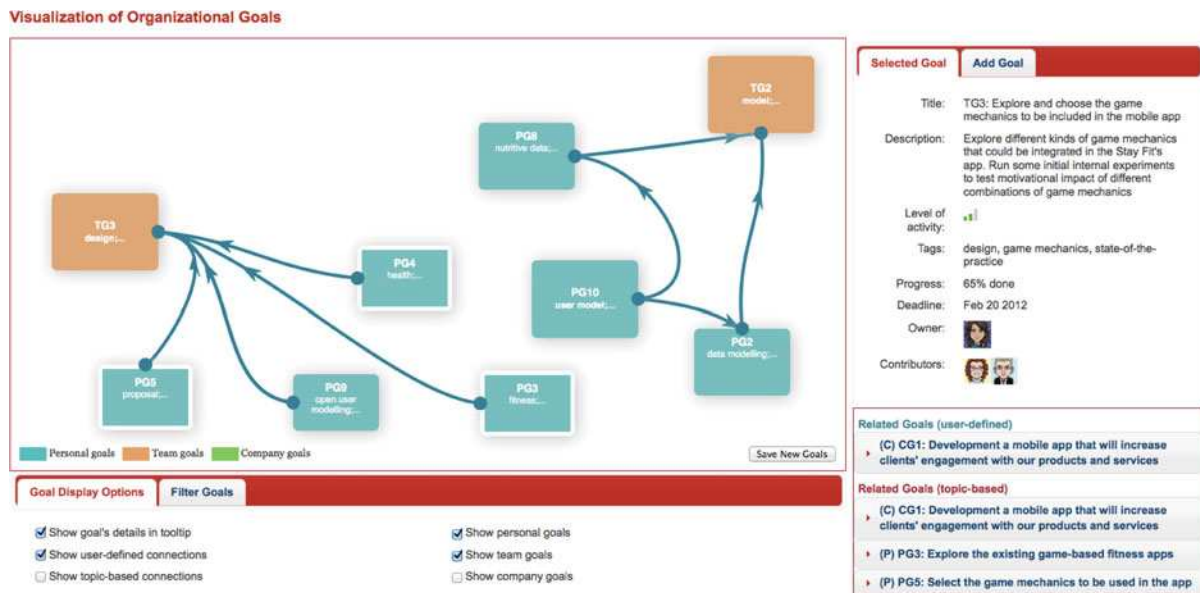


Fig. 3. Screenshot of the GVis prototype; goals are presented with rectangles (blue—personal goals, orange—team goals; the size of the rectangle reflects how “social” the goal is, i.e., the number of people directly/indirectly collaborating on its achievement); directed edges represent explicitly defined relations; information box on the right-hand side presents the details of the selected goal.

All participants were regular users of Web-based social software tools: 31 (79.5%) were using such tools on a daily basis, whereas the rest (8; 20.5%) used them a few times per week. Only three (7.7%) had some experience in using social goal/work management tools. None had experience in using the 7Geese platform.

Thirty-five (89.7%) participants had experience in using visualization tools (e.g., charts, graphs, dashboards) as a support for data/information comprehension and/or decision-making. Only two (5.1%) participants were familiar with the notion of social goals and goal-centric collaboration; 23 (59.9%) were somewhat familiar, whereas the others (14; 35.9%) were not familiar.

C. Questionnaires

Three kinds of questionnaire were used and are available online: <http://goo.gl/pBAXJX>.

The prestudy questionnaire gathered demographic data about the participants: professional position (PreQ1); educational level (PreQ2); experience with social software tools (PreQ3), Enterprise 2.0 applications (PreQ4, PreQ5) and the 7Geese platform (PreQ6, PreQ7); experience with visualization tools (PreQ8, PreQ9), and familiarity with the notion of social goals and collaboration around goals (PreQ10).

The second questionnaire comprised a sample scenario with associated goal comprehension tasks/questions and instructions

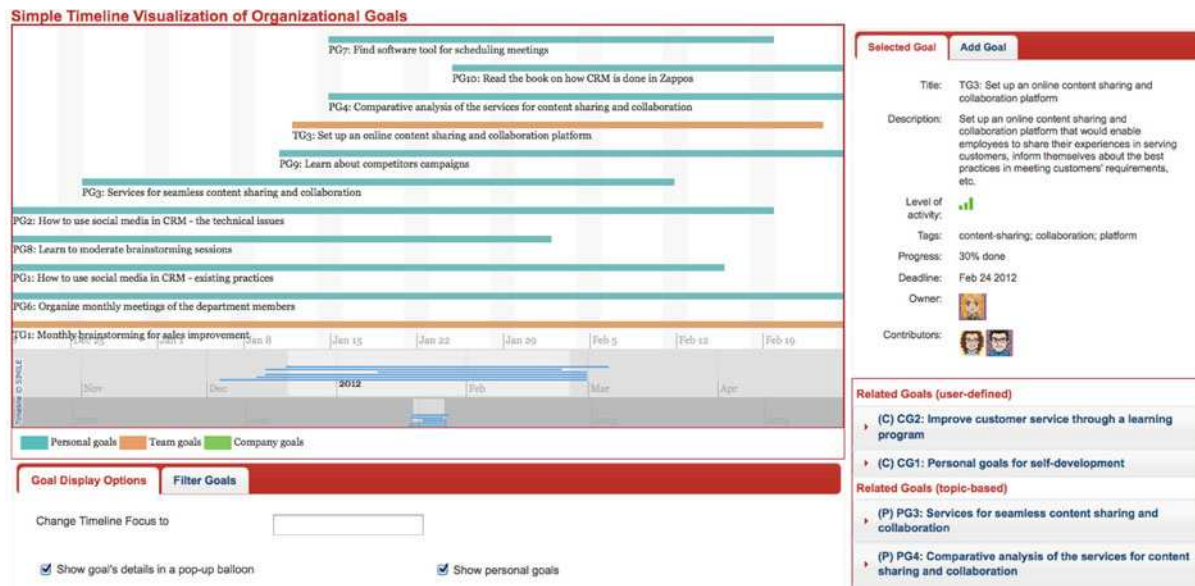


Fig. 4. Screenshot of the TVis prototype; goals are presented with colored stripes on the timeline (blue—personal goals, orange—team goals); each stripe spans from the date the goal was “initiated” to the (expected) date of the goal’s accomplishment; information box on the right-hand side presents the details of the selected goal.

TABLE I
FREQUENCIES AND PERCENTAGES FOR THE ACCURACY IN PERFORMING THE COMPREHENSION TASKS (TQ1–TQ8)

Task	Comprehension tasks (as stated in the study questionnaire)	The number (percentages) of participants who correctly completed study tasks TQ1–TQ8		
		GVis	TVis	FGB
TQ1	Name the colleague who has the highest number of personal goals	9 (69.2%)	13 (100%)	10 (76.9%)
TQ2	Who is the creator of the most social personal goal, i.e., personal goal with the highest number of contributors?	12 (92.3%)	13 (100%)	11 (84.6%)
TQ3	Which topics (keywords) are associated with the Betty’s goal to <i>explore the motivational power of open user modeling</i> ?	11 (84.6%)	12 (92.3%)	6 (46.2%)
TQ4	Identify goals (of all types) that are related to the topic “exercises.” If such goals exist, write their identifiers (e.g., PG1, TG2) in the answer line; if there are no such goals, put simply “none.”	10 (76.9%)	12 (92.3%)	11 (84.6%)
TQ5	Among your personal goals, which one is the most urgent (has the closest deadline)? Write the goal’s identifier in the answer line.	12 (92.3%)	12 (92.3%)	11 (84.6%)
TQ6	Which personal goals are due in the next 12 days? If there are such goals, write their identifiers in the answer line below; if there are no such goals, put simply “none.”	12 (92.3%)	12 (92.3%)	11 (84.6%)
TQ7	Which personal goal has the highest number of topic-based connections with team goals (i.e., connections based on the shared topic(s))? Write down the goal’s identifier.	9 (69.2%)	11 (84.6%)	0 (0%)
TQ8	Which team goal has the lowest number of associated personal goals? Only user-defined connections are considered. Write the goal’s identifier in the answer line.	12 (92.3%)	13 (100%)	7 (53.8%)

for performing the tasks. These tasks (see Table I) were aimed at validating our hypotheses about the effect of visualizations on goals comprehension (H1.1–H1.6; Fig. 1). There were two kinds of comprehension tasks: tasks focused on the comprehension of individual goals (tasks TQ1–TQ6) and those focused on the goals’ relatedness and structure (tasks TQ7, TQ8). The tasks of the former type were related to the characteristics of individual goals, such as the topic/subject of a goal, the deadline proximity, and the level of goal’s social aspect (i.e., how many users are involved in the accomplishment of the goal). The latter kind of tasks was about the goal’s relatedness to other goals, including relatedness to goals of the same type/level, as well as those of different type/level.

The poststudy questionnaire consisted of questions aimed at assessing the perceived support for social learning offered by the goal presentation (PostQ2.1–PostQ2.3, PostQ3.1). Thus, this questionnaire was aimed at helping validate hypotheses related to the effect of visualizations on social learning (H2.1–H2.2; Fig. 1). A 5-point Likert scale (ranging from “1–strongly disagree” to “5–strongly agree”) was used.

D. Variables

We have one independent variable (presentation of goals) with three levels: FGB, TVis, and GVis.

The five dependent variables were measured in the following way:

- 1) Overall comprehension accuracy (i.e., overall effectiveness), *OverallCompAccuracy*: solutions to the comprehension tasks (TQ1–TQ8) were scored on a 2-point scale: 1—incorrect, 2—correct; a sum of scores on the comprehension tasks was used to measure one’s overall performance on these tasks, i.e., overall comprehension accuracy.
- 2) Accuracy in comprehending implicit relationships among goals, *ImplRelCompAcc*: based on the participants’ scores on tasks TQ4 and TQ7 that required identification of topically related goals; it is assigned value 2 (correct) if answers to both tasks were correct, and 1 (incorrect) otherwise.
- 3) Accuracy in comprehending explicit relationships among goals, *ExplRelCompAcc*: it is based on the participants’ scores on task TQ8 that required identification of goals explicitly set as related by their creators; the value of the variable is equal to the participant’s TQ8 score (1—incorrect or 2—correct).
- 4) Overall comprehension time (i.e., overall efficiency), *OverallCompTime*: the amount of time (in seconds) required for getting insight into the goals described in the task scenario and solving/answering the associated set of tasks/questions.
- 5) Perceived support for social learning, *PerceivedSocLearning*: the participant’s perception of the support that the assigned presentation of goals offered for social learning; it was computed by aggregating (i.e., averaging) the participant’s answers to the poststudy Likert-like question items targeting the support for different aspects of social learning.

E. Procedure

The study was conducted using the Skype communication tool. The participants provided consent for the study. A separate study session, lasting approximately an hour, was organized with each participant. The researcher responsible for conducting the study and a participant were on the call throughout the study session. The researcher used Skype’s screen sharing feature to observe and record the participant’s work on the study tasks. The assignment of participants to the different types of presentation of goals was random.

Each study session consisted of two parts: training and main study. Right before a study session would begin, the researcher would send to a participant, via email, links to the materials required for training.

The participant was asked to complete the prestudy questionnaire and then complete the training. The objective of the training was to introduce the presentation of goals to be used in the study and the tasks. A video demonstrated the presentation of goals; it provided some basics about the presentation of goals and how it should be used.

The participant could ask questions after watching the training video. Then, the participant completed the training tasks by using the given presentation of goals. The participant was encouraged to ask any question that he/she might have had while working on the training tasks. After the training tasks were completed, the main part of the study would begin. The scenario and

the goal structure in the main part of the study were different than in the training part.

Right before the beginning of the main part, the researcher would email the participant links to the required materials. The participant was asked to complete a set of study tasks using the given presentation of goals. While observing, the researcher recorded the time when the participant started and finished working on the comprehension tasks. After completing the study tasks, the participants would fill in the poststudy questionnaire.

F. Data Analysis

We analyzed the collected data using standard descriptive statistics (mean and standard deviation). To analyze the effect of different presentations of goals on the participants’ overall comprehension effectiveness (*OverallCompAccuracy*) and efficiency (*OverallCompTime*) and the perceived support for social learning (*PerceivedSocLearning*), one-way between-subjects ANOVA was employed. We verified that the ANOVA assumptions were satisfied, including the Levene’s test and variance ratio to examine the homogeneity of variance. For variables that were not normally distributed, we applied parametric tests over transformed data: log-transformed values of the *OverallCompAccuracy* variable, and squared values of the *PerceivedSocLearning* variable. If the assumption of homogeneity of variances was not satisfied (as was the case with the *OverallCompTime* variable), instead of reporting and interpreting results based on “regular” F ratio, we relied on Brown-Forsythe and Welch versions of the F-ratio [17]. When an ANOVA test demonstrated a significant effect of the examined presentations of goals, and homogeneity of variances could be confirmed, we used Tukey posthoc tests for the pairwise comparison of the presentations’ effect.

For the variables reflecting the participants’ effectiveness in comprehending implicit and explicit relationships among social goals (*ImplRelCompAcc* and *ExplRelCompAcc*, respectively), we used Fisher’s Exact test.

All our statistical tests were performed in R.

V. RESULTS

Results were considered significant at $\alpha = 0.05$.

A. Facilitating Comprehension of Goals Through Goals Visualization

This section presents the study results related to RQ1 and the research hypotheses H1.1–H1.6. Table I shows the comprehension tasks and provides frequencies and percentages for the participants’ accuracy in performing each task (TQ1–TQ8). It could be observed that all the percentages for timeline-based visualization are above 80%, which is not the case with the other two presentations of goals.

To explore the effect of the presentation of goals on the participants’ overall accuracy on the comprehension tasks (H1.1 and H1.4), we performed a one-way between-subjects ANOVA test over log-transformed values of the *OverallCompAccuracy* variable (the variable was not normally distributed). Mean and standard deviation values for this variable are given in Table II. The ANOVA test showed a significant difference among the

TABLE II
RESULTS FOR THE THREE EXAMINED KINDS OF PRESENTATION OF SOCIAL GOALS

Dependent variables	Mean and standard deviation		
	GVis	TVis	FGB
<i>OverallCompAccuracy</i>	14.69 (1.18)	15.54 (0.66)	13.15 (1.46)
<i>OverallCompTime</i>	833.15 (193.32)	735.15 (240.07)	890.62 (382.45)
<i>PerceivedSocLearning</i>	4.27 (0.65)	3.88 (0.61)	3.40 (0.96)

presentations of goals, $F(2, 36) = 13.576, p < 0.0001, \eta^2 = 0.430$. The Tukey HSD posthoc test revealed a significant difference between each kind of visualization and FGB (see Table III); in particular, the groups that used visualizations (GVis or TVis) performed significantly better than the group who used FGB.

To test the hypotheses related to the effect of visualizations on the accuracy of comprehending relationships among social goals (H1.3 and H1.5), Fisher’s Exact test was performed on variables *ImplRelCompAcc* (for implicit relations) and *ExplRelCompAcc* (for explicit, user-defined, relations).

Regarding the comprehension of implicit, namely topic-based relations, the tests revealed that both kinds of visualizations performed significantly better than FGB (see Table III). As for the comprehension of user-defined relations among goals, significant difference was observed only between TVis and FGB (see Table III), i.e., the accuracy achieved using TVis was significantly better than when FGB was used. Note that we applied both sequential Bonferroni and the False Discovery Rate (FDR) correction methods [8] to all pairwise comparisons of goal presentations to prevent the rise of Type I error rate (alpha inflation) associated with multiple testing.

To test our hypotheses related to the effect of visualizations on the time required for performing the goal comprehension tasks (H1.2 and H1.6), we examined the *OverallCompTime* variable across the three studied presentations of goals. Table II suggests a difference among mean values of the three goal presentations, but also high SD, especially for FGB. Due to the difference in the variance of the *OverallCompTime* variable across the three groups, we relied on Welch’s and Brown-Forsythe’s corrections of the one-way between subjects ANOVA test. The test did not reveal significant difference among the presentations.

B. Supporting Social Learning Through Goals Visualization

This section addresses RQ2, visualization of social goals perceived as a facilitator of social learning, and research hypotheses H2.1 and H2.2.

Table IV presents the results of the poststudy questionnaire. As the table indicates, the support for social learning was generally well recognized by the study participants. One can also observe that for all the questions, GVis had the best scores, followed by TVis, whereas the perceived support for social learning provided by FGB was consistently the weakest.

We aggregated responses to these questions to determine the *PerceivedSocLearning* variable (see Table II) that we used to

test H2.1 and H2.2. Using transformed (squared) values of the *PerceivedSocLearning* variable, an ANOVA test showed a significant difference among the presentations of goals, $F(2, 36) = 4.021, p = 0.027, \eta^2 = 0.183$. The Tukey HSD posthoc test indicated a significant difference between the group of participants who used GVis and those who worked with FGB ($p = 0.02$). However, no significant difference was observed between TVis and FGB.

VI. DISCUSSION

A. Effect of Visualizations on the Comprehension of Social Goals

RQ1 explored the potential effect of goal visualization on the efficiency and effectiveness of goal comprehension. The study results demonstrated that when visualizations are used, the effectiveness (i.e., accuracy) of the overall goal comprehension is significantly higher than when no goal visualization is available, thus confirming H1.1.

Since a significant difference in comprehension accuracy was observed between each of the two visualizations (GVis or TVis) and FGB, we were not able to confirm our hypothesis that the *type* of goal visualization significantly affects the effectiveness of the overall goal comprehension (H1.4). Still, the results affirm that goal visualization in general significantly affects the effectiveness of the overall goal comprehension.

This advantage associated with the use of visualizations is also present when one needs to focus on and comprehend either explicit or implicit connections among social goals, as correctly hypothesized in H1.3. In particular, both kinds of tested visualizations (GVis and TVis) proved effective in facilitating comprehension of implicit, topic-based connections among social goals. However, only TVis proved as having significant effect on the comprehension of explicit, user-defined connections among goals. Based on these results, we can neither confirm nor reject the H1.5 hypothesis. When one needs to focus specifically on the comprehension of connections among different kinds of goals, certain types of visualizations might be more effective than others, but this requires further validation.

Based on the study results, we were not able to confirm our hypotheses related to the impact of goal visualization on the efficiency of goal comprehension (H1.2 and H1.6). However, the effect might be achieved by using other types of visualizations; this requires further investigation.

B. Effect of Visualizations on Social Learning in an Organization

The study results related to our second research question (RQ2) revealed that the support for social learning offered by the examined presentations of goals was generally well recognized by the study participants. On all the poststudy question items assessing the perceived support for social learning (see Table IV), GVis was consistently the best, followed by TVis, whereas FGB received the lowest ratings. The study results also demonstrated that GVis was perceived as significantly better than FGB in facilitating vicarious learning.

TABLE III
SIGNIFICANCE LEVELS FOR COMPREHENSION ACCURACY VARIABLES, AND THE CORRESPONDING ADJUSTED ALPHA VALUES; ROWS ARE SORTED BASED ON THE P-VALUE, AS THE TWO CORRECTION METHODS REQUIRE

Pair-wise comparison of goal presentations for the given dependent variable	p-value	adjusted alpha (Seq. Bonferroni)	adjusted alpha (FDR)
<i>OverallCompAccuracy</i> : TVis versus FGB	< 0.001*	0.008	0.008
<i>ImplRelCompAcc</i> : TVis versus FGB	< 0.001*	0.01	0.017
<i>OverallCompAccuracy</i> : GVis versus FGB	0.005*	0.012	0.025
<i>ImplRelCompAcc</i> : GVis versus FGB	0.015*	0.017	0.033
<i>ExplRelCompAcc</i> : TVis versus FGB	0.015*	0.025	0.042
<i>ExplRelCompAcc</i> : GVis versus FGB	0.07	0.05	0.05

Legend: GVis—Graph-based visualization; TVis—Timeline-based visualization; FGB—Faceted Goal Browser; star (*) indicates the compliance of the significance level (i.e., p-value) with the adjusted alpha level

TABLE IV
DESCRIPTIVE STATISTICS FOR THE POSTSTUDY QUESTIONS RELATED TO THE PERCEIVED SUPPORT FOR SOCIAL LEARNING

Variable	Question statement	Mean; Standard Deviation; Number of cases		
		GVis	TVis	FGB
PostQ2.1	Being able to see and comprehend the goals defined by my organization and my team, I was better able to create my own personal goals	4.38; 0.77; 13	4.00; 0.58; 13	3.62; 0.96; 13
PostQ2.2	Being able to see and comprehend the goals defined by my organization and my team, I was better able to align my personal goals with the organization's and team's goals	4.38; 0.96; 13	4.15; 0.90; 13	3.54; 1.13; 13
PostQ2.3	Being able to see how my colleagues related their personal goals to organization's and team's goals, I was better able to align my personal goals with organization's and team's goals	4.23; 0.83; 13	3.69; 1.11; 13	3.23; 1.01; 13
PostQ3.1	Being able to see the goals defined by my colleagues helped me define my own goals	4.08; 0.76; 13	3.69; 0.75; 13	3.23; 1.09; 13

Legend: GVis—Graph-based visualization; TVis—Timeline-based visualization; FGB—Faceted Goal Browser

We can conclude that hypothesis H2.1—the availability of social goal visualization is perceived as a facilitator of social learning in an organization—could be considered valid. The second hypothesis (H2.2), that the perceived support for social learning is significantly affected by the type of social goal visualization, can also be accepted as valid, as based on the available data, only GVis was perceived as significantly better in supporting social learning compared with FGB. This might be attributed to the fact that GVis allows one to examine different kinds of relationships among social goals, and thus offer an overall insight into the goal structure.

Considering that the study was not conducted in a real-world setting, the participants were not in a position to really experience social learning. On the other hand, as social learning in organizations is affected by various organizational factors, including organizational cultural norms and practices, and attitudes toward social learning [13], [11], the fact that the study was realized out of real workplace settings allowed for the control (i.e., exclusion) of these factors, and the focus on the visualizations and their effect.

C. Effect of Demographic Factors on the Study Results

The target population assumed by our research model generally consists of knowledge workers who are computer literate and regularly use computers and the Web for their work. However, this is a broad category of users, and there might be some differences among subcategories based on different demographic criteria such as professional position, familiarity with the notion of social goals, and goal-centered collaboration. To

get an insight into their potential effect on the obtained significant results, we performed exploratory data analyses. Neither the participants' professional position [see Fig. 5(a)], nor their familiarity with the notion of social goals [see Fig. 5(b)] had major influence on the impact of visualization on the overall comprehension accuracy (*OverallCompAccuracy*). However, we did observe a potential effect of the participants' professional position [see Fig. 6(a)] and familiarity with the notion of social goals [see Fig. 6(b)] on the perceived support for social learning (*PerceivedSocLearning*) offered by different presentations of social goals. Specifically, for those participants who held senior R&D positions, there was a notable difference between the two visualizations and FGB [see Fig. 6(a)]. In addition, a notable difference in the perceived support for social learning offered by GVis and FGB was observed among those participants who were at least somewhat familiar with the notion of social goals [see Fig. 6(b)].

Since there were only eight, out of 39, participants whose professional position was categorized as Senior R&D, it was not possible to more thoroughly examine the potential confounding effect of this demographic feature. Aiming to assess the impact of the other potentially confounding demographic feature—familiarity with the notion of social goals and goal-based collaboration—we removed from the sample eight participants with the Senior R&D professional position. However, factorial ANOVA with the perceived support for social learning as the dependent variable, and presentation of goals and familiarity with social goals as factors revealed neither significant main effects of the two factors, nor significance of their interaction. This suggests that those eight excluded participants

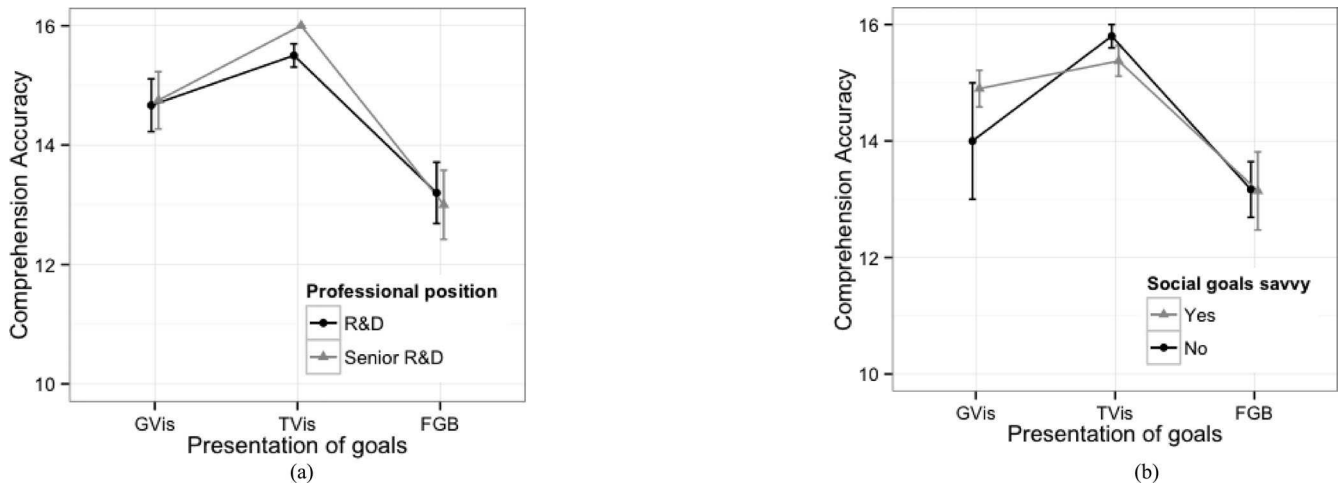


Fig. 5. Means and error graphs of the comprehension accuracy for different kinds of presentations of social goals, and the participants': (a) professional position; (b) familiarity with the notion of social goals.

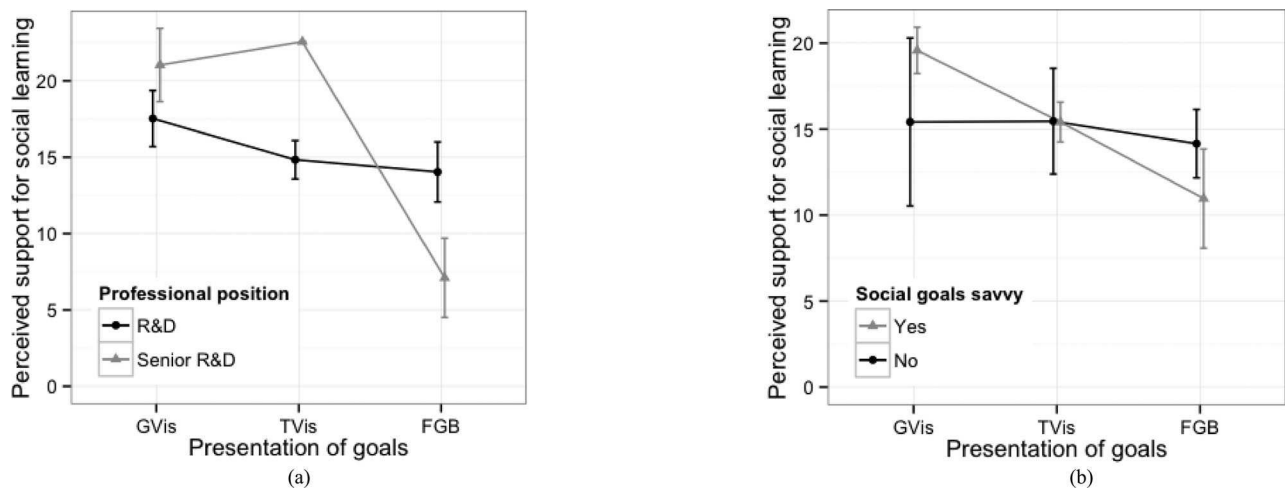


Fig. 6. Means and error graphs of the perceived social learning for different kinds of presentations of social goals, and the participants': (a) professional position; (b) familiarity with the notion of social goals.

made a difference. However, it might not be the case that it was just their professional position (Senior R&D) that had influence, since those participants claimed their familiarity with the concept of social goals, and were also experienced in using visualization tools for information comprehension and decision-making. Hence, the observed lack of significant results after excluding eight senior R&D participants might be a result of some interplay between professional position, familiarity with social goals, and experience in using visualization tools. However, this is an assumption that needs to be further examined with more data, i.e., in a larger study.

D. Limitations

First, the study was not conducted in a real-world organizational setting, but was based on scenarios of real world situations. Therefore, it could have been difficult for the participants to "immerse" in the realm of the imagined organization, its needs and goals. Accordingly, the obtained results should

be further validated in a field study that would be conducted in organizational settings.

Another threat to validity may be related to the usability aspects of the examined presentations. The two visualizations were at the level of research prototypes and not integrated into a social performance/goal management platform. On the other hand, FGB was a part of such a platform, though as its novel feature. Since the visualization prototypes were designed for research purposes, they might have been less comfortable to work with than commercial tools. Similar conclusion applies to FGB as at the time of the study it was still insufficiently tested with end users.

Finally, the three studied presentations of goals were evaluated with a set of 15 goals, which is a realistic number of goals in the case of small companies/organizations, but is rather small in the context of large organizations. To approach the challenge of visualizing large goal networks, we intend to follow one or a combination of the following strategies in our future work: 1) multiple interconnected visualizations (multiple views) where

a change in one visualization is reflected on other related ones; 2) focus & context paradigm that allows for a topic exploration starting from a more general/abstract view and then zooming in to focus and zooming out to see the context. A combined use of these strategies could enable a simultaneous insight into different kinds of goals as well as seamless change of focus between goals of different types.

VII. CONCLUSION

This paper presents our research work aimed at supporting management of social goals in an organization. In particular, the presented work examined the role of different goal presentations as affordances of goals comprehension, and facilitators of social learning in an organization. We examined and compared three kinds of presentation of social goals: faceted goal browsing, graph-based visualization, and timeline-based visualization.

The study results confirmed our assumption that a visualization of social goals can improve the overall effectiveness (i.e., accuracy) of goal comprehension. This positive effect is also present when one needs to understand how goals are mutually connected, either via explicit, user-defined ties, or via implicit, topic-based connections. In addition, the study results provided support for our assumption that a visualization of social goals, particularly graph-based visualization, could serve as a facilitator of social learning in an organization. This role of goals visualization could be particularly strong in organizations that have adopted or are in the process of adopting the social goals metaphor into their organizational culture. This further indicates that with the use of goals visualization, especially graph-based visualization, organizations can bootstrap learning about and adoption of social goals.

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