Self-Reported Cognitive Effects of AI Applications on Learning

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The purpose of this article is to assess whether cognitive abilities of college-level learners have been impacted, positively or negatively, by their use of AI tools. An 18-questions survey was administered at a U.S. public polytechnic university with 161 respondents, with the goal of measuring changes learners have noticed in their learning behavior and cognitive functioning since they started using AI tools in their coursework. Three separate one-sample t-tests were conducted and showed significant effect for cognitive skill erosion: $t(160)=10.816$, $p<0.05$, Cohen's $D=0.852$; Memorization issues: $t(160)=6.7$, $p<0.05$, Cohen's $D=0.52$; and Lack of in-depth understanding: $t(160)=9.6$, $p<0.05$, Cohen's $D=0.76$. However, 85.7% said that motivation to do coursework hasn't declined since they started using AI, and 74.5% agree that AI has an overall positive effect on their learning. Roughly equal number of participants feel they are becoming dependent on AI (48.5% yes and 51.5% no). Given the results, it is reasonable to conclude, at this time, that AI usage in college coursework can have significant consequences on the cognitive abilities of learners.

Keywords: AI, cognition, learning, education, ChatGPT

INTRODUCTION

Cognitive functions are mental processes involved in acquiring knowledge, reasoning, and manipulating information (Kiely, 2014). These mental abilities include, among others, attention, knowledge acquisition, thinking, remembering, problem-solving, decision-making, and language abilities. Most of these functions occur in three areas of the brain: the frontal lobe, cerebellum, and basal ganglia (Leisman et al, 2016), and are developed from infancy. This is enabled by networks of synapses that interconnect nerve cells, as well as the ongoing refinement of neurons as they adapt to the specific roles they play within their synaptic network (Shonkof & Phillips, 2000). Furthermore, these three areas of the brain are responsible for memory formation and storage, and thus are central to learning and knowledge acquisition.

At the risk of stating the obvious, we are in the midst of an unprecedented period of extensive technological developments, with the most recent examples being in the domain of Artificial Intelligence (AI). The recent release of sophisticated tools capable of general-purpose language understanding and generation is notable. Such AI language models (e.g., ChatGPT) have access to enormous amounts of data and, when queried, produce uncannily human answers. Furthermore, they are becoming widely available to the general public, including learners of all ages. Thus, it can be argued that there is no longer an objective

need for long thinking processes and logical reasoning when dealing with a problem (i.e., an academic one), as there is an easier path of turning to AI models for instant answers, despite the risk of erroneous, incomplete, or even biased answers. This poses a question of how access to artificial intelligence tools will impact the cognitive functions of their users and, in particular, learners.

There have already been some psychological phenomena documented when it comes to the relationship between the brain and information technology. For example, the "Google Effect" is a tendency of not committing new valuable information to our memory because we know it is easily accessible online (Sparrow et al., 2011). This propensity of our brains to forget information because we are assured that it is readily available to us on-demand, through our digital devices or search engines, is often referred to as digital amnesia. It is logical to assume that these ramifications are not reversible simply because the technology is becoming even more easily accessible and the information similarly more readily available for access to a wider population than ever. Thus, our recourse is to understand and mitigate such ramifications. The speed of technology adoption is also accelerating. It is a fact that AI applications, especially language models, have been adopted quickly and broadly in educational settings, and are used most commonly by learners for their coursework, both with and without permission from instructors. While some have already forecasted risks and consequences as a result of AI applications in education, such as reduced capacity for critical thinking, declined memory attention (Bai et al., 2023), others claim that this might actually increase motivation and engagement (Ali et al., 2023; Yildiz, 2023). Thus, this research aims to assess whether cognitive functions of college-level learners have been positively or negatively impacted by their use of AI tools.

MOTIVATION

Ever since AI became better-known to a wider audience of our society, the period of which can be reasonably traced back to the end of 2022 when ChatGPT first appeared, a debate, perhaps even concerns, have emerged regarding the impact of these tools on everything and everyone but particularly on the education system. Probably the most obvious reason for these worries was the sudden outburst of plagiarism-related issues that academic institutions across the world have suddenly started to experience. As a result, one segment of these educational institutions developed measures limiting, or in some places even banning entirely, the usage of AI tools in coursework, while another segment encouraged such use arguing that, with appropriate restrictions, it enhances students' engagement.

The main motivation for this research is to better understand the impact that AI tools can have on college level learners, specifically reporting on changes in cognitive processing that they have noticed. By gaining such understanding of these issues, appropriate strategies and interventions may be developed toward eliminating or reducing negative effects that learners report as a result of using AI tools in their education, and maximizing the positive ones. The goal is to mitigate the consequences of overreliance on AI, which lead to overdependence, by deepening learner engagement with the material, offering a personalized approach to conveying content and coursework, and increasing motivation to acquire knowledge. The results of this work will, first and foremost, be of importance to educators, those directly involved in teaching and the developing course content, and teaching, at all levels, as it will provide insight into learners' approaches and concerns when it comes to using AI for such purposes. In addition, higher education institutions and policy makers can find value in this work as well, and use it to inform the development of instructional programming and strategies on the topic of AI usage in education.

LITERATURE REVIEW

The most commonly investigated cognitive function impacted by technology is attention. This is not surprising considering the constant stimuli we are exposed to when using technological devices (e.g., common notifications, working in multiple tabs, seconds-long videos on social media, etc.). As the intensity of these stimuli increases, the level on which we interact with them decreases, now known as a behavioral pattern called "media multitasking".

Early researchers who studied media multitasking hypothesized that those who are more exposed to it will perform better in attentional task-switching tests–because they "practice" it when engaging in media multitasking (Ophir et al., 2009). However, research results showed the opposite, and analysis suggested that those who engage in frequent and extensive media multitasking show worse attention abilities because they are too susceptible to irrelevant environmental stimuli and distractions.

These results were also supported by MRI imaging of the brain observed while subjects performed attentional tasks (Moisala et al., 2016). Specifically, those who spend more time in media multitasking exhibit worse performance in attentional tasks and increased activity in the right prefrontal cortex (brain region responsible for attention) during those tasks. In other words, those who spend more time in intensive media use require more effort and focus top-down control to complete an attention task.

Language processing is an important cognitive function, most rapidly developing within the first couple of years or life. From a neuroscientific perspective, extensive media use is related to decreased brain white matter pathways responsible for reading and language (Hutton et al., 2020), as well as decreased brain connectivity between areas responsible for word recognition, language and cognitive control, and executive brain functioning (Horowitz-Kraus & Hutton, 2018). This was similarly established in other research showing that children with a higher amount of screen time demonstrated significantly poorer language development (Horowitz-Kraus&Hutton, 2018; Duch et al., 2013; Tomopoulos et al., 2010). However, it is worth noting that children, as more impressionable beings and their brain still being in the development phase, are more prone to these negative effects than adults.

Another cognitive function impacted by technology is memory. Researchers have investigated a commonly asked question, whether easy access to countless information on the internet will affect our semantic memory (i.e., memorizing facts). Their work has demonstrated that our ability to immediately access information online causes the tendency not to remember the information we read because we know it is easily accessible, a phenomenon known as "Digital Amnesia" or "The Google Effect" (Sparrow et al., 2011).

These and other similar important studies were conducted during a time when the internet was becoming more and more accessible. However, none of these studies reflected the recent proliferation of AI that we are currently subjected to. Hence, the impact of new technology, specifically AI, is presumed to have changed what we have known recently. For example, Sparrow's findings reflected changes in semantic memory, which only refers to memorizing facts, while other memory aspects were unaffected. However, now, we not only have access to information online, but to language models, such as ChatGPT), that can easily write an essay within seconds, or present us with step-by-step instructions for something that we would once have had to figure out by ourselves or by researching multiple information sources. It is, thus, reasonable to postulate that as technology, including AI, advances, the same and other aspects of our cognition are bound to be affected in the future as well.

A relevant cognitive process is motivation. Specifically referencing motivation in the context of learning, an obvious assumption may be that the presence of AI decreases motivation because learners no longer "have to" complete certain common tasks, such as essays, reflections, analyses, or even writing programming language code because these can be generated within seconds by ChatGPT. However, this does not appear to be the case, as already research studies agree that the integration of AI in coursework and academic environments greatly increases learner motivation (Ali et al., 2023; Yildiz, 2023; Moybeka et al., 2023; Huang et al., 2023). At the same time, it is important to note that these studies also call for caution on other fronts including possible ethical breaches when AI is introduced into the learning environment without adequate planning.

More recent research has motivated our work. A review of the opportunities and challenges (Sok & Heng, 2024) regarding the implementation of AI in higher education cited assessment innovation, instructional support for writing, remote learning, and research development as some of the benefits; while overreliance, security and privacy, learning assessment, and information accuracy are cited as negative effects. Others (Bai et al., 2023) highlighted the existence of both positive and negative effects of AI's content generation tools, such as ChatGPT, on learning and memory, taking into consideration basic ChatGPT functionalities (conversation, language translation, educational aid, coding, and creative content

generation). The positive effects include personalized learning, round-the-clock support, repetition and spaced learning, interactive learning, and reduced pressure; while the negative effects are overreliance on AI, impaired critical thinking, decreased motivation, reduced human interaction, superficial engagement, and accuracy of information.

Similar findings were also reported (Adiguzel et al., 2023) on productivity, engagement, and learning outcomes that may improve due to AI's integration, but also suggested that the ethical and practical risks need to be accounted for. Other researchers also reached the same conclusions (Baido-Anu & Anash, 2023; Firat, 2023; and Halaweh, 2023).

These research efforts have proposed the potential for positive and negative effects. In our work, we have constructed a survey, largely based on the cognitive effects that have been suggested in this recent research, to investigate whether college learners have, to their knowledge, experienced them.

METHODS

A survey consisted of 18 questions, including multiple choice questions, 4-point Likert scale questions, matrix questions, open-ended questions, and close-ended questions. The survey was completely anonymous to promote greater disclosure of sensitive or stigmatizing information among participants, and demographic data was collected solely for statistical purposes.

Participants were full-time and part-time college undergraduates from a R 1 Research University in the United States. To achieve more generalizable results, the survey was administered to learners in courses from different disciplines, including Computing, English, Humanities and Social Sciences, Philosophy, and Science, Technology, and Society. Learners completed the survey randomly and voluntarily, and were not compensated for their participation. The last question in the survey was an open-ended question asking learners whether there is an aspect of AI in education relating to cognitive functions that we did not ask but they felt was important. The question gave the researchers insight into the learners' experience completing the survey and was not part of the final statistical analysis presented in this article. The results from the survey were analyzed using the SPSS Software. A one-sample t-test was conducted to investigate the effect of AI usage on cognitive erosion, memorization issues, and lack of in-depth understanding of coursework.

RESULTS

Demographics

A total of 161 learners participated in the survey. The mean age of the participants was 20.4 with a standard deviation of 2.82. As for gender, 26.1% of participants were female, 72.7% were male, and 1.2% identified as "Other". The male/female proportion was expected, given the research was conducted at a polytechnic university with a significantly larger male population. The largest part of the participants had a freshman (first-year) class standing (35.4%), followed by juniors (29.8%), sophomores (23.6%), and seniors (11.2%). Full-time students comprised 98.8% of the participants, with part-time students being 1.2%. The majors (field of study) of the participants were as follows: Architecture/Design (3.7%), Business/Management (3.7%), Computing (63.4%), Engineering (19.3%), Humanities/Liberal Arts (5%), Science (4.3%), and Other (0.6%). Again, given that the survey was conducted at a polytechnic university, the prevalence of computing majors was expected.

Technology and AI Usage

Not surprisingly, an overwhelming 98.1% of the participants answered "yes" to whether they use computing technology when doing their college coursework. 157 participants were willing to report on the average number of hours they spend using technology for their coursework per week. The overall average number of hours was 11.7 with a standard deviation of 11.8 and variance of 138.8, suggesting a wide range of average hours reported. When asked how often they use it, the responses were as follows: "Always or almost always" (34.2%), "Frequently" (32.3%), "Sometimes" (23%), "Infrequently" (9.3%), and "Never or very rarely" (1.2%). Out of those, 99.38% said they use the internet for their coursework, 91.3% said they

use Smartphone and Web Applications, 67.8% said they use AI tools, and 1.9% selected "Other". In addition, 64% said they use generative AI tools, such as ChatGPT. Given that AI tools are relatively new, this percentage of learners using them can be considered quite high. Out of those that answered "yes" to the previous question, when asked what type of generative AI do they use in their college coursework, 94.3% answered ChatGPT, 17.2% for BingAI, 3.3% for Dall-E, 5.7% for Google Bard, and 2.5% for "Other".

As for how likely they are to use AI for their coursework, 10.6 percent selected "Very likely", 43.5% voted "Likely", 35.4% selected "Unlikely", and 10.6% selected "Very unlikely".

Effects of AI Usage

The majority of participants (74.6%) agreed that when they use AI for their coursework, they appear to show higher levels of learning. However, that comes with concerns about plagiarism that 69.6% of learners reported having in those situations. As for cognitive effects, 21.7% reported they have had difficulties memorizing information or analyzing coursework material more than before, but a twice as big percent (42.2%) agreed that they may have been experiencing an erosion of cognitive skills since they started using AI in their coursework. In addition, more than a third (36.6%) reported lacking an in-depth understanding of the topic when they use AI. Despite this, the vast majority (74.5%) of participants believe that AI positively impacts their learning, and 85.7% say that their motivation for learning has not decreased significantly.What came as a surprise, and perhaps brings up concerns, is that more than half of participants (55.3%) reported that they are more likely to ask an AI than a professor when they have a question about the coursework material. In addition, 40.4% are more likely to ask AI than a classmate, and 60.8% are more likely to ask AI than a parent. This also comes as a surprise given that 70.8% of participants stated they have received incorrect information from AI.

STATISTICAL ANALYSIS

The *t*-test for the erosion of cognitive skills as a result of AI usage in learners revealed a significant effect, $t(160)=10.816$, $p<0.05$, Cohen's $D=0.852$, indicating a large effect size.

The same one-sample t-test was also used to determine the effect of AI on memorization issues. The t-test showed $t(160)=6.7$, $p<0.05$, Cohen's D=0.52, indicating a significant effect with medium effect size, less than the cognitive erosion *t*-test.

The t-test for lack of in-depth understanding indicated $t(160)=9.6$, $p<0.05$, Cohen's D=0.76, indicating a significant effect with a medium effect size.

In addition, there is a moderate positive linear relationship (Pearson coefficient=0.4) between the lack of in-depth understanding of a topic and motivation drop, indicating that those who have reported lacking understanding of coursework material when using AI are likely to become demotivated.

Furthermore, a moderate positive linear relationship (Pearson correlation=0.31) was found between positive impact and likelihood of using AI, meaning those who believe that using AI positively impacts their learning were more likely to use it.

A moderate to strong positive linear relationship (Pearson coefficient=0.43) was also shown between dependance on AI and cognitive skill erosion, indicating those who feel they are becoming dependant on AI to do their coursework are more likely to report erosion of cognitive skills such as problem solving, critical thinking, etc.

DISCUSSION

Before discussing the results, it is important to note that these data were obtained from self-reported measures in a survey, meaning that the given results are a product of how learners feel that their use of AI tools has impacted them. Whether or not this feedback is consistent with any biological changes in the brain representing a potential effect on cognitive skills is a question for future research and does not fall within the scope of this paper.

With this background, when looking at the t-test results, one can conclude that learners feel the usage of AI has significant effects on their cognitive skill erosion, memorization issues, and lack of in-depth understanding, with a large effect size present for cognitive skill erosion, and medium effect sizes for memorization issues and lack of understanding. These results suggest that the integration of AI tools in higher education needs to be considered with extreme precaution, and calls for a precisely developed system and set of rules with the aim to minimize any negative effects. While such tools present many positive possibilities for the development of educational delivery and learning approaches and have already proven helpful and useful in several settings, they must not replace the engagement of students' cognitive and problem-solving skills. This is true for any level of education, especially since the adolescent brain is normally still in the development phase during the traditional period these learners enter college.

The moderate to strong positive linear correlation between the dependence on AI and cognitive skill erosion brings up concerns about how the too frequent usage of AI tools for coursework negatively affects cognitive skills. This is consistent with most psychological dependence situations that result from easy access to information we need to remember or construct ourselves, and is also along the lines of the "Google Effect" phenomenon we previously referred to earlier in the paper. It is also important to note that, just like with any other digital or real-life "substance", becoming overly dependent on AI is not only a possibility, but a threat that can easily rise up, especially given the easy access to these tools. As with any other addiction, this one too has a potential for consequences on the human (especially child or adolescent) brain that surpasses problem-solving or logical skills. While addiction to AI was not a topic we considered in this work, the Pearson correlation between dependence on it and experiencing cognitive erosion is an important thing to consider in future research.

Another positive linear relationship found was between the lack of in-depth understanding and motivation drop. While this is not a surprising finding, given that the inability to understand or comprehend a topic in a certain course is not uncommon to lead to a feeling of hopelessness or demotivation in learners, it is still important to understand the exact role of AI in such an issue. A possible explanation is that learners may turn to AI hoping for a better understanding of a topic and to gain a different explanation and perspective, or a more personal approach than the one they may have gotten from a different source. However, the problem arises when instead of using AI tools for a deeper understanding, the accessibility of information becomes tempting to use it to simply answer homework questions, and do assignments or quizzes using AI, without having to think or understand the topic at hand. The speed at which ChatGPT can write an essay or answer an exam question, and the temptation for a better grade that the learner expects, often results in the simple input of the question into the chatbot, and copying the answer without giving it much thought. If, due to the instructor's approach or the nature of the class, this shows results (in terms of better grades), the students are likely to experience less and less motivation, knowing that they can pass the class by simply inputting assignments into a chatbot, and not having to spend their time learning the material. Here too, a possible explanation is the "Google Effect" where learners are aware that any information they can spend time learning, is way too easily accessible through AI tools, hence lowering their motivation to learn and practice it. This may be the area where instructors can have the most impact, and carefully create the structure of their lectures following the AI era (e.g. avoiding giving assignments easily answered by AI chatbots, practicing applied knowledge of coursework material in real-life situations rather than requiring simple memorization, encouraging responsible usage of AI, etc.).

Continuing with the importance of the instructor's role, a rather concerning result we got was that 40.4% of learners are more likely to ask AI than a classmate regarding a question about coursework, and 55.3% are more likely to ask AI than a teacher. Not only is there a preference to ask a classmate than an instructor (which, however, is likely relative both to the specific instructor and to the nature of the question), but there is also a preference (teacher vs. AI) or almost an equal chance (classmate vs. AI) to ask for an answer from AI or a computer, then to ask a person. This is especially surprising given that 70.8% of learners have reported receiving incorrect information from AI in the past. Whether the preference to ask AI is based on accessibility, trust in the accuracy of information (which does not appear to be the case given the incorrect information rate reported), the feeling of shame to ask an instructor, or the absence of social contact required to ask a peer, remains a topic for future research to determine.

Another moderate positive linear relationship was found between the likelihood of using AI and the belief that it positively impacts one's learning. If we assume that the belief there is a positive impact arises from responsible usage, then this may be considered a positive effect. However, it is still worth noting the previously mentioned potential for dependence and over-dependence that can arise from excessive use of AI tools and the appearance that it leads to cognitive skill erosion.

CONCLUSION

Based on the statistical analysis of survey data, it can be concluded that the usage of AI tools for college coursework has significant effects on the cognitive abilities of learners, specifically memorization, cognitive abilities such as problem-solving and critical thinking, and in-depth understanding of coursework material. However, no negative effect was shown on learners' motivation. In addition, almost half (48.5%) of learners surveyed claimed they feel they are becoming dependent on AI for their coursework.

It is worth mentioning again that our findings are based on a self-report measure in the form of an anonymous survey distributed to learners, meaning that the results represent only the awareness that the learners themselves have observed in their learning behavior. Hence, this can form motivation for future research, in neuroscience and other fields, to determine whether these self-reported results by young learners on cognitive skill erosion align with actual changes in the learning systems of their brains. Another obvious direction for future research is replicating the survey in other settings, domains, and subject communities. Given our own survey results, an environment without or with a smaller number of learners specializing in computing fields, given that this may have been a reasonable factor in some of the answers (in other words, testing to see whether those in computing report more usage of AI tools for their coursework than those specializing in, for example, humanities or liberal arts).

To be clear, while the results suggest significant changes in the cognitive abilities of learners, the authors of this paper are not arguing against AI usage, but rather recommending a more pensive usage, following reasoned guidelines on how and in what circumstances AI has its place in college coursework, in order to minimize the negative effects identified in this research.

In conclusion, given the continuous advancements in technology and AI, it is inevitable that it is here to stay and make impact, and has already found a place in the educational system at all levels as well many other aspects of our lives. This article has highlighted some potential effects on young learners' cognitive abilities that AI usage can contribute to. The results of our work call for more future research on this topic in order to create a conducive environment where AI does not diminish education, but rather enhanced and developed to suit the needs of all learners and benefit from the technological revolution we are witnessing.

REFERENCES

Adıgüzel, T., Kaya, M.H., & Cansu, F.K. (2023). Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. *Contemporary Educational Technology*, *15*(3), ep429. https://doi.org/10.30935/cedtech/13152

Ali, J.K.M. (2022). The Impact of Online Learning amid COVID-19 Pandemic on Student Intrinsic Motivation and English Language Improvement. *Dirāsāt. Al-'ulūm Al-insāniyyaẗ Wa-al-iğtimā'iyyaẗ/DirāSāT. Al-'ulūM Al-insāNiyyaẗ Wa-al-iğTimā'iyyaẗ*, *49*(6), 125–134. https://doi.org/10.35516/hum.v49i6.3726

Bai, L., Liu, X., & Su, J. (2023). ChatGPT: The cognitive effects on learning and memory. *Brain-X*, *1*(3). https://doi.org/10.1002/brx2.30

Baidoo-Anu, D., & Ansah, L.O. (2023). Education in the Era of Generative Artificial Intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. *Social Science Research Network*. https://doi.org/10.2139/ssrn.4337484

Duch, H., Fisher, E., Ensari, I., Font, M., Harrington, A.H., Taromino, C., . . . Rodríguez, C.F. (2013). Association of screen time use and language development in Hispanic toddlers. *Clinical Pediatrics*, *52*(9), 857–865. https://doi.org/10.1177/0009922813492881

Firat, M. (2023). What ChatGPT means for universities: Perceptions of scholars and students. *Journal of Applied Learning and Teaching*, *6*(1). https://doi.org/10.37074/jalt.2023.6.1.22

Halaweh, M. (2023). ChatGPT in education: Strategies for responsible implementation. *Contemporary Educational Technology*, *15*(2), ep421. https://doi.org/10.30935/cedtech/13036

Horowitz-Kraus, T., & Hutton, J. (2017). Brain connectivity in children is increased by the time they spend reading books and decreased by the length of exposure to screen-based media. *Acta Pædiatrica*, *107*(4), 685–693. https://doi.org/10.1111/apa.14176

Huang, A.Y., Lu, O.H., & Yang, S.J.H. (2023). Effects of artificial Intelligence–Enabled personalized recommendations on learners' learning engagement, motivation, and outcomes in a flipped classroom. *Computers and Education/Computers & Education*, *194*, 104684. https://doi.org/10.1016/j.compedu.2022.104684

Hutton, J., Dudley, J., Horowitz-Kraus, T., DeWitt, T., & Holland, S.K. (2020). Associations between Screen-Based Media Use and Brain White Matter Integrity in Preschool-Aged Children. *JAMA Pediatrics*, *174*(1), e193869. https://doi.org/10.1001/jamapediatrics.2019.3869

Kiely, K.M. (2014). Cognitive function. In *Springer eBooks* (pp. 974–978). https://doi.org/10.1007/978-94-007-0753-5_426

Leisman, G., Moustafa, A.A., & Shafir, T. (2016). Thinking, walking, talking: Integratory motor and cognitive brain function. *Frontiers in Public Health*, *4*. https://doi.org/10.3389/fpubh.2016.00094

Moisala, M., Salmela, V., Hietajärvi, L., Salo, E., Carlson, S., Salonen, O., . . . Alho, K. (2016). Media multitasking is associated with distractibility and increased prefrontal activity in adolescents and young adults. *NeuroImage*, *134*, 113–121. https://doi.org/10.1016/j.neuroimage.2016.04.011

Moybeka, A.M., Syariatin, N., Tatipang, D.P., Mushthoza, D.A., Dewi, N.P.J.L., & Tineh, S. (2023). Artificial intelligence and English classroom: The implications of AI toward EFL students' motivation. *Edumaspul: Jurnal Pendidikan*, *7*(2), 2444–2454. https://doi.org/10.33487/edumaspul.v7i2.6669

Ophir, E., Nass, C., & Wagner, A.D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(37), 15583–15587. https://doi.org/10.1073/pnas.0903620106

Shonkoff, J.P., & Phillips, D. (2000). From neurons to neighborhoods. *National Academies Press eBooks*. https://doi.org/10.17226/9824

Sok, S., & Heng, K. (2024). Opportunities, challenges, and strategies for using ChatGPT in higher education: A literature review. *Journal of Digital Educational Technology*, *4*(1), ep2401. https://doi.org/10.30935/jdet/14027

Sparrow, B., Liu, J., & Wegner, D.M. (2011). Google Effects on memory: Cognitive consequences of having information at our fingertips. *Science*, *333*(6043), 776–778. https://doi.org/10.1126/science.1207745

Tomopoulos, S., Dreyer, B.P., Berkule, S.B., Fierman, A.H., Brockmeyer, C., & Mendelsohn, A.L. (2010). Infant media exposure and toddler development. *Archives of Pediatrics & Adolescent Medicine*, *164*(12). https://doi.org/10.1001/archpediatrics.2010.235

Yildiz, T.A. (2023). The impact of ChatGPT on language Learners' motivation. *Journal of Teacher Education and Lifelong Learning*, *5*(2), 582–597. https://doi.org/10.51535/tell.1314355