GoCo: A Gamified Activity for Winnowing Visualization Projects with Interdisciplinary Experts

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Abstract

Interdisciplinary collaboration in an academic context is challenging, particularly when the basis of collaboration is data. Even with datasets that overlap in their spatiotemporal dimensions, underlying disciplinary assumptions may not allow it to be meaningfully synthesized without thorough alignment among its experts. We encountered this issue while tasked to develop a visualization that combined data from different disciplines. The breadth of possibilities within these interdisciplinary settings meant that winnowing was needed to align all experts before further process could be made. We therefore designed and deployed a winnowing technique specifically apt for multi-disciplinary settings. Our design, GoCo, a hybrid system consisting of a tangible and digital counterparts, uses abstract concepts, playfulness, gamification and network visualizations, to uncover promising research directions. Through findings from its deployment, we believe this work informs early stage visualization activity practices on aspects of gamification, tangible tokens and hybrid documentation[1].

Index Terms: Human-centered computing—Visualization—Visualization systems and tools

1 Introduction

Interdisciplinary collaboration provides opportunities to uncover new realms of knowledge and create radically new problem conceptualizations [10]. Achieving such collaboration however is challenging as new, holistic understandings need time commitment, good infrastructure and motivation by all participating experts [8]. Interdisciplinary *scientific* collaboration additionally requires empirical data to be synthesized before generating common insights. Data from different disciplines however, cannot be directly combined, since they may originate from incompatible conceptual grounding, conflicting methods or contain rivaling assumptions [1,5,20]. Consequently, while visualization can be a valuable means through which to generate new data insights in interdisciplinary settings, the meaningful synthesis and representation of interdisciplinary data may require significant alignment and winnowing before reaching the stage of visualization design.

Winnowing [18], describes the pruning or scoping [16] process that identifies promising research directions among visualization researchers and domain experts. Design thinking techniques such as ideation workshops [6, 13] and other participatory activities are commonly deployed for early stage project scoping as they help stakeholders align on crucial aspects of the collaboration. Data visualization projects are no exception, as early-on meetings among domain experts and visualization researchers are additionally needed to assess data availability, domain problems, tasks and expectations. Creative visualization opportunity (CVO) workshops [9], i.e. creative and intensive visualization-oriented sessions among experts and visualization researchers, are successfully used for winnowing in such cases. They have demonstrated that collective and focused thinking, clarifies expectations while simultaneously overcoming organizational constraints [9]. Inspired by such collaborative sessions, we set up to create a structured participatory activity specifically for interdisciplinary winnowing; i.e. where alignment between multiple domains as well as visualization researchers is required.

Figure 1: GoCo is a hybrid game for interdisciplinary winnowing in visualization projects. It uses physical tokens and a digital application to track conceptual connections among experts.

We encountered the need for interdisciplinary winnowing while embedded within a multi-domain setting, the Sagalassos Archaeological Research Project. The scientists, originating from archaeology, ecology and human geography were studying the same geographical region in south-west Turkey, albeit from different perspectives under the broad conceptual umbrella of '*manifestations of socio-ecological change in the region*'. The experts' data, varying from historical pollen samples and excavated artifacts to modern resident interviews, only occasionally overlapped in their dimensions; leaving much to be discussed before arriving into synthesized understandings. As visualization researchers embedded in this project, we planned to design a collaborative visualization to support joint analysis. Nevertheless, the still quite conceptual stage of our collaborators was especially challenging since while they did indeed have datasets, the potential directions in which they could be combined and used were too open to kick-off any visualization task analysis.

We thus created the **G**ame **o**f **Co**nnections (GoCo), a hybrid - digital and physical- technique for supporting winnowing during the early stages of interdisciplinary visualization research projects (see Figure 1). In the form of a game, GoCo progressively incentivizes participants to connect discipline-specific concepts. These connections are captured as links of a semantic network that can be visualized and reflected upon by participants and visualization researchers together. We describe GoCo as well as its deployment with the above mentioned disciplinary groups. Our deployment surfaced some usability and practical issues in our design, yet the overall goal of alignment was achieved. Our main contribution is

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1Supplementary material to this work, including higher resolution images can be found at `https://osf.io/gsqb8/`

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a rich description of the GoCo activity, which can be adapted by other visualization researchers who need support early stages of data collaboration among experts from multiple disciplines. We believe this work informs visualization activity practices on aspects of gamification, tangible tokens and hybrid documentation.

2 Activity Requirements and Design Rationale

Our core requirement with this interdisciplinary winnowing activity was to help map and decide among potential future directions of collaboration. Early on in our interactions with the research group we had collected a series of concept maps from each discipline representing how they defined *Change* (the project conceptual umbrella). We therefore used these concepts as units on which to map and explore future collaborations. These concepts, 45 in total, included terms such as *Society*, *Biodiversity*, *Continuity* and *Forest Cover*[2] and in essence, represented the diverging theoretical views by which the study region could be analyzed (this process has been further documented in previous work [14]).

We wanted to have wide and balanced representation of the disciplines as wider participant diversity also brings additional creative brain power for coming up with innovative solutions [13]. In crowed workshops however, it can be challenging for all individuals to be heard without enforcing time boundaries. To achieve such balance we decided to adopt a rule-based process in the form of a game that is shown to successfully coordinate collaborative processes [4, 7, 19]. Moreover, we chose competitive scoring as the game's necessary incentive mechanism to drive the process and maintain motivation [17].

At the same time, there was a need to promote creative, generative thinking yet in a familiar way to our participants. Research has shown that creative environments successfully inspire exploration and conversation towards innovative directions [12, 13]. We noticed that in this group, creative exchange and communication was often happening through narration-based techniques. For example it was commonplace for an expert to narrate aspects of daily life in an Imperial Roman village to argue about roman wood consumption. We therefore opted for storytelling as the core means for creative enactment. Additionally, to counter-balance the abstract, ambiguous nature of using concepts during a narration, we used physical artifacts. Physical artifacts support collaborative sessions by grounding discussions, promoting tangible thinking [11] and by externalizing co-constructed ideas [11, 15].

Finally, given the high expertise of this interdisciplinary group it would be hard to evaluate any future directions without further feedback and reflection from all its members. Accordingly, we wanted to easily capture and quickly disseminate the activity outcomes for further validation and reflection. That meant that efficient analysis methods were necessary especially since analyzing workshops such as these is a tedious work that can span many days after the activity it self [9]. Consequently, we decided to design the activity so that its progress is captured in a structured, digital and ultimately machine-readable way.

3 GoCo: A Game of Connections

GoCo is based on the premise that concepts can be read and interpreted quite openly by participants - regardless of discipline - but can still be quantified, analyzed and represented through a digital visualization. A link between two concepts suggests they are theoretically related and therefore that relation can be further explored through empirical research. Moreover, a full network of concepts can be analyzed through its centrality and density measures to additionally highlight obvious or strong future research directions.

Based on this premise, through GoCo participants create original yet scientifically valid connections between concepts, collectively identify clusters with most potential and ultimately narrow a broad space of possibilities. Besides the concepts, the activity consists of the following parts: (1) a competitive game that uses storytelling, (2) tangible tokens representing the concepts, (3) a digital application to capture the created connections and signal points, and (4) a post-game discussion.

[2]For clarity, concepts are formatted in *italic* throughout the text.

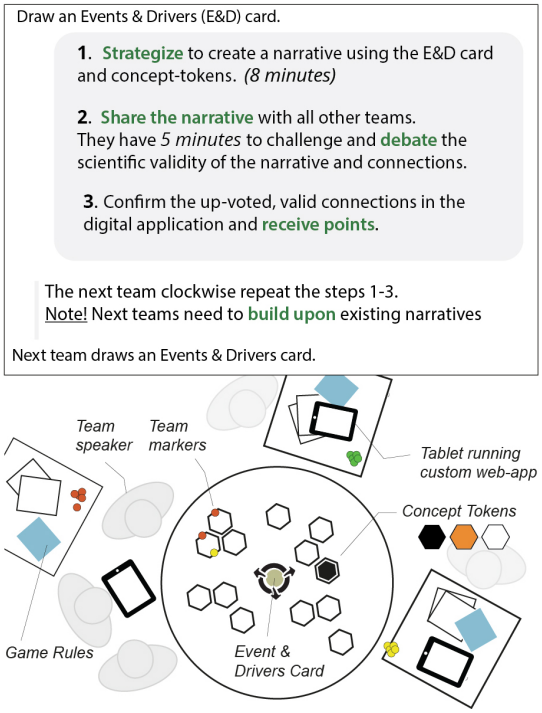

Figure 2: Top: The actions taken during a game round. Bottom: The basic setup of GoCo including the central circular table with the tokens and a satellite table for each disciplinary team.

3.1 Components

The game. GoCo is a team-based game where teams include multiple experts from a single discipline. Each team has a dedicated speaker who is responsible to synthesize and share the points of view of all other members.

During a round, teams progressively build connections among concepts by narrating plausible contextualized situations in which these are correlated. For example *Demographics* and *Drought* hold such a relation: an extensive *Drought* impacts crops and eventually the *Demographics* of a region. The game evolves in such a way that each team is obliged to continue on what the previous teams have already discussed, thus ensuring convergence of narratives. The game is competitive, with the winner scoring highest at the end of a dedicated amount of rounds.

Teams earn points whenever they create a valid connection between two concepts. Validity is established collaboratively within the whole group of players of all teams. Meaning that whenever a narrative is proposed, all others question and debate its underlying connections before they are considered confirmed. This gives other teams additional reasons, in term of points, to scientifically scrutinize any proposed narratives. To incentivise creative, out-of-the-box thinking as well as encourage specificity in the narratives, rarely repeated concepts score higher than frequently used ones, and concrete concepts score higher than abstract ones.

As such, for scoring purposes, the concepts are classified and color-coded, based on their relative abstraction on three scales. To exemplify, the broad concept *Social* can be combined much easier than that of *Community* or the directly measurable *Demographics*.

Since we wanted to reward specificity, these are valued accordingly as 2, 4 and 5 points and color-coded as black-white-orange. To reward originality, all subsequent reuses of concepts in narrations decrease their original value exponentially.

The concepts. We built GoCo on the 45 concepts mentioned above describing socio-ecological change. From these, 29 could be connected at any point during the game and the remaining 16 were kept separately as Events & Drivers and were only used to initiate narratives. In practice, Events & Drivers (E&D) signified concepts that are used to drive *Change* or describe a state in a socio-ecological system and included terms such as *Earthquake*, *Ideological Change*, *Sudden Change* and *Stability*.

The Tangible Tokens. The tangible tokens act as the physical units that carry the concepts. The tokens are designed to be laid out, centrally on a table among all participants (see Figure 2) and are used during the game rounds to indicate and debate around shared connections. In their physical manifestation, the tokens are thin, hexagonal placeholders in which concepts could be inserted. The tokens are fabricated with MDF wood with a slot on the side. That slot accommodates color-coded paper print-outs of the concept-terms. Additionally, each team uses small color-coded team markers to signal the tokens used while sharing their narratives.

Digital Application. A custom digital application is used by each team to document their own confirmed connections. The application (see Figure 4b) replicates the tangible tokens virtually. The digital application runs on touch tablets handed to each team. To input a narrative connection between two concepts and create a tentative link, a participant simply selects them progressively from the interface. When creating any link, its score is directly visible (as the sum of the two node values). Teams can therefore use the digital application to strategize; namely generate tentative connections, track their score, and decide on their final narrative based on the point values. The tentative links are eventually deleted or confirmed depending on the group validation process. To maintain competition, each tablet runs a local instance of the application meaning that participants only access their own team's links and scores. Finally, at the end of a game, through a dedicated button the application synthesizes all the links made an edge table (csv file) which is ready to be analyzed.

Post-Game Discussion. Using the resulting csv files from all tablets, the separate graphs are merged and visualized as a single one using Gephi [3]. In our deployment, we performed quite rudimentary analysis including simple centrality measures and used Gephi mostly for its ability to generate fast and accessible visualizations. From the full network, we made three facets to probe further reflection and discussions among the experts. The first visualized all the valid connections made by all teams with node size representing usage, the second facet visualized a single team's connections and the third visualized the nodes with highest degree centrality and their links. These network visualizations were printed out and shared with the experts in a separate group session. We asked experts to annotate these prints with any insights, unexpected or promising concept clusters. Finally these insights and annotations we presented among all for discussion.

4 Playing GoCo

We deployed GoCo during a two-day project meeting including ten participants from Archaeology (1 Professor, 1 Post-Doc, 3 PhD), Human Geography (2 Professors, 1 PhD) and Ecology (2 Professors). During the first day, all ten participants played GoCo divided into the three disciplinary teams. The evening of the same day, the facilitators merged the resulting networks as described above, and then shared them the following morning with the professors of the group for annotation. Figure 4c shows a resulting annotated example from the Human Geography team.

4.1 Results

The game took 4 hours, with an additional hour break half-way. In total, the participants went through six rounds during which they created 76 unique connections (95 when including duplicates) among the 29 tokens. We present a simplified snapshot of round five to clarify later results (see also Figure 3). We chose this round as aspects of it (specifically the relations between land use and forestry) eventually found their way into the final directions for collaboration.

During round five, the starting team, Human Geographers (red), having drawn a *Stability* E&D card, discussed among themselves about adding links between *Tradition*, *Land use* and *Household*. They argued that in the region of study, communities have been changing their *Land Use* practices such as their chosen crops, to adapt to shrinking plots sizes. Shrinking plots could be a side-effect of *Traditions* related to inheritance and changing *Household* constellations. Adding their team markers on the corresponding tokens, they shared their narrative and suggested connections with the other teams. Team Archaeology (green) challenged some of the connections by asking further contextual questions regarding the current *Household* constellations and the empirical data that connects these to *Land Use*. Human Geographers contextualized their narrative by describing the interviews and land use surveys they had conducted with locals. After a short debate, the Archaeologists accepted the connections as valid. Consequently, team Human Geography confirmed these (together with another 4) on the digital application and received a total of 52 points. Next, team Ecology built upon the same narrative and described how the over-division of farmland comes in clash with grazing availability; an impact that would be directly visible in the surrounding *Forests Cover*. The other teams did not challenge the fact, and the Ecologists (yellow) connected *Forest cover* with *Household* and *Stability* receiving 17 points. Archaeologists in a similar manner added the final 2 connections of this round gaining 19 points.

4.1.1 Interdisciplinary Winnowing

Overall, Ecology made 26 connections scoring 204 points, Archaeology made 33 links scoring 254 and Human Geography made 36 connections scoring 285, making the latter the winning team. The most frequently used nodes were *Household* (11 times), *Politics & Governance*(10), *Forest Cover*(10), *Demographics*(10), *Traditions*(10). Still, decontextualised from the conversations that drove them, these values are not meaningful or actionable; and we found that the actual disciplinary alignment took place during the post-game discussions.

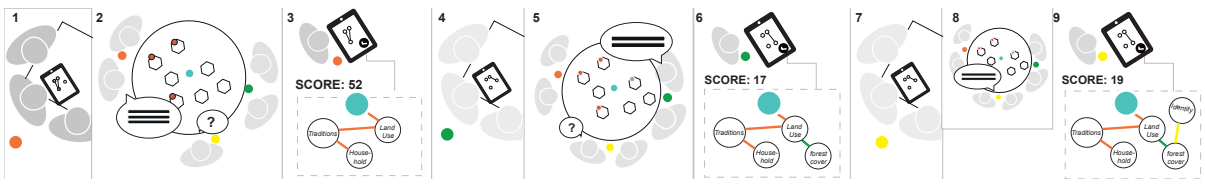

Figure 3: An illustrated game round: Each team first negotiates internally, then shares their narrative, debates it, makes points and contributes to the evolving network. Here, red represents Human Geography, green: Ecology, and yellow: Archaeology.

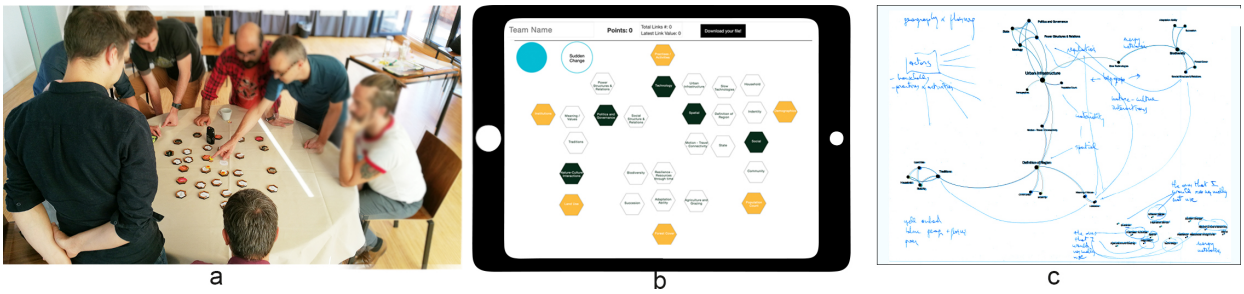

Figure 4: (a) Playing GoCo: a team is sharing their narrative and placing their team markers on the tokens. (b) The interface of the digital application. Participants tap on the virtual tokens to create links. (c) An annotated print-out of the networks of a single team (Human Geography).

The interdisciplinary group managed to identify future collaboration possibilities and thus winnow towards three common research agendas while discussing and annotating the network print-outs the following day. These research agendas were later titled as *Land Resources*, *Settlement Patterns* and *Rural Transformation*. While annotating, participants recognized and reflected on both their individual disciplinary contributions as well as the collective discussions in the graphs and even drew additional links of connections (see Figure 4c). We received positive feedback as participants mentioned that working with concrete examples helped ground discussions (HG1) but also 'educated' them relating topics they were less aware about. "*It was a good idea to work with triggers for which we had to think of very concrete examples. This really helped stepping away from the theoretical type of discussion.*" (E2).

Unexpectedly, using the captured networks in discussions also gave us the opportunity to witness attitudes towards visualization more broadly. When annotating the faceted network that only visualized the high-centrality concepts, a participant (HG2) was critical, describing this faceted view as partial, decontexualised and consequently even misleading. This need for contextualization eventually became a focus point for our later visualization prototypes.

4.1.2 Deployment Observations

Scoring. During the game teams were not using the tablets to explore alternative connections that would yield more points, even if they did announce their points overall along the way to the groups. On the contrary they focused on discovering new connections in a narrative, regardless of the token originality. We believe this was partially because our scoring incentive was too complicated or too implicit (i.e. only through the tablet) to engage with directly, and also because the narrative in itself acted as a stronger incentive.

Game. Regardless of the scoring, calling and enacting the activity as a competitive game seemed to engage the participants more actively than what we had witnessed in previous meetings. Previous meetings lasting more than two hours generally resulted in some disengagement yet during GoCo the participants pointed, touched, moved and debated around the central table in a lively manner.

Tangible tokens. While the narrations helped drive the game flow, the tangible tokens did not completely alleviate the cognitive load of associating multiple abstract concepts. Combining concepts on the spot was a cognitively challenging task, especially since the selection space was quite broad (29 concepts). This difficulty was best exemplified by the fact that participants were additionally keeping their own notes to recall information.

Data-capturing. The close mapping (in layout and color-coding) between the tangible and the virtual tokens seemed to adequately blend the digital and physical mappings. Participants adopted the two modalities fluidly with only minor inconsistencies relating to the human-driven and thus error-prone data capture. Specifically, comparing the resulting networks to video material of the deployment we noticed some missing graph edges. Still, when annotating the networks, participants did not notice the absence of these few edges among the rich graph of connections nor interpret them differently.

Time allocation. The time per round was quite high, even if not consistent, as we found we had miscalculated the allocated time for some of the tasks. We allocated those time-slots based on research of the benefits of rapid ideation (aiming for breadth versus depth) [6] and through mock test-runs. Our deployment showed however that eight minutes was often not enough time to deliberate in a team, create an original narrative and calculate the connection points.

Facilitation and participation. The rule-based system brought indeed greater balance between disciplines (in terms of speaking time) than in previous meetings. Nevertheless, the rounds were uneven time-wise, partially because of the learning curve, but also because we, as facilitators, encountered difficulties in maintaining the predefined time-slots of the tasks. Stopping or controlling a seemingly engaging and innovative professional conversation was a daunting task we did not always enforce. In our case, being embedded in this interdisciplinary group as well as facilitating the activity might have brought some of this reluctance as we perhaps judged the situation subjectively [2], and allowed ourselves to be flexible with the pre-defined structure.

5 Discussion and Conclusion

We developed GoCo with the primary goal to help scope an interdisciplinary visualization project. This was indeed achieved and eventually three directions emerged in which further data-driven discussions and visualization prototypes were generated. Yet perhaps contrary to our original hypotheses, it was the use of the resulting networks for reflection during the post-game discussion that brought this alignment rather than the game. Nevertheless, we believe it was the game, that established that common ground and infrastructure from which to drive that alignment. Future research can more systematically examine the impact of visualizing activities and using them to probe discussions.

Our deployment indicated that in highly situated settings such as ours, human data-capture techniques are sufficiently accurate to describe the process. Yet, additional mechanisms, perhaps even beyond tangible tokens, were needed to alleviate the cognitive load of working with concepts. While we chose to share the resulting networks only the following day, we can imagine that a hybrid set-up such as GoCo allows for graphs to be visualized real-time alongside the activity. Finally, while there was merit in using a game metaphor, our scoring incentive mechanism was less influential than the drive for creative narration in itself. Future research can consider simpler scoring mechanisms or then keep only the narrative as incentive transforming the game in to a collaborative one.

This paper presented GoCo, a hybrid technique for assisting winnowing during early stages of visualization collaboration. We discussed the design of this activity as well as the main findings from its deployment in an interdisciplinary project. We believe our findings inform future early stage visualization activities.

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