“The Effect of Technology on Academic Achievement”

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The Effect of Technology on Academic Achievement: Exploring the Impact of Personal Device Usage on Cognition

Introduction

In most modern-day classrooms, technology is present in multiple forms, ranging from laptops to tablets and cell phones. Students are becoming increasingly comfortable with bringing and using their devices in the classroom, often during their lessons. Texting, replying to emails, checking social media, playing games, and researching topic-related questions are some of the activities in which students partake. Proponents of technology argue that digital learning enhances students' understanding and acts as a supplement to the materials covered. Some studies have shown that students may learn better in classrooms where technology is interwoven with lessons, encouraging students to be more curious and engaging in the material being taught. Others disagree, contending that technology is a distraction to students and should be removed from classrooms completely in order to improve academic performance. Utilizing the framework of Cognitive Load Theory, which considers the learning of cognitive tasks in relation to the brain's architecture, this paper examines the negative effects of personal device usage by students in the classroom. Through the analysis of the research on deep thinking, parallel processing/task switching, and postphenomenology, as well as the evaluation of various cases, the claims presented here intend to demonstrate that students' cognitive processes are negatively impacted, causing attention shifts, distraction, and other detrimental changes to the brain that hinder academic achievement.

Cognitive Load Theory

Cognitive Load Theory (CLT) was developed by psychologist John Sweller in 1988 as a result of his study on problem solving abilities in learners. Sweller's findings suggest that meaningful learning occurs when complex cognitive tasks are attuned to the brain's architecture. As mentioned in "Cognitive Load Theory: Instructional Implications of the Interaction Between Information Structures and Cognitive Architecture," CLT assumes that the brain "consists of a working memory that is limited in capacity when dealing with novel information, and that includes partially independent subcomponents to deal with auditory/verbal material and visual/2- or 3-dimensional information" (Paas 2). As the brain attempts to process information about an unfamiliar or new topic, it uses the working memory, which cannot handle a cognitive load that exceeds its capacity. After information has been processed in the working memory, the brain constructs "schemas," which are a categorization of the information to better organize it within the long-term memory; this process facilitates in "schema automation," the unconscious retrieval of information that decreases cognitive load for future application of the learned material (Paas 2). Pertaining to student learning, this implies that cognitive demands should be within the brain's working memory capacity and learning materials should be designed to minimize the extraneous cognitive load as much as possible. Extraneous loads are "imposed by information and activities that do not contribute to the process of schema construction and automation" (Paas 2). Information from off-task personal device usage can be considered as an extraneous cognitive load that is ineffective in the learning process. The concept of cognitive overload, the overwhelming of the brain with various sources of stimuli, arises in this discussion of the CLT. When students' brains are overloaded with information from their personal devices, they are

unable to successfully convert the classroom lessons from their working memory to long-term memory, which ultimately diminishes meaningful learning.

Deep Thinking

With the increasing availability of technology and information, students are prone to becoming dependent on their devices, and are gradually losing the ability to think critically. The level of cognition required decreases when solutions to difficult assignments can be found using a few keystrokes and clicks. The concept of "deep thinking" refers to the cognitive skill that allows one to focus and carefully process thoughts, which leads to a greater understanding about a topic (Cavanaugh). Deep thinking must be practiced and strengthened, but technology may be weakening the analytical thought process of students. In the article, "Facebook® and Academic Performance," Paul Kirschner and Aryn Karpinski comment that students in this generation "can Google®, but [they] lack the information skills to effectively find the information they need, and they also do not have the knowledge to adequately determine the relevance or truth of what they have found" (1238). Students have transformed into passive receivers of information because they are cognitively overloaded through a multitude of resources. This abundance contributes to the inability of students to distinguish between credible and false information, and think critically about how the information they find can be applied to help them beyond the lessons they learn in a school setting. Penny Thompson, in "The Digital Natives as Learners: Technology Use Patterns and Approaches to Learning," discusses the emergence of rapid communication technology, which includes text messaging, using Facebook, calling on a cell phone, chatting, and multitasking using different technologies at the same time. She investigates the behaviors of the "digital native" generation, which describe the modern-day students who grew up utilizing technology. In Thompson's study of a class of 388 freshmen in a Midwestern university, she

found that “when digital natives use a web search engine, they tend toward a “get in, get the answer, get out” approach” and that they are “significantly less likely to report that they read in a reflective way rather than merely gathering information” (21, 19). Reflective learning, which emphasizes the immersive method of obtaining and developing knowledge, is lost in the one-way process of retrieving information through search engines. Students have become accustomed to using their devices to access information quickly and use their findings for the task at hand, rather than delving deeper into the material. When students fail to involve themselves in the course topics, they miss the opportunity to develop a greater understanding and appreciation for their lessons.

Consistent exposure to technology can influence brain development and erode the capability of deep-thinking skills. The brain is rewired as students use technology, meaning that parts of the brain that engage in deep-thinking are not active or cultivated. In Michael Cavanaugh’s article, “Digital Technology and Student Cognitive Development: The Neuroscience of the University Classroom,” he remarks that “millennials, the unwitting guinea pigs in this story, scramble to keep up with the tide of content streaming across their screens by grazing data…remapping their brains in the process. The problem is that this new, fast twitch, horizontal normal leaves insufficient time to deep think things through” (390). As students take in streams of information and stimuli from their plethora of digital devices in the classroom, their brains are overloaded and unable to think critically about topics that require careful thought. When there is no longer a need to practice deep thinking, the brain readjusts to fit the learning habits of the digitally-involved student. Over time, there is a loss of deep-thinking abilities, producing students who only understand the surface-level of complex topics as they navigate through a wide range of educational and off-task engagements. A study mentioned in “In-Class

Multitasking and Academic Performance" also examined the effect of students' off-task activities in relation to their academic achievement and cognitive capacities. The cognitive demand of representational holding, the process of retaining mental representations in the working memory part of the brain, is necessary for effective learning. Researchers found that "there is only a limited amount of information that can be held in working memory and when that limit is reached, other information cannot be held…If representational holding is limited, the presented information cannot be encoded for deeper learning" (Junco 2241). Students are unable to process and critically develop their knowledge about a concept if their brains must also process other sources of information. Deep-thinking is diminished, resulting in an incomplete understanding of course material and an overall decline in academic performance.

Parallel Processing and Task Switching

The presence of personal devices leads to multitasking, which distracts students and reduces their focus on each individual task. Students often engage in "parallel processing," which is the act of simultaneously mentally processing different things due to a variety of incoming stimuli (Cavanaugh). Processing instant messages, email alerts, and other stimuli from technological devices can be mentally taxing and distracting. "Task switching," the unconscious shifting of attention between different tasks, is another practice exhibited by students using technology (Cavanaugh). Research shows that performance on each task is slowed when someone engages in task switching. This demands time and attention, especially for tasks that are more cognitively challenging. In Carrie Fried's "In-Class Laptop Use and Its Effects on Student Learning," she states that "although attention is often controlled voluntarily, external events and visual stimulation can result in involuntary shifts of attention…Recent research on cognitive interference…has shown that new information, such as a pop-up message, appearing while a

subject is performing a primary task slows performance speed and increases errors" (908). With technology competing with educational tasks in the classroom for a student's attention, the student's brain is overwhelmed with processing the various stimuli in parallel, leading to mistakes and gaps in learning. This phenomenon supports the CLT since students cannot transfer knowledge from their working memory to their long-term memory if the processing and understanding phases are interrupted by this overload. Students retain less information when they task-switch between using their devices and the lesson because their attention is divided, and they cannot focus completely on the educational material.

One reason for the decrease in performance while task switching may be attributed to the required cognitive preparation period before starting a new task, and the reconfiguration of the brain as it switches between the physical or mental requirements of each task, known as a "task set." In Iring Koch's article, "Cognitive Structure, Flexibility, and Plasticity in Human Multitasking-An Integrative Review of Dual-Task and Task-Switching Research," she suggests that "an activated task set is assumed to be the precondition for performing a task, so that performing a task switch requires a switch in the mental task set because it might be structurally impossible to have two task sets activated at the same time" (563). This cognitive demand of task switching implies that students who use their technological devices in the classroom constantly engage in a cycle of preparation, involvement, and reconfiguration of task sets for each task that they perform. The costs of multitasking make it clear that students are harmed through the practice of interacting with technology during the main setting of a classroom. By introducing new stimuli that their brains struggle to process, students slow their performance and attention, resulting in errors and distraction. The limitations of the brain's architecture emphasize the importance of avoiding multiple task sets at once. Since the brain cannot handle numerous

stimuli from personal devices in the classroom, technology use for personal reasons during educational instruction time can cause cognitive overload from the attempt to multitask and process information simultaneously.

Postphenomenology and Perception

Technology has become an extension of the human body, and its prevalence in classrooms shapes the experiences of students by introducing a strong subconscious attraction towards personal device usage, which then results in increased distraction that draws students away from their education activities. This blending of the body with technology is described by the theory of "postphenomenology," which is a contemporary school of philosophy that focuses on bodily use of technology rather than mental processes. This differs from classical cognitive theory as the body is considered instead of the mind. Jesper Aagaard's "Drawn to Distraction: A Qualitative Study of Off-Task Use of Educational Technology" explores the role of technology in students' lives through a postphenomenological framework. By conducting a study on Danish college students, Aagaard observed that "students often described the temptation to engage in off-task activity as a prereflective attraction towards frequently visited, educationally unrelated websites (paradigmatically encapsulated by Facebook, which is widely used among all students)" (93). Students expressed that they would log in to their social media sites before consciously realizing that they had logged on to their computers for a completely different purpose. Social media and other non-educational sites attracted students and resulted in their fingers typing in website names without awareness of this decision. As students use technology more often in classrooms, the act of performing off-task activities becomes habituated in their bodies, and they become increasingly accustomed to turn to their devices when they experience boredom or confusion during their lessons. In "Technology Use and

Academic Performance," Diane Wentworth and June Middleton draw from a study conducted by Zivcakova Wood on the impact of off-task multitasking with technology. Students were directed by their teachers to not use their devices for some time during the lesson, and "When these students were asked if they complied with the instructions on whether to use technology or not, only 57% reported compliance, suggesting that for a large percentage of students, the availability of technology was irresistible" (Wentworth and Middleton 307). Students seemed to be drawn to their technology, and personal device usage was more attractive in comparison to the lessons in the classroom; almost half of the students were unable to concentrate on the lecture and turned to their devices despite being instructed otherwise. This indicates that educators' attempts to curb this attraction are seldom effective. Technology dictates the decisions of students and may lead to misconduct if they are unable to resist the desire for technology. Bodily habituation and attraction towards technology decreases students' self-control and complicates students' ability to separate their roles in the classroom from their roles as consumers of technology.

Technology fuels distraction by altering students' perception of productivity and meaningful learning. Students may view their learning in the classroom as effective, but in reality, they may be retaining far less due to their technological practices. In "Facebook® and Academic Performance," a study conducted on undergraduate students and their Facebook usage showed that "students reported having poor time-management skills and that FB use allow[ed] them to put off studying while not giving them the feeling that they [were] 'not working'" (Kirschner and Karpinsk 1243). Students perceived themselves as being productive through the use of Facebook, even though it was unrelated to the material being taught in the classroom. By providing students with a false sense of productivity, technology adds to a student's lack of time management and distorts their focus on tasks that would help them learn the course material.

Instead, personal device use leads to a higher rate of social media consumption and causes students to drift from the educational goals of the lesson. Students also neglect their academic responsibilities by not giving their full attention to the professor while they are speaking. The pull towards technology is often stronger than their awareness of their expected roles in the classroom. Through perception altering, technology clouds students' ability to focus in the classroom and leads to a greater immersion in distracting tasks.

Counterarguments

As technology is becoming a common addition to the classroom, it is important to also consider the potential benefits of students' increased digital involvement. By recognizing how students' brains and behaviors are influenced by technology, educators can alter their pedagogical styles to increase student retention of information, ultimately leading to higher academic achievement. The article, "Use of Technology in Classroom for Professional Development" emphasizes the necessity of cognitive tools, which are technologies that engage cognitive processing in learners. These technologies can include concept maps, note-taking software, drawing tools used for simulation, or articles and websites on the Internet. Proponents of cognitive tools argue that they assist in developing critical thinking and are thought to be learner-controlled since the student constructs their knowledge to reach their highest possible cognitive potential. It is believed that by using cognitive tools in the classroom, "learners are also engaged in knowledge creation rather than knowledge reproduction. Learners utilize the available software to use technology to both make and show knowledge" (Sabzian 689). The significance of cognitive tools is that while they contain valuable information, they must be integrated into student activities to be beneficial. These tools challenge students to think deeply about the course material and support the creation of new ideas based on their current

knowledge. Cognitive tools may increase students' cognitive capabilities, however, introducing multiple cognitive tools into a classroom can be a drawback because students will be exposed to the Internet, different software, and other technology sources that can increase the level of distraction. Additionally, it is possible that these cognitive tools may be causing students to become dependent on them, and unable to think critically without these tools. Many students turn to cognitive tools to obtain answers to their assignments without exerting any mental effort to determine the answers themselves. The availability of tools can diminish critical thinking abilities of students over time instead of developing them.

In a study mentioned in "Wireless Laptops as Means for Promoting Active Learning in Large Lecture Halls," students in a Computer Science class used their laptops to learn key programming concepts and participate in lab activities to practice writing programs in Java. The researchers observed that in-class collaboration increased and "while the instructor was explaining an idea to one of the students, other students sitting nearby listened and, in some cases, joined the discourse by posing their own questions or adding remarks" (Barak 256). There was an increase in student-teacher and student-student interactions since students felt more comfortable asking and answering questions while working on the class assignments together on their laptops. In this case, technology facilitated active learning and students reported a greater understanding of the material through hands-on technology usage. One student reported that "'Actually DO[ing] the things [they were] just talking about [made] lectures less hand-wavy and more concrete,'" while others complained that "'Computers are distracting toys'" (253). Though many students benefitted from the in-class exercises integrating technology, there were still some students who could not focus due to the attractive nature of the Internet's seemingly-endless browsing possibilities. For teachers to correctly integrate technology into their lessons, they must

ensure that the element of distraction is eliminated as much as possible, enabling students to direct their undivided attention towards the activities and learning objectives. The issue of technology in education is complex since it is often unlikely that all distraction is removed as the Internet, different applications, and messaging features provide multiple channels of distraction. Students would benefit from not utilizing their devices at all if they are unable to concentrate on tasks relating to the class material. While pedagogical styles may be altered to accommodate the rise of technology in classrooms, they may be unsuccessful in ensuring complete student engagement.

Conclusion

The increase of technology in classrooms requires an understanding of its effects on student learning and cognition. The various studies and research explored have shown a negative correlation between off-task technology usage and student academic performance, suggesting that the human brain is unable to handle the amount of information that students attempt to process while using their devices in the classroom. Cognitive Load Theory is instrumental in analyzing the mental changes that take place in the brain, as well as the implications of burdening the brain with stimuli. Many researchers agree that there exists a limited capacity for processing information, and task-switching and parallel processing diminish meaningful, deep learning. Off-task usage of technology not only distracts the user, but also their peers in the same classroom. Students are also losing their ability to think critically due to the dependence and "fast twitch" nature of easily accessible information. In addition to the mind, research supports that technology habituates the body to seek more technology to the point where students' personal devices serve as extensions of themselves. A limitation of current research is that a majority of such studies involve self-reporting methods of collecting data from students. Future

research could monitor technology use directly on personal devices to eliminate bias. Advanced software can be tailored to the groups studied and downloaded to these devices to track the time spent on certain applications, providing more accurate data about the digital footprint of students. While the negative effects of technology were emphasized in this paper, there may be uses of technology that benefit students if implemented properly. Educators who use technology in their lessons must take preventative measures to eliminate distractive stimuli from personal devices in the classroom. Teachers and students can work together to evolve their teaching and learning methodologies to better navigate the digital world. This will require the consideration of current research about cognitive impacts of technology, and discussions between the education, cognitive science, and technology communities to develop an effective model to minimize costs and maximize knowledge cultivation. Undoubtedly, technology will continue to advance and change, shifting traditional classrooms to technology-integrated settings. The appropriate analysis of the impacts of technology will benefit students if the educational system is able to prepare students to be responsible consumers of technology in the digital age.

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