Revealing And Resolving Disorientation In An Online Course Module Of Java Programming

Neelma Bhatti*, Imdad Ali Ismaili†, Lachhman Das Dhomeja‡ and D. Scott McCrickard§
*§ Department of Computer Science and CHCI, Virginia Tech, Blacksburg, USA
†‡ IICT, University of Sindh, Jamshoro, Pakistan
Email: *neelma@vt.edu, †iai_a@yahoo.com, ‡lac_d@hotmail.com, §mccricks@vt.edu

***Abstract*—While web-based learning is becoming a notable medium for learners opting for distance and open education, it poses its own challenges in terms of usability and navigation. One of these challenges is disorientation in hypermedia settings, resulting in deviation from learning goals. We provide a novel interpretation of the term disorientation by combining the effects seen in virtual relocation in hyperspace (navigational disorientation) with mental relocation seen in mind wandering or external distractions (mental disorientation) based on their similar characteristics and consequences on learning outcomes. This research uses this distinction to measure and resolve disorientation in web-based learning environments. We implement a system with disorientation module which reveals and resolves disorientation, enabling the study of the impact of different kinds of disorientation on learning of students in an online programming course. Study results reveal that learner performance in a web-based learning environment is negatively affected by disorientation, and that learners have to reorient themselves to their learning goals in situations of both navigational and mental disorientation.**

***Index Terms*—disorientation, web-based learning, mind wandering, distraction, e-learning**

I. Introduction

Technology and the internet are bringing revolutionary changes in many domains, including education. A large number of web-based systems augment the traditional classroom approach toward knowledge dissemination, making web-based learning environments increasingly popular [1]. Such systems use different adaptation techniques to help learners achieve their learning goals. One of the reasons of learners' inability of meeting their learning goals is the lack of sense of orientation. Cited as one of the two main issues in the navigation of web-based environments [2]–[11], disorientation is a pertinent and under-addressed problem which impacts user experience in a negative way, resulting in a decrease in expected learning outcomes from such users [12].

Current literature recognizes disorientation and losing in hyperspace as similar phenomena, both resulting in user deviating from their expected navigational path in hypermedia information systems [13], [14]. Bhatti et. al [15] present a model specifying certain unexplored distracting phenomenon experienced by the user, which are not quoted as disorientation in the literature. We build on this work by specifying some distracting elements resulting in disorientation particularly in web-based learning environments. Bhatti et al. define three types of disorientation in e-learning systems including back to square one, high level content and losing in hyperspace [15]. We classify the first two types as disorientation caused by "mind wandering" and the third type as "navigational disorientation", making them arguably similar phenomenon with comparable consequences. We employ Bhatti's Disorientation Model (DM) to develop an adaptive web-based learning system, which takes student disorientation as a context to changes its contents and layout. A classroom study seeks to answer the following questions:

1) What factors constitute disorientation in a web-based learning system?
2) Does course design contribute towards orienting a learner to the task?
3) Can the proposed system improve the learning outcomes in a web-based system?

This study makes the following contributions in the field of educational computing:

1) Presenting a case for similar characteristics in navigational disorientation and mind wandering.
2) Presentation and implementation of strategies to expose and resolve disorientation experienced by students in an online module of Java programming course.

Rest of the paper is structured as follows. Section II discusses the related work. Section III discusses the proposed approach, then section IV details our experiment design. We discuss the findings and implications of the study in Section V and V-E, with conclusions in Section VI.

II. Related Work

Adda et al. [16] define disorientation as the difficulty of relating initial browsing project to the navigational path that ensues, due to cognitive overload experience by the learner. Conklin defines disorientation as "a tendency of losing one's sense of location and direction in a non-linear document such as hypertext." [2]. According to Kahn [17], disorientation is the failure of understanding or making connection between two pieces of information read by the learner. Similar accounts of disorientation have been reported in literature under the term "mind wandering". Smallwood and Schooler define mind wandering as "a shift of attention away from a primary task toward internal, task-unrelated information [18]. They term it as a difficult to observe and measure phenomena because of its non-explicit and unintentional nature. [19]. Several studies [20]–[22] have shown talking and texting on mobile phone to be external distractions which result in mind wandering, and can impair performance such as driving. Lab studies have revealed students having a sudden realization of mind wandering while skimming through the words without understanding the gist of the content [23]. Such unintentional mind wandering can also be an indicator of ADHD [24], making it difficult for the student to focus on the task on hand. We fuse the interpretation of the term disorientation by combining the effect of "virtual relocation in hyperspace" (navigational disorientation) with "mental relocation" (mind wandering). Our work aims to establish that in both the cases, learners in a web-based learning environment has to reorient themselves to their learning goals. Thus from hereon, we refer to both of these phenomenon as disorientation.

Users' ability to navigate freely in an open-corpus web-based learning environment places an additional responsibility on the learners: navigating through a plethora of resources and orienting themselves with respect to the task. This multitasking results in the learner not being able to focus on their learning task. Studies carried out to understand the correlation between disorientation and learning outcomes suggest that learners sometime feel less motivated to use web-based educational systems because of decline in their learning performance [25]. Missing relevant content while being in a state of disorientation may cause a decrease in students' learning performance [26]. Edwards [13] also acknowledge disorientation as a cause of degraded performance of a learner. Szpunar et. al communicate the prevalence of disorientation in educational environments [27]. Studies also show a negative correlation between disorientation and task performance [18], [28]. Individuals with low WMC reported higher rates of disorientation while studying [29]. Kane et. al [30] relate WMC with disorientation by stating that possessing high WMC yields less chances of mind wandering during attention demanding activities. Joseph M. et al [31] also describe the credibility of working memory in the academics. Based on the work citing the correlation between disorientation and WMC, we incorporate measures of WMC to utilize as a means of identifying disorientation caused by learners limited attention span and high level content. We utilize operation span test to calculate the WMC of a learner to resolve disorientation caused by factors other than being lost in the hyperspace.

III. High level architecture of proposed system

The system mainly consists of three components namely Learner Module (LM), Course Module (CM) and Disorientation Module (DM). Figure 1 illustrates the high level architecture of proposed system. The composition of each individual module is detailed in [15].

A. Learner Module

The system performs learner modeling for detecting disorientation. User profile is developed using information acquired from registration, OSPAN (Operation Span Task) scores and module test scores. Initially, the user logs in with his/her roll number and provides registration details (demographic

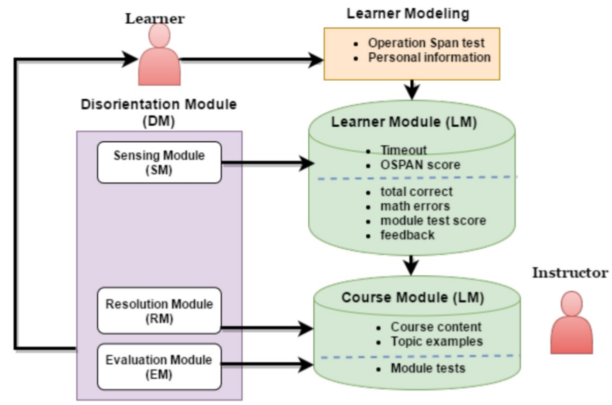

Fig. 1. High level architecture of proposed system

information consisting of user's name, gender and age), after which OSPAN test is presented to the user. The logical nature of content in Java Programming course lead us to select OSPAN test for measuring attention span of the students. For this study, an automated version of OSPAN test has been developed as described by Nash Unsworth et.al [32]. At the end of task, system reports three scores namely OSPAN score, math errors and timeout.

B. Course Module

Course Module (CM) stores the course contents and their structure. It consists of all a specific course's contents, description of division of each module into sub-modules, and module specific tests used to measure learner's knowledge gain. For our experiment, CM consists of course contents of Java Programming divided into sub sections. No more than 5 lines of text are stored into each subsection. Each module also stores its relevant examples and subsequent module test.

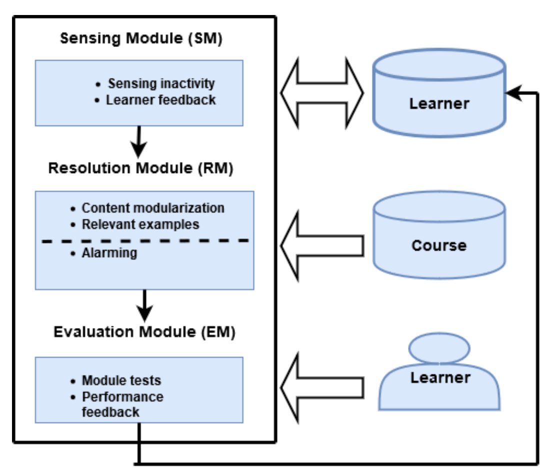

Fig. 2. The Disorientation Module

C. Disorientation Module

Our system incorporates the Disorientation Module (DM) for performing the functions of sensing and resolving disorientation, and system evaluation. It comprises of three components namely Sensing Module (SM) and Resolution Module (RM) to sense and resolve disorientation, and Evaluation Module (EM) to evaluate the system based on user performance and feedback. Figure 2 describes interactivity of components in DM.

1) Sensing Module: Sensing module is the most important component in DM as it identifies and categorizes disorientation, and activates suitable resolution strategy for the occurrence of particular kind of disorientation. SM periodically checks for inactivity by keeping a check of the time elapsed since the last scroll or click by comparing it with time threshold (obtained from OSPAN test of learner). If the timeout elapses without the user interacting with the system, system displays a modal to determine the type of disorientation encountered. We adopt this method to detect the first two kinds of disorientation specified by Bhatti et al. [15] namely back to square one and high level content, which can both result in disorientation caused by mind wandering. The given feedback determines the kind of strategy to be adopted.

2) Resolution Module: After SM passes information to RM, RM adapts course contents based on the type of disorientation encountered. For "Show me more examples", an indicator of high level content, system presents examples relating to the topic. Figure 3 shows an example for a subtopic in module one.

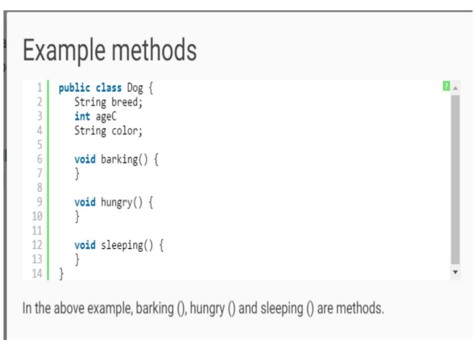

Fig. 3. Example for subtopic "Methods"

For "I can't grasp the content", the content is further modularized by showing lesser content. Figures 4 and 5 show the transaction from more content to lesser content. For every occurrence of external distraction such as "I was distracted by noise/phone", user is simply alarmed about their distraction.

3) Evaluation Module: Proposed system is evaluated by taking subject-oriented tests followed by performance feedback from the learner. Evaluation Module (EM) is made up of two components including module tests and feedback form. Each topic in course module is followed by a module test related to the subject material of the topic, consisting of 10 multiple choice questions derived from the course content. The total score for test is 100, each correct question carrying 10 points. Module test scores determine the learning performance.

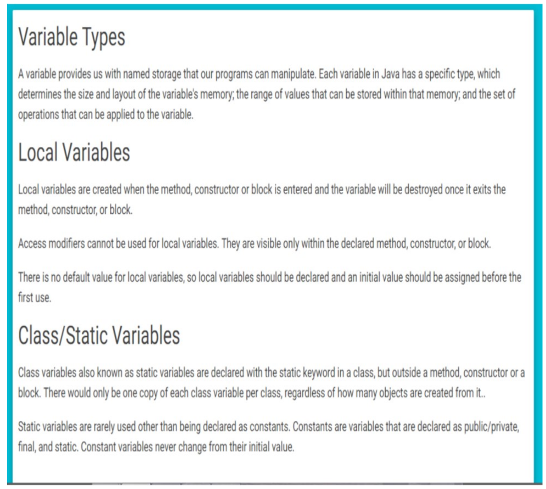

Fig. 4. Complete topic displayed in course module one

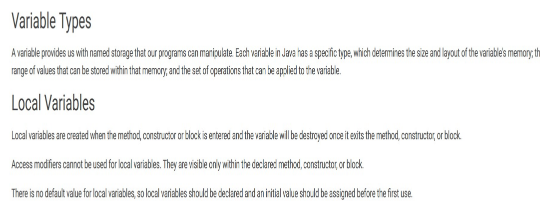

Fig. 5. Modularized topic for users with limited attention span

Proposed system exploits ease and neutrality of feedback mechanism by presenting an embedded Google form with evaluation parameters set on the Likert scale. Users rate the application on the basis of ease of course contents, effectiveness of examples provided and effectiveness of system to resolve disorientation. They could also provide additional comments regarding the system. The results acquired by EM determine user satisfaction and overall impact on learning of user.

IV. Method

We used true experimental design to explore the relatedness of disorientation with overall learning of students in a web-based learning environment. In our experiment, the independent variable was disorientation, while the dependent variable was learning outcome of the students. Based on the occurrence of disorientation, course contents were adapted to suit the learner's knowledge level. Participants were evaluated by using two preliminary course topics from Java Programming course, to demonstrate the effectiveness of our proposed model.

A. Study participants

36 participants were selected for a session of the course titled Object Oriented Programming (OOP). All participants

TABLE I
PARTICIPANTS' DEMOGRAPHIC INFORMATION

Gender	Percentage
Male	55%
Female	45%
Age	**Percentage**
18-20	56%
21-23	45%
Midterm Score	**Percentage**
20-25	61%
26-30	39%

were enrolled in second semester course OOP taught to undergraduate classes in the institute. To ensure that the participants had the same level of prior knowledge regarding the course, only students who scored more than 20 out of 30 marks in midterm test of OOP were selected. Contact numbers of all participants were registered before the session. Incentives offered were participation certificates for completing the lessons. None of the students were enrolled in the course offered by any of the authors during that semester. The demographic information of the participants is given in table I.

B. Course description

Our tested application covered two preliminary topics named "Objects and Classes" and "Variables types". Each topic had two relevant programming examples to illustrate their usage. Course contents are derived from "Java Programming" section of a popular online tutorial's library named Tutorials Point. This course material has been refined over the course of many years and is freely available. Course contents presented in this session were purely text and image based, no video or audio lectures were provided. Learners navigated through topics ranging from preliminary to advanced.

C. Experimental setup

Course lessons were administered into a laboratory for system evaluation. Participants were randomly assigned to control and experimental group by giving them a user type. Control group's session did not have a DM, while the learning session of experimental group had DM incorporated in it. Participants were allowed to keep their cell phones, and were specifically advised to switch off the silent mode. The session was administered by the researcher and two instructors at the institute.

An introductory session was arranged to brief participants about working of the system. Participants from both groups logged in by entering their user type and roll numbers in the log-in screen. When the participant first registered and logged into the system, his/her demographic and personal information was collected. It was followed by OSPAN. For experimental group, the course contents displayed incrementally according to their OSPAN score, whereas the control group had all course materials were displayed in their entirety.

Participants of both groups were exposed to different kinds of disorientation. Participants were also allowed to browse the internet during the learning session. Periodically, some distracting factors such as calls and SMS on participants' phone, and knocks on the laboratory door were introduced. Topics higher than the knowledge level of participants (determined by the midterm test scores) were also introduced as distractions.

Module tests were taken after the learning session from both group of participants. The scores from both groups were analyzed to determine the correlation between disorientation and learning outcomes. Participants were also asked for feedback regarding the system based on 5-point Likert scale, for gathering user satisfaction regarding the proposed approach. Figure 6 shows the flow of test procedure.

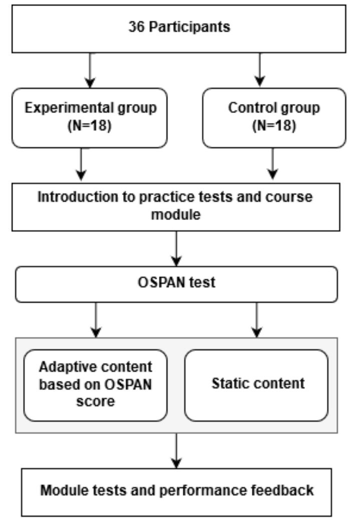

Fig. 6. Test procedure flow

V. FINDINGS AND OBSERVATIONS

This section presents our findings and observations from study of the implemented system, and the causes and effects of our results.

*A. **RQ1: Factors constituting disorientation***

"Internet issues (distracted)"
"Network problem (page reloading without my satisfaction)"

85% of 36 participants in both control and experimental group reported to have experienced disorientation during e-learning. Most participants selected *external factors* such as social media, noise and internet connectivity issues as primary distracting factors. Other responses included feeling hungry and bored. When asked about the type of distraction experienced, majority of users rated distraction by phone or social media as their primary distraction, followed by high level content and limited attention span. Participant responses aligned with our definition of disorientation, which accounts for factors other than navigation to be the cause of a learner's lack of knowledge gain in a web-based learning environment.

B. *RQ2: Efficacy of course design to orient learners*

"Theory section is little bit annoying so in my assumption text should be reduced in every section"

69% participants from experimental group went towards additional examples to understand the concept, pertaining to disorientation caused by high level content. The remaining half reported to have the required background knowledge, because of which they did not need to see additional examples. The course structure and examples used in the study were taken from the popular e-learning website "Tutorials Point". In spite of the fact that most of the users found course distribution and module tests satisfactory, additional comments in the feedback (both obtained during the study, and given to the researcher offline) indicated the necessity of having a good instructional design. The right amount of text coupled with adequate examples can help in engaging students, as students sometimes felt overwhelmed by the text, and needed more graphics or code examples to grasp the concepts. Other things that students wanted to be incorporated in the system include easier examples and programming exercises in the module tests.

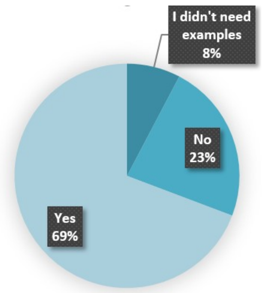

Fig. 7. Ratio of participants who used examples to cope with disorientation caused by high level content

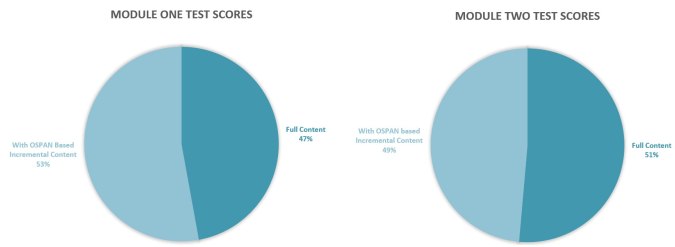

Fig. 8. Comparison of test scores for control and experimental groups

C. *RQ3: System performance and learning outcomes*

"There should be a timer upside to tell the user that he/she is running out of time."

"The delay at which the distraction message was being displayed should be elongated as it wasn't giving enough time to be able to read the course completely."

Around 67% users, constituting the majority, found the application interface easy to use. Obtained comments and feedback show user's satisfaction with learning process. For some participants, frequent appearance of feedback modal proved to be distracting instead of being a means to orient them towards the task. Apart from displaying the feedback modal, participants desired to have graphical representation of their calculated attention span. Finally, participants in the experimental group had 6% and 2% improved scores from participants in control group, in test module one and two respectively. There was 8% accumulative increase in test scores of both modules for experimental group. Figure 8 show the side by side comparison of scores from both modules. In their feedback, around 62% participants from the experimental group expressed that they the system to be effective in resolving disorientation during their learning session.

D. *Threats to Validity*

The level of disorientation experienced by control and experimental groups to see if it was equivalent across conditions has not been measured. The students in the institute are generally strictly invigilated to stop any occurrence of cheating during the examination. However, the nature of experiment did not allow us to actively check for instances where students copied or sent answers to test questions via SMS or phone, which could have an impact on the test score results.

E. *Discussion*

Students complained about their session being disrupted by network connectivity problems. The lab where the study session was administered had a back up power generator, but it took a while for it to start in case of power failure. Because power outages are unpredictable and inevitable in most places in Pakistan, this was not in researcher's ability to control them. However, we relate these issues to a type of disorientation caused by external factors, which hinders the learning performance. Although not part of the experimental setup, these issues added to the function of distracting students.

One participant showed discontent over the selection of examples provided for resolving disorientation caused by facing high level course contents. User feedback suggested that with proper course structuring and examples, the system's performance could be improved. The expressed the need of having tailored examples and snippets of basic information to go with each topic for the learner to be rooted towards the course, providing hands on programming exercises and adaptive feedback were some of the desired elements in an online programming course.

Overall, participants in experimental group performed better under same disorienting conditions. Some participants attributed their low scores in the module tests to course design than system's ability to resolve disorientation. Many students did not understand that frequent appearance of feedback modal was an indicator of their limited attention span and WMC, as obtained from their OSPAN score. Hence for some students, the feedback modal itself seemed to be distracting, necessitating a graphical representation of their calculated attention span. This was not part of the system design, but could be interesting to incorporate as an implicit method of controlling disorientation.

VI. Conclusion and Future Work

Researchers have been significantly attracted to web based learning systems lately, many of which address issues in different educational domains. One dominant issue in such systems is disorientation, which negatively affects learning outcomes of a student, causing the learners to reorient themselves to their learning goals. This study set out to investigate what factors constitute disorientation, and how it affects the learning outcomes of a student in an online programming course. Findings indicate that mental relocation has similar distracting effects on a student as navigational relocation. We present a case of disorientation which includes navigational and mental relocation based on their similar characteristics. Some research directions propounded by feedback from participants include exposing and resolving disorientation in collaborative e-learning environments and campus management systems (cMS). We also aim to devise effective evaluation strategies to assess system performance and students' learning performance. Finally, identification of disorientation caused by different degrees of mental and physical impairments is also a considerable research direction.

References

[1] O. R. Zaíane, "Building a recommender agent for e-learning systems," in *International Conference on Computers in Education, 2002. Proceedings.* IEEE, 2002, pp. 55–59.

[2] J. Conklin, "Hypertext: an introduction and survevj," *Computer*, vol. 20, no. 9, pp. 17–41, 1987.

[3] R. E. Beasley and M. L. Waugh, "Cognitive mapping architectures and hypermedia disorientation: An empirical study." *Journal of Educational Multimedia and Hypermedia*, vol. 4, pp. 239–55, 1995.

[4] J. Nielsen, "The art of navigating through hypertext," *Communications of the ACM*, vol. 33, no. 3, pp. 296–310, 1990.

[5] N. Hammond, "Hypermedia and learning: Who guides whom?" in *International Conference on Computer Assisted Learning*. Springer, 1989, pp. 167–181.

[6] S. McDonald and R. J. Stevenson, "Effects of text structure and prior knowledge of the learner on navigation in hypertext," *Human factors*, vol. 40, no. 1, pp. 18–27, 1998.

[7] S. Chen, "A cognitive model for non–linear learning in hypermedia programmes," *British journal of educational technology*, vol. 33, no. 4, pp. 449–460, 2002.

[8] E. C. Shin, D. L. Schallert, and W. C. Savenye, "Effects of learner control, advisement, and prior knowledge on young students' learning in a hypertext environment," *Educational Technology Research and Development*, vol. 42, no. 1, pp. 33–46, 1994.

[9] H. van Oostendorp and I. Juvina, "Using a cognitive model to generate web navigation support," *International Journal of Human-Computer Studies*, vol. 65, no. 10, pp. 887–897, 2007.

[10] J. R. Hill and M. J. Hannafin, "Cognitive strategies and learning from the world wide web," *Educational technology research and development*, vol. 45, no. 4, pp. 37–64, 1997.

[11] F. Rezende and S. de Souza Barros, "Students' navigation patterns in the interaction with a mechanics hypermedia program," *Computers & Education*, vol. 50, no. 4, pp. 1370–1382, 2008.

[12] L. P. Dringus, "Towards active online learning: A dramatic shift in perspective for learners," *Internet and Higher Education*, vol. 2, no. 4, pp. 189–95, 2000.

[13] D. Hardman and L. Edwards, "Lost in hyperspace': Cognitive mapping and navigation in a hypertext environment," *Hypertext: Theory into practice*, pp. 105–145, 1989.

[14] C.-M. Chen, H.-M. Lee, and Y.-H. Chen, "Personalized e-learning system using item response theory," *Computers & Education*, vol. 44, no. 3, pp. 237–255, 2005.

[15] N. Bhatti, I. A. Ismaili, and L. D. Dhomeja, "Identifying and resolving disorientation in e-learning systems," in *2017 international conference on communication, Computing and Digital Systems (C-CODE).* IEEE, 2017, pp. 169–174.

[16] S. Ait Adda, N. Bousbia, and A. Balla, "A semantic analysis of the learner's disorientation." *International Journal of Emerging Technologies in Learning*, vol. 11, no. 6, 2016.

[17] P. Kahn and G. P. Landow, "The pleasures of possibility: What is disorientation in hypertext?" *Journal of Computing in Higher Education*, vol. 4, no. 2, pp. 57–78, 1993.

[18] J. Schooler and J. SMALLWOOD, "The restless mind," *University of British Columbia Psychological Bulletin*, vol. 132, no. 6, pp. 946–958, 2006.

[19] J. Smallwood and J. W. Schooler, "The restless mind." 2013.

[20] D. L. Strayer and F. A. Drews, "Cell-phone–induced driver distraction," *Current Directions in Psychological Science*, vol. 16, no. 3, pp. 128–131, 2007.

[21] D. L. Strayer, F. A. Drews, and W. A. Johnston, "Cell phone-induced failures of visual attention during simulated driving." *Journal of experimental psychology: Applied*, vol. 9, no. 1, p. 23, 2003.

[22] J. K. Caird, C. R. Willness, P. Steel, and C. Scialfa, "A meta-analysis of the effects of cell phones on driver performance," *Accident Analysis & Prevention*, vol. 40, no. 4, pp. 1282–1293, 2008.

[23] J. W. Schooler, "Zoning out while reading: Evidence for dissociations between experience and metaconsciousness jonathan w. schooler, erik d. reichle, and david v. halpern," *Thinking and seeing: Visual metacognition in adults and children*, vol. 203, 2004.

[24] M. S. Franklin, M. D. Mrazek, C. L. Anderson, C. Johnston, J. Smallwood, A. Kingstone, and J. W. Schooler, "Tracking distraction: The relationship between mind-wandering, meta-awareness, and adhd symptomatology," *Journal of attention disorders*, vol. 21, no. 6, pp. 475–486, 2017.

[25] R. D. Ruttun and R. D. Macredie, "The effects of individual differences and visual instructional aids on disorientation, learning performance and attitudes in a hypermedia learning system," *Computers in Human Behavior*, vol. 28, no. 6, pp. 2182–2198, 2012.

[26] T. Mitchell, S. Y. Chen, and R. Macredie, "Cognitive styles and adaptive web-based learning," *Psychology of Education Review*, vol. 29, no. 1, pp. 34–42, 2005.

[27] K. K. Szpunar, S. T. Moulton, and D. L. Schacter, "Mind wandering and education: from the classroom to online learning," *Frontiers in psychology*, vol. 4, p. 495, 2013.

[28] E. F. Risko, N. Anderson, A. Sarwal, M. Engelhardt, and A. Kingstone, "Everyday attention: Variation in mind wandering and memory in a lecture," *Applied Cognitive Psychology*, vol. 26, no. 2, pp. 234–242, 2012.

[29] N. Unsworth and B. D. McMillan, "Mind wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience." *Journal of Experimental Psychology: Learning, Memory, and Cognition*, vol. 39, no. 3, p. 832, 2013.

[30] M. J. Kane, L. H. Brown, J. C. McVay, P. J. Silvia, I. Myin-Germeys, and T. R. Kwapil, "For whom the mind wanders, and when: An experience-sampling study of working memory and executive control in daily life," *Psychological science*, vol. 18, no. 7, pp. 614–621, 2007.

[31] J. M. La Lopa and G. Hollich, "The critical role of working memory in academic achievement," *Journal of culinary science & technology*, vol. 12, no. 3, pp. 258–278, 2014.

[32] N. Unsworth, R. P. Heitz, J. C. Schrock, and R. W. Engle, "An automated version of the operation span task," *Behavior research methods*, vol. 37, no. 3, pp. 498–505, 2005.