A Framework for Effective Guided Mnemonic Journeys*

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Abstract. The memory palace, also known as the memory journey, is a mnemonic technique where information to be remembered is encountered along a predetermined path through envisioned places, creating strong spatial and visual connections between the material and specific locations and vivid images. Constructing a memory palace for complex computer science concepts may prove challenging for students, as it requires the identification, selection, and organization of essential ideas from the material. This task is better suited to an expert on the curriculum, such as the instructor.

In this paper, a framework for designing and delivering Guided Mnemonic Journeys is proposed. Led by a teacher in person or via audio or video, the approach uses a virtual tour of the university campus at its core. The approach combines various mnemonic techniques to create a more comprehensive approach to memory enhancement. The instructor plans the story arc and places various mnemonic cues along the path and then guides the students through the narrative and imagery, providing context, clear structure, and instructions for each step.

A pilot study indicated that students perceived the delivered Guided Mnemonic Journeys positively, appreciating the rich didactic activity and the opportunity to learn new mnemonic techniques.

Keywords: Mnemonics · Memory Palace · Virtual Tour

1 Introduction

According to the revised Bloom's Taxonomy the verb associated with the first level of learning is remembering [13]. This explains why improving memory performance is so important. Numerous techniques have been suggested to enhance memorization, among which mnemonics stands out as one of the most popular [31]. Mnemonic strategies support both information encoding and retrieval. One of the most attractive ancient mnemonic devices is the method of loci (MOL), also called the memory palace (MP) technique [33]. The effective implementation of this method implies the invention of a familiar visuo-spatial mnemonic

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environment (familiarity criterion) and the repeated imaginary walks through it. During the "encoding walk" objects serving as landmarks are paired with to-be-remembered items. Information is retrieved sequentially by retracing the encoding walk (from landmark to landmark).

Of course, ancient Greek orators used the method of loci based on a completely mentally created environment (traditional MOL). However, in recent decades, as computer-supported education has gained more and more space, the concept of virtual MOL (vMOL) has been introduced [7,6,14]. Researchers in computer science (CS) and psychology have begun to explore the potential of virtual worlds to provide students with a template and support for their mental representation of the memorial palace. The findings seem to establish the prediction that virtual reality (VR) solutions will play a key role in the effective implementation of MOL in the future [11,23].

Most vMOL implementations are based on computer-generated MPs. To be familiar to most students, environments such as a common room or building were usually created. Obviously, these imagined environments can only partially satisfy the "familiarity criterion". In this paper, we present a VR-solution that provides a very familiar environment by immersing students in a virtual tour of their university campus. Unlike previous research, in which students navigated the virtual environment on their own, in the present study, we used a teacher-led guided journey. The adoption of this approach enabled a teacher-level implementation of several principles suggested by previous studies on the MOL technique [7]. Furthermore, several other mnemonic techniques were utilized to augment the students' MP-experience, including but not limited to, the story method, chunking, alliteration, acrostics, spelling, visual and association mnemonics, as reported in [1]. Increased teacher involvement is also justified by survey studies, indicating that while students may be aware of mnemonic techniques, they tend to opt for alternative study strategies instead [28,29,21]. Complex methods such as the MOL are the least popular.

2 Background

2.1 Method of Loci: a mnemonic-specific technique to improve memory

"If nothing has altered in long-term memory, nothing has been learned" [30]. This powerful statement clearly emphasizes the key role of memory in learning. Consequently, cognitive psychology defines learning as an adjustment in long-term memory [3]. Although there are multiple ways to improve memory [20], the peculiarity of mnemonic techniques lies in their focus on enhancing the recall of information.

The term "mnemonics" is rooted in the Greek word mnēmonikos, which translates to "of memory" or "relating to memory". This word is associated with Mnemosyne, the Greek goddess of memory and remembrance in mythology [12]. The concept of mnemonics involves finding better methods for encoding information for easier retrieval and recall. Furthermore, [12] emphasize that mnemonic

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devices can be considered both as systematic memory enhancement techniques and as learning strategies that can improve the learning process and increase recall of information. They involve using methods such as elaborative encoding, retrieval cues, and imagery to encode information in a way that makes it easier to remember. Mnemonics connect new information to something more familiar or meaningful, resulting in improved retention.

The Method of Loci is an ancient mnemonic technique that involves linking information to be learned with specific locations. Accordingly, the MOL serves as the foundation for constructing a MP. To apply the MOL or build a MP, one must mentally place the information to be learned in familiar places, referred to as "loci" (place = lat. locus, pl. loci), which serve as landmarks for navigating the memory palace. A considerable body of research confirmed that this method of association aids in the memorization and retrieval of information [33]. For example, [17] examined ten superior memorizers (eight of them placed at the highest levels in the World Memory Championships). The interviews of the participants revealed that all of them used mnemonics during the learning phase, and nine out of the ten superior memorizers used the MOL technique for some or all of the tasks. On the other hand, previous reviews on the use of mnemonics in the classroom have reported inconsistent results [15,19,5]. In addition, Putman [24] emphasizes that importance of the right circumstances [31].

Hedman and Bäckström [7] collected nine key principles to effectively implement the MOL technique: place-like environments (information is organized into location-based settings), striking imagery (visual impression is generated to anchor information within loci), association (visual representation must be linked to the information or concept to be remembered), creative use of spatiality (the constructed mental locations do not have to mirror physical locations), architectural guidance (environment should be designed with a degree of architectural diversity), positioning of elements (information elements in the environment should be easily visible), perspicuity (it should be simply to obtain a sense of the location of items), calmness (create environments that enable deep concentration), grouping and order (systematic organization of the information). These principles can also be interpreted as a fusion of the fundamental MOL with other mnemonic techniques [1].

2.2 Brief review of previous work on virtual memory palaces

According to [32], creating and using a MP is challenging. It requires personal and familiar locations, extensive training, and a significant amount of cognitive effort and attention. To reduce cognitive demands and make the learning process easier, researchers have begun integrating virtual MPs (vMPs) into the mnemonic process. The vMP acts as a template for the traditional mental representation of a MP and helps ease the burden. Several studies have investigated various aspects of the MOL in virtual settings. A fundamental question examined was whether vMOLs could be more effective than traditional ones. Previous work has also revealed several elements that can contribute to more effective vMP im-

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plementations. In the following, we provide a concise overview of some relevant studies in this field.

Hedman and Bäckström [7] developed a virtual museum-like platform where loci were essentially text displayed on virtual walls. Although the study did not demonstrate any superiority of vMP over traditional learning methods, the authors also reported that the distance between rooms and loci could cause navigation difficulties for students.

The study by Legge et al. [14] consisted of two experimental groups, using traditional and virtual MOL respectively, and found that both groups outperformed the control group (which had no specific learning strategy), with no significant differences between the MOL groups. The peculiarity of this study was that the vMOL approach did not include loci, which required participants to invest more mental effort to generate the item-location pairings.

Jund et al. [11] conducted a study to evaluate the impact of two different frames of reference (egocentric vs. allocentric) on the recall performance of participants when using vMOL. They found that designing the loci as images of colorful textures and patterns can help avoid semantic bias in participants' memory processes.

Huttner et al. [9,10] investigated whether participants perform better with learning content that was presented virtually through visualized loci, or if the MOL is more effective when users have to imagine the content through text-only loci. The researchers noted that using visualized loci proved to be more effective for the memorization process and concluded that greater immersion in virtual environments leads to better recall.

Recently, Yang et al. [32] conducted an exploratory study to examine the use of VR techniques and mnemonic devices to aid in the retrieval of knowledge from scholarly articles (participants were asked to read, memorize, and recall abstracts of scientific publications). Three different conditions were analyzed: without a predefined strategy (control condition), image-based memory palace, and VR-based memory palace. The results showed that the use of a vMP significantly improved the amount of knowledge retrieved and retained compared to the control condition and showed moderate improvement over the image-based memory palace. These authors conclude that their findings support the usefulness of VR for certain cognitive tasks and offer insights for enhancing future VR and visualization applications.

The prior research mentioned above demonstrates the potential of the vMP technique to enhance memorization. Most of the research investigated how the method helps to recall lists of items, which is a relevantly elementary task [32]. In the realm of CS education, a pertinent utilization of the vMP approach would undoubtedly involve more than just aiding in the recollection of a word list. Interestingly, recently Robins et al. [25] noted that they have not found any particular investigation of study skills or the use of mnemonic techniques in computing education. On the other hand, the findings of the study conducted by Yang et al.[32] are promising, as they effectively used the vMP technique for more complex tasks, also involving comprehension and retention.

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Furthermore, the studies examined have revealed some possible difficulties and suggested effective implementations of vMP. We anticipate that the proposed increase in teacher involvement will help alleviate the identified deficiencies and achieve significant improvements. For example, navigation difficulties such as those indicated by [7] can be avoided by using teacher-led guided journeys. If the teacher is responsible for selecting the locations and planning the item-locus pairings, it can eliminate the additional mental effort required by the student (noticed by [14]) and prevent the occurrence of the phenomenon of semantic bias in the memory process, as brought to attention by Jund et al. [11]. Obviously, such an implication of the teacher can support higher-level immersion in virtual environments, as highlighted by Huttner et al. [9,10].

3 Guided Mnemonic Journeys

The Guided Mnemonic Journey (GMJ) is built upon and emerges from a meticulously planned [7] virtual tour of a familiar environment. The virtual environment is purposefully customized with strategically placed embedded virtual cues and actionable hotspots that serve as contextual anchors for mnemonic exercises and information item-locus pairings. An overarching narrative is woven into the journey, serving as a unifying thread that binds together the various mnemonic exercises and information items that students will experience along the way.

In the classroom setting, the instructor assumes the role of a navigator that guides students through the vMP. The instructor reveals the accompanying story in a step-by-step fashion, presenting each item and mnemonic exercise as they are encountered in the virtual environment. By doing so, the instructor creates a synchronous learning experience for the students, ensuring that they are all on the same page and working together to build their mnemonic skills and retain the presented information.

3.1 Virtual Tours as Memory Palaces

A virtual tour of a well-known and frequently visited environment, such as a house, workplace, or school, possesses the essential elements required to build an effective vMP, namely navigability and familiarity. A virtual tour allows for the exploration of the environment in a structured and controlled manner, allowing users to move through the environment at their own pace and take in details and information in a logical sequence. Additionally, using a virtual tour of an everyday environment ensures that users are already familiar with the layout and features of the space, which makes it easier to associate new information with specific locations within the environment. This familiarity also helps reduce the cognitive load, making it easier to focus on encoding and retaining information [32].

Using readily available virtual tour editors, the virtual memory palace can be easily populated with (actionable) virtual cues that are used to anchor the information that needs to be retained. Triggering virtual cues can also prompt

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Fig. 1. Two similarly outfitted computer laboratories. Neural Style Transfer and live bidirectional morphing was used to infuse uniqueness and achieve a striking imagery.

pre-programmed actions such as displaying detailed content, opening a web page, streaming a YouTube video, and more. These mechanisms can be used to provide additional information and context that will be tied through the method of loci to the spot within the tour.

Compared to computer-generated virtual reality environments, 360 virtual tours are more accessible and easier to create. Virtual tour editors offer sophisticated tools to achieve interactivity and customization, such as adding animations or avatars within the 360 environment. This ease of use makes it effortless for instructors to create virtual memory palaces quickly and with minimal technical skills.

While computer-generated virtual reality can deliver a higher degree of interactivity because objects and elements within the environment can be freely moved and even manipulated to create new experiences, constructing a photo-realistic computer-generated VR requires advanced technical skills to program and develop. As a result, we believe that 360 virtual tours are a more practical and effective tool for creating vMPs for most instructors.

When designing and constructing the virtual tour, it is essential to carefully consider the effective implementation of the MOL technique by adhering to established key principles [7]. To illustrate, we utilized a strategy to achieve architectural guidance for comparable locations. This was achieved by gradually back-and-forth transforming the 360 scenery of similarly outfitted computer laboratories to assimilate the style of distinct renowned artworks. This approach had the added benefit of presenting remarkable and visually striking imagery, which is another key tenet of an effective MOL. The style transfer process and morphing, which involves a gradual and seamless transition between the photo-realistic depiction and the painting style, is depicted in Figure 1.

3.2 Combination of mnemonic techniques

The use of multiple mnemonic techniques is a sound strategy, since different methods can aid in the retention and recall of different types of information. MP is particularly useful in remembering sequential lists, such as the steps in an algorithm or recipe, and the names of famous computer scientists throughout

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history in chronological order. However, it may not be the optimal choice for other types of non-sequential information, such as facts, relationships, or definitions. By combining different mnemonic techniques, a more comprehensive and adaptable memory system can be established [1].

The Story Method, for instance, involves creating a narrative or story that connects different pieces of information, thereby assisting in recalling related concepts or ideas. The chunking technique involves breaking up large amounts of information into smaller, more manageable chunks. Grouping related concepts together and placing them in specific locations within the MP helps students to recall the connections between items as well. Acronyms and acrostics techniques involve creating a word or phrase from the first letter of a series of words to be remembered and incorporating them into the corresponding locations in the MP.

3.3 Guided learning experience

In previous studies, the MP technique was used mainly as a self-directed learning activity. On the contrary, the third central concept of our approach is to have the instructor plan, build, and deliver the learning experience in the form of a guided tour of the MP. The reasoning behind this is two-fold. First, students often lack proficiency in the use of mnemonic techniques, and second, constructing a memory palace for CS topics that are not yet mastered can be challenging, since it requires the identification, selection, and organization of key concepts from the material.

Mnemonic techniques have been proven to be effective in aiding memory and learning, but, like any skill, they require practice and mastery to be used effectively. This can be challenging or intimidating at first for many students, particularly those who may not be familiar with mnemonic techniques or have had little exposure to them. As guided meditation can be an excellent tool for beginners to learn and establish regular practice, we believe that guided mnemonic exercises led by an instructor can be useful for students to become comfortable and adept at using mnemonic techniques. Guided exercises can provide clear instructions, structure, and support that can help students understand the techniques and practice them effectively.

Second, learning complex CS topics goes beyond memorizing and remembering, the first level of the Revised Bloom's Taxonomy [13]. To facilitate higher-level learning objectives such as understanding and analysis, the memory palace and information delivery must be constructed in a way that logically structures concepts, visualizes the relationships between them, and provides a depiction on how they fit together in a broader framework [32]. Suitable visual and spatial associations must be constructed to make abstract concepts more concrete and easier to understand. Additionally, the mental images that are established often must simulate problem-solving scenarios and have to engage and reinforce the application of concepts in different contexts. Producing such clever associations, highlighting nuances and corner cases, providing additional meaning and under-

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standing for a given context, etc. can only be effectively achieved by someone who already mastered the material, which in a classroom setting is the instructor.

3.4 Journey dynamics

Our proposed approach enhances the logical structure provided by the story and locations by integrating additional mnemonic techniques that facilitate retention. The instructor can design and customize the mnemonic anchors and virtual cues depending on the level of active audience participation they aim to achieve.

Passive journeys In this approach, audience participation is limited mainly to observing the unfolding of the mnemonic journey, and engagement and retention of information must be achieved through activation of emotional responses, primarily through the use of humor, shock, and surprise. The release of dopamine, a neurotransmitter associated with pleasure and reward, in response to startling stimuli enhances the encoding of information in memory, leading to better subsequent recall [16]. Moreover, there is a positive correlation between the level of emotional arousal evoked by the material and the extent of subsequent recall [22].

Humor can also make information more relatable and easier to remember by connecting it to something familiar or amusing. Shock and surprise can break our expectations and create a strong impression that can enhance our recall of the information.

An effective technique that we tried is assigning each room or lab in a virtual tour to host algorithms of a certain complexity time. As we pass down the "ever increasing complexity hallway", after the linear running time room, we "enter the realm of $O(n \log n)$". In a passive journey, a virtual cue displayed on the entrance door might contain some seemingly random item, such as a fish, as shown in the left pane of Figure 2. To grab the attention of the audience, the narrator could open with a shocking and unexpected line: "Let us stop briefly to honor a H&M Quilted Jacket wearing mosquitofish". What does the clothing item and mosquitofish have to do with algorithms?

Then the narrator activates the hotspot and a Wikipedia page appears, displaying a monument constructed in Sochi honoring the western mosquitofish[1]. This hopes to surprise the audience and arouse curiosity as the narrator asks "You wonder why?". After a dramatic pause, it continues with the following, strongly emphasizing the highlighted words: "For *merging* into many habitats to *quickly* eradicate Malaria by eating *heaps* and *heaps* of mosquito larvae." This opens the process where gradually the associations are revealed and explained, connections with the Heapsort, Mergesort and Quicksort are established.

To strengthen the mnemonic anchors, the instructor can present fun trivia, such as the fact that the quilted jacket seems to be the only wearable starting

[1] `https://en.wikipedia.org/wiki/Mosquitofish#/media/File:Monument_of_a_Fish.JPG`

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Fig. 2. Virtual cues relying on outlandish associations in the left panel, and discovery and recognition in the right panel.

with the letter 'Q'[2] or that there are very few common words that contain the letters HMQ concomitantly, with mosquitofish being one of them.

Active journeys In an alternative approach, the guided journey serves as a broad framework, and the nuances and intricacies are uncovered collaboratively with the audience. The focus is on the social experience and, therefore, the design of virtual cues and exercises should be tailored accordingly. Rather than being jarring, they should act as clues and enable the identification and comprehension of the underlying meaning. In this scenario, students embark on a detective or reverse engineering journey to decipher and reveal the meaning behind the mnemonic anchors. In case of confusion or difficulty, the instructor provides additional context and support to aid in discovery and understanding.

For instance, the premise of the story could be that related software design patterns are being held captive in different rooms. To rescue them, participants must solve the "seal" on each door by interpreting the symbols and correctly identifying the patterns being held hostage. This requires active participation and critical thinking, as participants must analyze clues and metaphors and recall the names and characteristics of each pattern. When the experience is interactive and challenging, participants are more likely to remember the information and be motivated to learn more.

An example of such "seal" or ideogram is illustrated in the right panel of Figure 2. Upon closer inspection, students may recognize that it is based on the most prominent symbol in Michelangelo's fresco painting "The *Creation* of Adam", depicting the outstretched arms of Adam and God. If not, on the left of the door there is help available: the entire fresco is displayed. Clicking on the image of the fresco opens the dedicated Wikipedia page, providing additional context and information. Additional clues, such as Adam being a *singleton* immediately after creation and the *prototype* for humanity - The Primordial Man, the step-by-step approach for creating / *building* something complex, *factory*

[2] https://englishenglish.biz/a-z-things-you-can-wear/

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and *builder* cap iconography, and other mnemonic cues, help guide students in deciphering and coming up with the right solution.

Another way to encourage active participation of the audience is to introduce mnemonic exercises, where students are challenged to devise a solution, such as creating a humorous or catchy wordplay or acrostic for a mnemonic anchor, such as the starting letters of sorting algorithms HMQ (for example, “Hunky Male Quartet”, “Happy Meal Queen” or “Holy Molly Quacamole”). This type of exercise not only activates the audience but also promotes creativity and enhances the personalization of the mnemonic device. It encourages students to think beyond the surface level and come up with something unique and memorable to aid them in their retention of information.

4 Pilot study

In a pilot study with 30 freshman CS students, we conducted a 20 minute GMJ to reinforce their learning of ten basic search and sorting algorithms. Participants observed the virtual tour-based journey on a projector screen while the narrator followed a carefully planned script to provide context and deliver the learning content. The style of the journey was passive, allowing participants to focus on visuals and narration with no active involvement required.

To create a clear and logical structure, the algorithms were grouped based on their time complexities, and each group was anchored to a different computer laboratory on campus.

The overarching narrative was crafted to be engaging, unusual, and also relatable to the students. It begins with a tired and unmotivated student visiting the university campus to seek inspiration before the upcoming exam on search and sorting algorithms. As the story progresses, the student embarks on a journey characterized by surreal and abstract elements that challenge the boundaries of reality. The narrative is punctuated by humorous and absurd situations where often teachers are the protagonists, wordplay, unexpected developments, and imagery that at first appear nonsensical. However, as the journey continues, the seemingly disconnected elements are gradually linked to the algorithms studied through associations and connections, hopefully making them and their characteristics and properties easier to understand and remember. The accompanying virtual tour depiction reinforces the narrative by incorporating visually striking imagery and cues that correspond to the various mnemonic exercises and information items encountered throughout the journey.

To make the virtual environment more engaging and memorable, each laboratory was designed with specific characteristics, such as a billiard room, a bistro, a fishing colony, etc. To aid in the retention of algorithmic characteristics such as worst-case, best-case running times, and other relevant information, a variety of mnemonic exercises were presented as the tour explored the premises of each computer laboratory. By combining these elements, a clear spatial representation of the algorithms and their respective time complexities was provided.

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Following the guided activity led by the instructor, the students were prompted to mentally revive and retrace the plot and recall as many specific details as possible related to the characteristics of the algorithms. This exercise not only solidified their understanding of the material but also served as a form of self-assessment, allowing them to somewhat gauge their mastery of the content.

We measured the Perceived Usefulness (PU) of the experienced learning technique by asking participants to complete a questionnaire at the end of the class. PU is a central construct in the Technology Acceptance Model (TAM) [4] that is widely used in the field of information systems to understand how users regard the value and utility of a particular technology or system [2,27,10]. The TAM proposes that users' intention to use a technology or system is influenced by their perceived usefulness of the technology, which refers to the extent to which a user believes that a technology or system will help them perform a task more effectively or efficiently. Users are more likely to adopt a new technology or system if they perceive it to be useful in achieving their goals.

We adapt the original survey elements to the educational setting, assessing the degree to which students believe that using the proposed technique would ease and enhance their learning performance and outcomes. Participants indicated one a 7 point Likert scale their level of agreement with statements regarding the guided memory journey 1) helping them learn new concepts more rapidly (time saving), 2) making it easier to remember complex things (effort saving), 3) improve knowledge, 4) improve learning performance and grades, 5) help make most out of their time while learning (effectiveness), 6) being a flexible learning technique, 7) being overall useful in learning.

At the end of the survey, students had the opportunity to express their opinion and provide written feedback on the educational experience.

5 Results and Discussion

Figure 3 displays the distribution of responses using Likert plots, also known as diverging stacked bar charts. The width of each horizontal bar represents the percentage of respondents who gave a specific response. The sum of the percentages for the disagreement, neutral, and agreement responses are shown on the left, middle, and right of each item. Additionally, the bars are color-coded to represent the degree of agreement or disagreement, with darker shades indicating stronger responses.

The figure clearly shows that the participants found the evaluated method valuable with functional utility, expressed by the predominantly positive responses to the questionnaire items. The level of agreement ranged from 100% for perceived flexibility to 60% for perceived effectiveness in supporting the learning process. The neutral and disagreement percentages were low, ranging from 0% to a maximum of 20%, again for effectiveness. Other studies have also reported that vMP implementations are perceived as useful by students. For example, [10] conducted a TAM evaluation of their vMP and found a positive trend with respect to this factor. The central tendency of the responses to all items, except

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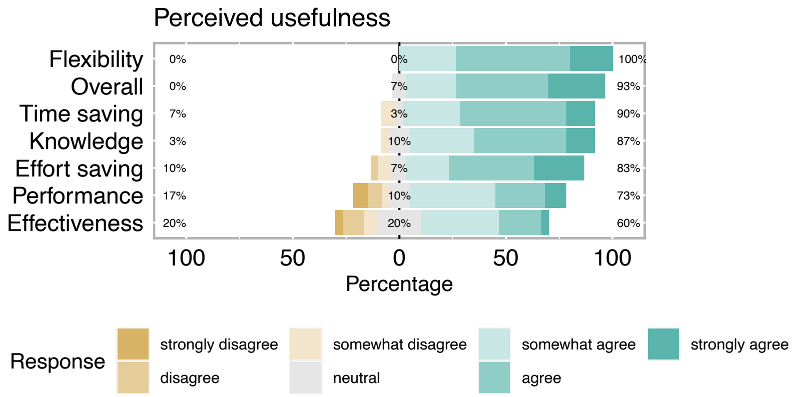

Fig. 3. Distribution of responses along the Likert scale for the various factors assessing Perceived Usefulness.

for Performance and Effectiveness, is reflected in a median score of 2. This finding reveals that a minimum of 50% of the participants either "agree" or "strongly agree" that the presented technique can save time and effort, enhance retention and knowledge, and possess general utility and adaptability.

The 100% level of agreement for the flexibility factor is an extremely promising result, demonstrating that students recognize the significant potential of the method in terms of its applicability to other topics as well. In addition, the high level of agreement regarding the Time saving factor (the mean score on the scale $[-3, 3]$ was $M = 1.6$, with the standard deviation $SD = 1.0034$) and Knowledge ($M = 1.5333$, $SD = 0.9732$) factors indicate that most of the participants perceived the proposed GMJ method as an effective way to improve their knowledge and accelerate their learning of new concepts. These encouraging findings are consistent with other recent studies that have predicted that the use of vMPs can significantly improve the overall learning experience [18,8,23].

The 10%-83% disagreement-agreement ratio, median score or 1 ("somewhat agree") for the Effort saving factor reveals that some students did not find the application of this technique self-evident, especially when trying to remember complex information. Furthermore, written feedback indicated that participants recognized the significant time and training required to master this method, which is a common drawback mentioned in previous studies on MOLs implemented by students [14,26]. On the other hand, these findings further emphasize the benefits of teacher-led guided journeys.

Participants rated the Performance and Effectiveness factors the lowest, which is a plausible result. It is understandable that after only one use, students may not fully recognize and evaluate how the method can contribute to their learning outcomes. However, the fact that the students disagreed the most with the statement that the method could help them make the most of their learning time suggests that this technique should be used as a complementary tool.

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The students' comments also provide valuable feedback on the evaluated method. These remarks reveal that some students had a complete change of opinion, starting with negative prejudice and ending with a highly positive experience. For example, one of them commented, "Honestly, I used to think that teaching using unusual things just to aid memorization and learning was foolish, but my opinion changed after today's class. It can really help a lot in learning! In my opinion, it would be very useful to incorporate this technique into education, without exaggerating it. People need to use creativity and imagination because in the modern world, we have fewer chances to do so." Appreciation for the creativity, imagination, and invested work behind the implemented mnemonic journeys appeared in other comments as well. Another participant stated that "It can be a useful learning method, but it takes a lot of time to work well and effectively. It requires a complex technique and creativity to be truly effective and useful. It may not be suitable for everyone, but those who master it can learn more efficiently and in a shorter period of time, and the learned material will stick."

Overall, it can be stated that developing effective GMJs involves a significant initial investment in effort on the part of the instructor. Creating an amusing and captivating mnemonic script demands meticulous planning, ideation, and a wealth of experience in identifying the curriculum's intricate and challenging areas. However, the first feedback results are optimistic, indicating that the benefits derived from this one-time investment are considerable, and the created mnemonic journey can be repurposed for subsequent student cohorts annually.

Limitations While the study provides a valuable first insight into the effectiveness of the GMJ technique in CS education, it is important to note that the results are limited to a single context and a specific set of participants. The potential of this technique in various educational contexts, such as different academic levels and subject areas, and the comparison of passive and active journey styles has yet to be explored. Additionally, the long-term effectiveness of the technique in promoting memory retention and enhancing learning outcomes requires further investigation.

Furthermore, it is important to evaluate the capacity of the foundational virtual tour for repeated use. Although it may be effective for initial use, its saturability must be gauged in terms of repeated application for different topics. As locations become associated with specific concepts and information, the tour may become less effective in anchoring new information and creating new associations. Overuse of the same loci and cues can also cause interference with existing associations and may lead to confusion and decreased retention.

6 Conclusions

This paper presented a detailed account of our methodology and first outcomes in developing and administering Guided Mnemonic Journeys covering computer

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science topics. The proposed approach is based on three key principles: the extension of 360 virtual tours to leverage the benefits of familiarity, navigability, and easy technological accessibility, the integration and layering of various mnemonic techniques, and the provision of guided instruction within a synchronous learning context.

Feedback provided by students highlighted the appreciation for the guided approach and its potential as a tool for enhancing memory retention and improve learning outcomes. The positive reception of the approach underscores the importance of incorporating mnemonic techniques in CS educational settings, and provides evidence for the value of utilizing Guided Mnemonic Journeys as a means of enhancing learning and memory. More research is needed to explore the full potential of this technique, including its applicability to various educational settings and its effectiveness in promoting long-term memory retention.

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