Investigating the emergence of strategy in VR based reflective tasks.

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Abstract

Virtual Reality (VR), as part of the wider Technology Enhanced Learning (TEL) space, presents novel opportunities for enhancing inquiry-based learning in education. VR provides an immersive 3D space for the reflective process of individuals to emerge unhindered in the form of spatial patterns. Abstract reflective tasks like mind mapping are central to inquiry-based learning and scaffolding strategies. Mind mapping has been proven to be an effective pedagogical tool by reducing cognitive load and allowing students to make associations between information objects that aids recall. This paper investigates the emergence of users' strategies towards constructing mind maps in VR through an exploratory user study (n=24). Our results show that users approach the task of mind mapping through two distinct strategies - *sequential* and *grouping*. We characterize and classify these previously unreported strategies both qualitatively and quantitatively. We discuss the implications of these strategies on the design of future VR mind mapping tools in both single user and collaborative contexts, and from an application designer and educators' perspective. Allowing these strategies to emerge unhindered, such as through shared and private workspaces and other recommendations, will ensure students remain active learners rather than being passive. We recommend that future implementations of VR mediated collaborative mind maps include design considerations that support both strategies.

1 Introduction

VR has the potential to significantly impact education and specifically students' engagement in the learning process (O'Connor and Domingo, 2017). This engagement is in part facilitated by VR being able to offer pseudo-physical interactions (Moehring and Froehlich, 2005) with objects and allowing users to interact with and manipulate objects within a 3D space. Advances in VR technology have made low-cost VR headsets more accessible. Low-cost VR devices such as the Oculus Go, open-sourced Google Cardboard and Meta Quest 2 are untethered and consequently more manageable in a traditional classroom environment. These devices have the potential to be a core element for delivery of teaching and learning by educational institutions. These devices can support TEL (Cox *et al.*, 2004) and flipped learning (Burden *et al.*, 2015) strategies, which allows students to learn core concepts outside of the classroom.

We chose the reflective task of mind mapping, specifically spider-diagrams, as a prime candidate for a topic agnostic VR-based application. The spatial information organization aspects of the mind map are suitable for VR-based interactive manipulation. Prior research shows that traditional 2D mind mapping supports effective learning (Abi-El-Mona and Adb-El-Khalick, 2008) leading to improved educational outcomes. The open question for VR-based mind mapping, given the additional spatial dimension available for use, is how the environment can better support the users engaged in reflective learning. By identifying and understanding individual behaviors associated with the information organization process, we can refine the role of VR in supporting this process. The individual behaviors, resulting from the users' information organization strategy, can better inform the design of applications about the affordances necessary in a collaborative environment.

Recognizing individual strategy is a key element to managing conflict, a prime criterion in collaborative spaces (Olaniran, 2008). CSCW (computer-supported co-operative work) research has shown that territoriality emerges during collaborative working in groups (Avery *et al.*, 2018). Additional research (Tang *et al.*, 2006) has identified the need to support users in their specific way of working during a collaborative activity. When collaborative mind mapping is carried out on tabletops, the collaborative exercise results in specific patterns of communication and strategies for managing conflict (Jamil *et al.*, 2017). These arise due to the need to control shared pieces of information (e.g., images, keywords, relationships) and their relative positions.

Our research question is thus twofold. Firstly, we wish to identify behaviors or strategies that emerge when participants construct a mind map through a VR mediated application. Secondly, if unique behaviors or strategies emerge, what are their implications when considering collaborative mind mapping in VR? We answer these questions by conducting an exploratory study to identify and quantify the presence of individual behaviors or strategies in a learning setting using VR-mediated mind mapping.

2 Background

The motivation for this paper is to understand how students' learning behaviors and strategies emerge in a VR-based mind mapping environment. As an emerging application space, there are very few VR mind mapping applications that support interactive reflection and information organization. Currently, we could only identify two commercial products (VR-AR-Corp, 2018; Coding Leap LLC, 2019). While these products can help with the qualitative aspects of the study, they do not support the instrumentation necessary for the quantitative aspects. We used an alternative proof-of-concept VR mind mapping tool called VERITAS (Sims, 2019) as it allows data collection of user interactions in real-time and via log files. The useability of this tool is validated in a previous study (Sims and Karnik, 2021) and our study aims to build on this previous work to contribute to the understanding of mind mapping in VR as a whole.

2.1 Technology-enhanced inquiry-based learning

Inquiry-based learning, a form of active learning (Pedaste *et al.*, 2015), is a pedagogical approach that can be applied across domains and topics. Inquiry-based learning aims to trigger the advanced cognitive processes of application and analysis. Inquiry-based learning is key to stimulating students' desire to learn (Kirschner, Sweller and Clark, 2006) through interest (Wade *et al.*, 1993) or active engagement in a cognitive activity (Schraw and Lehman, 2014) such as mind mapping due to situational interest (Linnenbrink-Garcia *et al.*, 2010). Scaffolding is one of the key strategies of effective inquiry based learning (Sandoval and Reiser, 2004). Scaffolded inquiry-based learning allows learners to discover information semi-independently of the teacher and/or classroom.

2.2 Mind mapping in pedagogy

Recalling and managing disparate elements of information are recognized as learning tasks with a high cognitive load (Tergan, 2005). Mind maps can alleviate this cognitive load by allowing the learner to interact with a graphical representation of ideas and their relationships (Davies, 2011). The learners can engage in reflective tasks that otherwise might be too complex for them to manage given their current abilities. Specifically, learners can offset difficulties commonly ascribed to natural limitations of working memory and its capacity (Ying *et al.*, 2014). It also develops students intrinsic motivation by enabling them to understand complex topics and relationships, improving their sense of competency (Mento, Martinelli and Jones, 1999). Mind mapping is well established as an effective pedagogical tool (Ying *et al.*, 2014). Mind maps are implemented as an abstraction of the knowledge from the environment where it is applied. Cognitively, mind maps are closer to how the human mind organizes the information than how the information is applied. A study by Abi-El-Mona and Adb-El-Khalick (2008) found significantly higher conceptual understanding in students who utilized mind maps to explore scientific topics. In addition, research has shown that students engaged in mind mapping tasks are active participants with the teachers being facilitators (Buran and Filyukov, 2015), which aligns well with the aforementioned inquiry-based learning paradigm.

2.3 VR-based mind mapping

VR-based educational applications are not new. They are commonly used to simulate real-world tasks, like clinical protocols (Ruthenbeck and Reynolds, 2015), using specialized environments. In engineering, research has demonstrated how Building Information Modelling and evacuation planning can be facilitated by VR ((Hilfert and König, 2016)) and VR applications like Construct3D (Kaufmann H. Schmalstieg D. Wagner M., 2000) allow students to experiment with their own ideas. These domain-specific applications have their benefits, but they are not generalizable to other subject areas without significant modifications. Mind mapping is an excellent candidate as it is subject agnostic. It also adapts easily to the VR-medium as it is an information organization activity and VR provides an interactive 3D environment for spatial organization of virtual content. The use of virtual 3D collaboration spaces is known to help with spatial organization of information (Bochenek and Ragusa, 2004). Other reasearch (Arvanitis *et al.*, 2009) has shown that virtual environments can assist students in visualizing abstract concepts and complex visual relationships mediated through other related immersive technologies such as Augmented Reality (AR). However, VR-based mind mapping is less understood as an activity itself since very few commercial examples (VR-AR-Corp, 2018; Coding Leap LLC, 2019) are available. VERITAS application

3 Implementation

3.1 VR Platform Requirements

We selected the Oculus Go as the test hardware. The Oculus Go is a 3DoF (Degrees of Freedom), untethered and affordable unit. Within the intervening time between this study being conducted and presented, additional lower end devices such as the Meta Quest and Pico Neo have become available and the Oculus Go has since been sunsetted (Oculus, 2020) although it remains usable as a legacy device.

3.2 System Overview

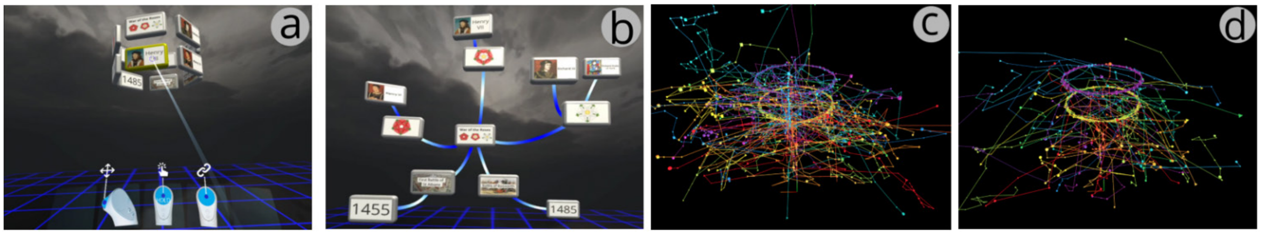

Figure 1 Mind mapping using VERITAS. (A) Initial 'carousel' of interactive tiles, (B) completed "War of Roses" mind map with animated links showing directional relationships, (C) visualization of tile movements by users using the grouping strategy showing increased tile movements, (D) contrasting difference in visualization of tile movements by users using the sequential strategy. Note how grouping visualization is denser than the sequential one.

A full system description, design justification and implementation walk through is available in the VERITAS user study (Sims and Karnik, 2021).

4 Experiment

4.1 Methodology

We approach the research question of investigating the presence of strategies through a controlled exploratory study. The study is intentionally performed in a single-user setting. The aim is to control the unmitigated effects of conflict within the collaborative activity and study the individual strategy in isolation. Our hypothesis is that if individual strategies exist, we should be able to identify and classify these by observing individual users as they perform the mind mapping task in VR. To such effect, we collect data for analysis through quantitative and qualitative means. As a spatial positioning task, the mind map provides quantitative metrics like task completion time, interaction error rates and spatio-temporal information related to individual elements of mind map. Video recordings of the activities are further used to generate qualitative metrics such as completeness of the resulting mind maps and mind map patterns. Thematic coding was conducted to identify differences and similarities between participants so that behaviors could be classified and categorized.

4.2 Task

The task was a mind mapping exercise using a topic provided to the participant as a one-page document. Three topics were selected by sampling unrelated subject areas – the animal kingdom, web technologies and historical events. We setup the mind mapping exercise in VERITAS for each of these topics. Participants were instructed to organize and connect tiles containing text and pictures (see Fig. 1B). Text included keywords and numerical values like dates. Pictures represented physical entities (i.e., animals, people or objects) and illustrative entities (i.e., maps, actions or symbols).

4.3 Apparatus

We used an Oculus Go VR headset for the study. The default factory settings were retained for the purpose of the study, including brightness and volume. The headset has a fixed interpupillary distance (IPD) of 63.5mm accommodating users between 61.5 to 65.5mm IPD. The headset stored runtime application logs and videos.

4.4 Participants

Participants were recruited from Lancaster University through an open call via mailing lists and student forums. The experiment was conducted after acquiring the requisite ethical approvals from the FST Research Ethics Committee[1] with each participant being required to provide informed consent.

Twenty-four participants consisting of twenty males and four females participated in the study. While this does present a gender imbalance, it is simply an artifact of the open call for participation and the study commencing on a ‘first come – first served basis’.

4.5 Procedure

The experiment was run as one continuous session of 30 minutes. First, each participant completed a short demographics questionnaire (age, gender, VR familiarity). Each participant was assigned a pre-selected topic to balance participation for each topic. The participants received a short introduction session to familiarize themselves with the controller and the apparatus and completed a short tutorial inbuilt to VERITAS. Once comfortable, the participants read through the provided information sheet that covered details of the topic. The participants were instructed to build a mind map using the provided tiles and based on the text they had just read. Due to the open-ended nature of this activity, the participants were told to stop once they were happy with the mind map they had produced. Once they finished, they completed the questionnaires and provided feedback on their experience.

4.6 Measures

4.6.1 Video Coding

The video feed of the VR space was captured to obtain a participant view of what was visible on the headset. Video coding analysis of these videos was carried out by two independent coders. The coders looked for patterns that indicated a preferred strategy of organization of information in the mind map. The video coding analysis of the task revealed a between-subjects factor. All relevant measures were then analyzed as a between-subjects design.

4.6.2 Task Metrics

VERITAS logs each controller input along with the relevance to the state-model of the interaction workflow. If the controller input was invalid for the current state, it was logged as an error. The position and size of all tiles are logged at a periodic interval. These logs allowed us to extract useful data like task completion time, error rates and position tracking for tiles.

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[1] https://www.lancaster.ac.uk/sci-tech/research/ethics/

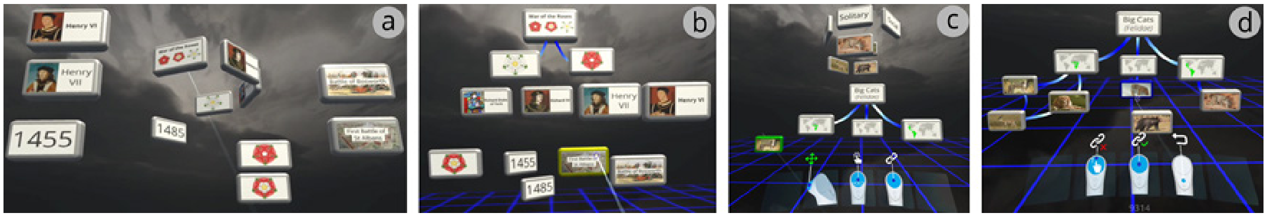

Figure 2 Two distinct patterns of building the mind map. (A) User ordering tiles first before, (B) creating links when all tiles are roughly in position. (C) User dragging tiles from the carousel one at a time and D) immediately linking the last two tiles.

4.6.3 Questionnaires

Participants completed a standardized User Experience Questionnaire (UEQ) (Laugwitz, Held and Schrepp, 2008) designed to measure user experience of interactive products, a standard Simulator Sickness Questionnaire (SSQ) and were given an opportunity to provide open-ended feedback.

5 Results

The quantitative analysis of the collected data was performed using SPSS 26.

5.1 Cohort Identification

We performed a thematic analysis (Braun and Clarke, 2006) of the twenty-four task videos. The objective was to identify distinguishing features which could be interpreted as differing mind mapping strategies. Two coders looked at the way the participants interacted with the tiles and how they approached the mind map creation activity. This helped identify two distinct behavior patterns. The first approach was named *grouping*. A *grouping* participant dragged tiles out of the carousel and organized them into small, related groups until the carousel was empty (Fig. 2A and 2B). They then rearranged the tiles spatially before creating the links (relationships) between the tiles (Fig. 2B). The second approach was named *sequential*. A *sequential* participant dragged a pair of tiles from the carousel and immediately created a link between them, before dragging another tile from the carousel that was related to the first two tiles and created a fresh link (Fig. 2C). This cycle was repeated tile by tile until the mind map was complete and the carousel empty (Fig. 2D). These observations were made independently during the video coding step by the coders and there was no disagreement about the code (*sequential* or *grouping*) assigned to each participant creating two distinct cohorts. The styles were distinct and no blended style was observed.

To characterize the cohorts quantitatively, the coders recorded the timestamp when a clear gestalt grouping of three or more similar tiles (e.g., cats, computer languages or battles) emerged in the video. Next, we extracted the timestamp from the system logs to identify the point where the participants created their first link. These event timestamps for link and group creation were normalized using the individual task completion time (100×event_ts/activity time), allowing us to compare the relative position of the event (link/group) within the overall activity. The timestamps were tested using the intraclass correlation coefficient (ICC) test with a consistency, two-way random effects model. A high degree of reliability was found between the two coders' measurements. The average measures ICC was .967 with a 95% confidence interval from [.924, .986], $F_{(23,23)}=30.42$, $p<.001$.

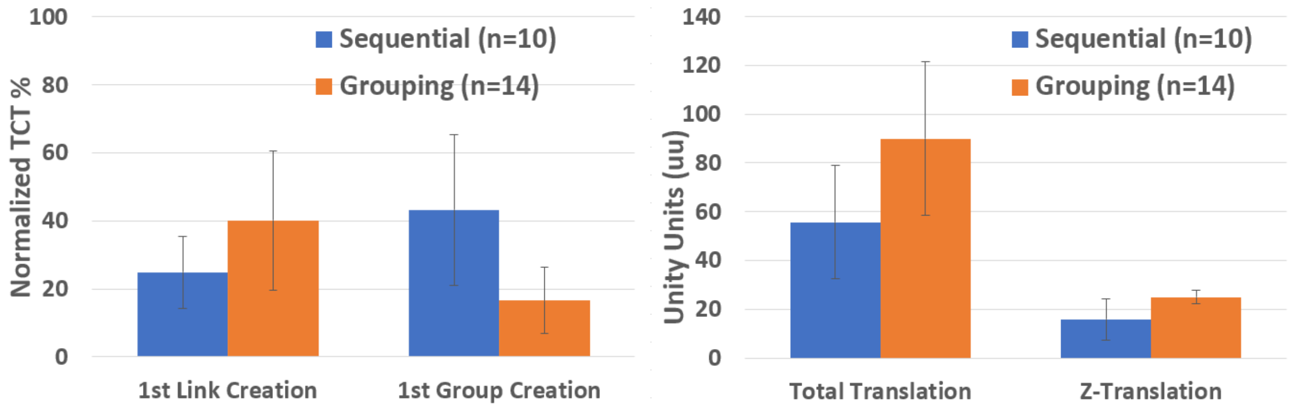

Figure 3 Cohort comparison for 1st Link and Group Creation (A) and tile movement (B).

Next, we used one-way ANOVA, with between-subjects factor as “cohort” for analysis of the two events - first link-creation time and first group-creation time. We found a statistically significant difference between the two cohorts for both first group creation ($F_{(1,23)}=15.99$, $p<0.05$) and first link creation ($F_{(1,23)}=4.59$, $p<0.05$), thus quantitatively validating our visual observation that the two cohorts had different strategies for building the mind map. The *grouping* cohort created the first group significantly earlier ($\mu GG=16.61\%$) as compared to the *sequential* cohort ($\mu SG=43.25\%$) in the activity timeline. Conversely, the *sequential* cohort created their first link significantly earlier ($\mu SL=24.90\%$) compared to the *grouping* cohort ($\mu GL=40.10\%$). Thus, the factor of cohort informed our further analysis of the task metrics. We explored the possibility that the topics selected for the mind map activity could present as an experimental confound. We ran the above tests with the topic as a factor and found no statistically significant difference to suggest that the topic was a factor.

5.2 Cohort Based analysis

5.2.1 Quantitative Metrics

Having established the two mind mapping strategies, we analyzed the quantitative metrics with the additional between-subjects factor "Cohort" with two values, "*Grouping*" and "*Sequential*". For all the following tests, we used one-way ANOVA, with between-subjects factor as cohort.

We did not find a statistically significant difference between the two cohorts for mean task completion times ($F_{(1,23)}=2.38$ $p>0.05$). We analyzed the spatial volume usage using three different metrics. We computed a bounding box volume for the entire activity per user using the maxima of positions of all the tiles along each axis in Unity units (uu^3). There was no statistically significant difference between the *sequential* cohort and the *grouping* cohort means as determined by one-way ANOVA ($F_{(1,23)}=2.461$, $p>0.05$) for bounding volume. Both groups made similar use of the volume which extends beyond the default starting viewport volume. This matched our observations during the video coding analysis step. Next, we looked at how much tile movement was performed by the user. We computed two values per user: a) the total distance travelled by all tiles; b) the distance travelled along the z-axis only (depth). Here, we found statistically significant differences for total distance ($F_{(1,23)}=8.39$, $p<0.05$) and also for z-axis traversal ($F_{(1,23)}=5.16$, $p<0.05$). In both cases, the *grouping* cohort moved the tiles more ($\mu GD=89.8$uu, $\mu GZ=25$uu) than the *sequential* cohort ($\mu SD=55.7$uu, $\mu SZ=15.8$uu). These results are tabulated in Table 1 and displayed in Fig. 3. Using the logged tile position data, we created a 3D visualization to illustrate tile movements (Fig. 1C and 1D shows a composite of five participants in each cohort respectively). The plot displays the movement of every tile for each user. The time (t) spent by a tile at each location is represented by a shape

Table 1 Quantitative Metrics

Metric	µ *Sequential*	µ *Grouping*	Significance
First Link	24.90%	40.10%	p<0.05
First Group	43.25%	16.61%	p<0.05
Mean TCT	337s	442s	NS
Bounding volume	$66uu^3$	$95uu^3$	NS
Total Translation	55.7uu	89.8uu	p<0.05
Z-Translation	15.8uu	25uu	p<0.05
Interaction Errors	11.4	13.9	NS

enclosed in a sphere of diameter = $\log_{10}t$. The visualizations match the tile related quantitative metrics and qualitative observations.

5.2.2 Qualitative Observations

We observed that completed mind maps followed one of three styles – radial, tree or star (Fig. 4). These styles were spread across both cohorts (*grouping* and *sequential*), with radial being the most common style with twelve occurrences, seven for tree and five for star. These styles are consistent with completed mind maps seen in other traditional mind mapping activities.

5.3 Questionnaires

5.3.1 UEQ

We wanted to see if the strategy in creating the mind maps (i.e. *sequential* or *grouping*) influenced user experience, building on previous studies (Sims and Karnik, 2021). We used one-way ANOVA, with between-subjects factor as cohort. We found a significant difference for the attractiveness ($F_{(1,23)}=12.58$, $p<0.05$) and stimulation ($F_{(1,23)}=6.81$, $p<0.05$) metrics between the two cohorts. For attractiveness, the *sequential* cohort rated the application significantly higher (µSA=2.08) than the *grouping* cohort (µGA=0.96). For stimulation, the *sequential* cohort rated the application significantly higher (µSS=2.00) than the *grouping* cohort (µGS=1.32). These results are displayed in Fig. 5.

5.3.2 SSQ

The SSQ responses did not highlight any significantly elevated (moderate or severe on the SSQ) discomfort or any type of nausea.

Figure 4 Hierarchical organization styles used by participants, (A) Radial, (B) Tree and (C) star.

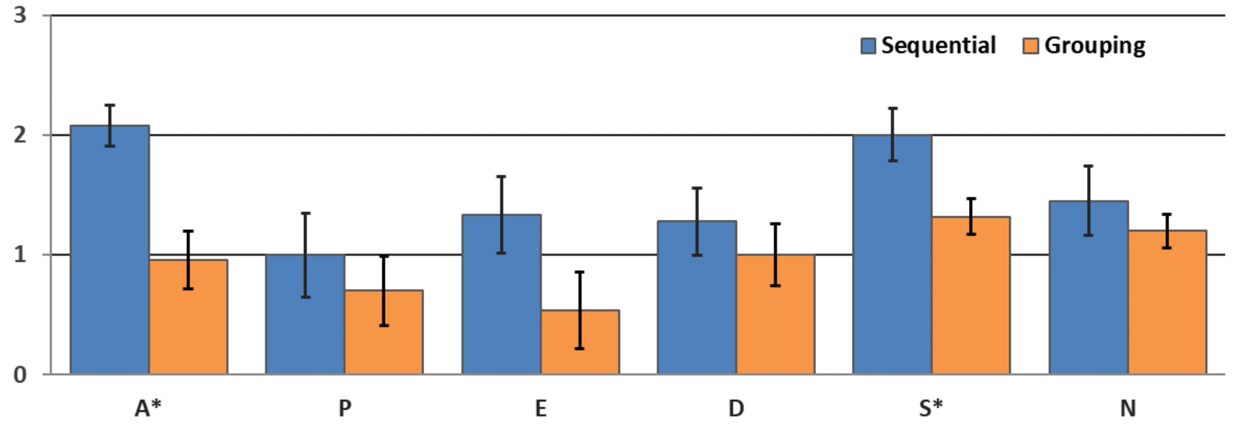

Figure 5 UEQ Metrics: A = Attractiveness, P = Perspicuity, E = Efficiency, D = Dependability, S = Stimulation, N = Novelty. UEQ scale range is [-3, 3] but is truncated due to absence of negative values. For A and S, significant difference was found between the two cohorts.

6 Discussion

In this experiment, we wanted to see if interesting mind mapping strategies would emerge when mediated through VR. We found promising outcomes and discuss their implications in general next.

6.1 Mind mapping Strategies

6.1.1 Identification

Through the analysis of the task, we identified the emergence of two previously unreported distinct strategies for organizing the mind map: "*grouping*" and "*sequential*". This answers the first part of our research question, 'what behaviors or strategies emerge when participants construct a mind map through a VR mediated application'. These strategies showed clear visual differences in how the task was executed by participants. The *grouping* cohort created groups of related tiles first and re-organized these groups before creating their first links. The cohort worked linearly, extracting tile pairs from the carousel, and then defining the relationships immediately. Quantitatively, we identified significant differences in first link event (*Sequential* ↑), first group creation event (*Grouping* ↑) and translation distances (*Grouping* ↑). Surprisingly, this did not increase the TCT (NS), the bounding volume (NS) or even errors (NS) for the *grouping* cohort. Qualitatively, the mind maps created by both cohorts were complete, of similar quality and utilized the full spectrum of available interactions. We also found significant difference in UEQ ratings for the attractiveness and stimulation metrics (*Sequential* ↑).

6.1.2 Explanation

We propose that the emergence of the two distinctly different styles of engaging with mind maps is a result of differing use of epistemic versus pragmatic actions (Kirsh, 1994). The *grouping* cohort performs grouping of tiles as an epistemic action. The *grouping* cohort sampled and built parts of the mind map, with frequent revisions and rebuilds, to explore how things fit better. In contrast, the *sequential* cohort used a cumulatively locked down approach. Kirsh et al. (Kirsh, 1994) originally identified that the main goal of epistemic actions is towards optimizing input. In our case, task completion times did not differ significantly. Thus, we propose that the observed epistemic actions focused on supporting pedagogical synthesis of the mind map, i.e., supporting the primary goal of recalling the topic's content while building the mind map.

The variance between the average scores for two UEQ metrics (attractiveness and stimulation) between the two cohorts is an interesting observation. The *grouping* cohort scored the attractiveness and stimulation positively but lower than the *sequential* cohort. There is no obvious correlation to any of the other relevant metrics. The only indication comes from the free form feedback collected in the previous VERITAS usability study (Sims and Karnik, 2021). In querying the results from that study, user comments indicate a significant number would have liked to have been able to move groups of tiles at once. While the significance of these comments was not apparent in this previous study, the emergence of the two strategies in this current study provides context for these comments. It suggests that not allowing or enabling users to construct the mind map in a way that is most efficient for them leads to a significantly reduced user experience. These scores highlight the need to understand individual strategies for task execution in order to provide all the required affordances. Otherwise, the users adapt as best as possible, but the overall attractiveness of the application is lowered.

6.1.3 Generalization

An interesting area for future work would be to see if these strategies emerge in other mind mapping activities. The difference in the two strategies could create conflict when individuals from both cohorts work together in a collaborative mind mapping activity. The conflict resolution would require conversation related to spatial positioning of the mind map elements. We see evidence of such conversation being reported by Jamil et al. (Jamil *et al.*, 2017). Future work can definitively confirm the hypothesis that the strategies are inherent to individuals and independent of the medium.

6.2 Design Implications

To answer the second part of our research question, 'if unique behaviors or strategies emerge, what are their implications when considering collaborative mind mapping in VR', we need to consider previous CSCW research, educational perspectives and application design.

6.2.1 Paragogy and Collaboration

The current scope of VERITAS, as a single-user mind mapping application, was essential to allow individual strategies to emerge. However, mind mapping is commonly carried out as a collaborative activity among peers. Peer-based collaborative learning or paragogy is commonly associated with inquiry-based learning and thus mind maps. Designers of collaborative mind mapping applications need to carefully consider our observations in their design. The naïve approach of offering a shared environment with different view-points is no longer a viable option. While the awareness of the actions of the collaborator is required, a whole new design approach is needed to display the mind map to the users.

The two mind mapping strategies, (*grouping* and *sequential*) that we identified, reveal challenges. When VERITAS is implemented in a collaborative environment, the two strategies may work well together, with users naturally mediating control to allow for their distinct strategy to continue unhindered. However, it is equally possible a user employing the *grouping* strategy may face disruption in reflection due to a competing user applying the *sequential* strategy or vice-versa. Unlike digital tabletops or paper-pen exercises that consist of a shared space and single perspective, VR headsets can operate independently of each other while supporting '*one-world, multiple* *perspectives*', but the designer needs to look beyond merely supporting separate personal and shared workspaces.

The variety of mind maps built by the participants provide an insight into the information organization process. While the space mediates the organization of information, the correspondence of spatial coordinates to individual tiles is loose. This can be leveraged by a design wherein the tile positions in each user's view are loosely coupled to their positions in another user's views (i.e., if a user moves a tile to a new location, this change doesn't need to be reflected exactly in another user's view or the movement is replicated on a 'diminished' proxy). Interesting design choices need to be made when the collaborative discussion focuses on such a tile or when the relative spatial position of the tile becomes relevant to the structure of the mind map. An ideal implementation would allow both strategies to flourish on their own without hindering the reflective paragogy it is meant to foster. One possible outcome can be visually dissimilar but pedagogically similar mind maps. The implementation would also account for the hardware-imposed constraints of VR headsets that restrict the natural communication through face-to-face interactions and make contention issues harder to manage. The designer can leveraging existing work to virtualize face to face interactions through avatars (Piumsomboon *et al.*, 2018) to facilitate non-verbal communication and introduce elements that increase situational awareness (Benford *et al.*, 1994).

In addition to these finding being useful for designers of collaborative VR mind mapping applications, they are also useful for educators. Now that these behaviors are known and identified, educators can ensure any application they procure or utilize encompasses and facilitates these behaviors. Interactions that occur naturally ensures active learners do not become passive learners through frustration and disengagement. Learning activities can also be tailored to ensure such behaviors are catered for.

7 Conclusion

In this paper, we investigated how VR based mind mapping can support emergence of individual mind mapping strategies. Using a proof-of-concept VR mind mapping application, VERITAS, we identified the emergence of two distinct mind mapping strategies, *grouping* and *sequential,* through our user study. Our findings of the mapping-strategies have implications for future research into VR-based mind mapping in educational settings, especially for collaboration-based paragogy.

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