Chunk Learning Media for Cognitive Load Optimization on Science Learning

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***Abstract*— The sudden shift in the education world due to the pandemic of Covid-19 bring both challenge and opportunity at the same time. Since decades ago, the understanding of the importance to manage cognitive load for effective learning had been applied in multiple methods. Having said that, only a few addresses the opportunity to combine it with the latest trend attractive for today's young learners to minimize more extraneous cognitive load. This research discusses the matter by proposing the adoption of the combination of chunk learning, animation, and super short video in social media platforms to convey learning materials on nervous system science, which has been stamped as a hard subject for high school students. The adaptation of super short video animation on nervous system science successfully helps students cope with the daunting pile of materials align with the cognitive load theory.**

Keywords—cognitive load, chunk learning, short video, animation, nervous system

I. INTRODUCTION

Education world never been challenged as much as happened during the pandemic era of Covid-19 recently in which abruptly school and education process should be swift to online learning. This situation would eventually change the face of education and there would be no turning back. People can go back to school, but the habit and mindset would never be the same as previously. Thus, the educator must adapt and figure out a better way to convey information and learning materials using the new habit and trends to help their students cope with the new normal.

The importance of cognitive load consideration while designing the education material and delivery method to ensure effective learning has already been recognized and applied [1]. When people learn something new, this new knowledge would be absorbed while he revisits the previous relevance knowledge kept in his brain. The absorption process however, not always smoothly occurred. One of the influence factors is the limitation of cognitive load one could handle.

Many researchers had discussed about teaching methods which adopt the cognitive load theory [2][3][4][5][6]. Some studies adapt it into game-based learning to promote enjoyment [6]. Others simply adapt cognitive load theory by rearrange traditional delivery method in classroom which promote more cognitive load friendly [2][4]. Very few, however, try to use and combine it with recent technology and address young learner characteristics and habit which inevitably influenced by the recent pandemic situation.

This paper tries to propose a solution to incorporate cognitive load theory with recent social media which gain more popularity during the pandemic era. Nervous System topic is chosen as a study case since it is considered as a challenging topic among high school students according to an interview conducted to 29 students. Moreover, most of them stated that it is hard to fully understand and picture the topic wholly using recent delivery method using verbal lecture. Thus, it is hard for them to maintain their spirit of learning in the situation.

II. LITERATURE REVIEW

Cognitive load can be defined as how much effort one brain had to cope in order to learn something new because of the very small size of working memory which has the responsibility to process it first [5][7]. If the learning process works well, the knowledge would be transferred to the long-term memory, or it will be dumped otherwise.

Because of working memory small capacity, overloading on cognitive load would be occurred when the working memory overwhelmed by data transferred during the learning process. Cognitive load overloading could occur due to the intrinsic or extraneous factor. Too much complex learning points would lead to intrinsic cognitive load overloading while too complicated visualization could lead to extraneous cognitive load overloading [1][8]. Sometimes educators become overexcited to share too many topics he considered as an important one which happened to be complicated as well, this situation would hardening intrinsic cognitive load, and, in the end, the students undesirably may learn nothing. Likewise, creative multimedia design which are not relevant with the topic serve more as a distraction rather than a tool to help student topic easier, this design would give more burden to extraneous cognitive load rather than promoting germane cognitive load [5].

There are many approaches promoted to reduce either intrinsic or extraneous cognitive load while promote germane. To reduce intrinsic cognitive load, one could create a summary to help students spot the most important points quickly. One study claims student learn from mere summary could reach a similar or even better achievement than students learn from the complete texts [9]. The same study points out that additional relevant illustrations and other multimedia elements could add deeper understanding, while additional text on the other hand decrease its effectiveness. While summary proved to be adequate for learning process, it should

be noted that this approach might not be suitable for every learning topic. There are topics which require more detail explanation and elaboration and pushing summary for this type of learning topics might lead to a failure in learning result.

Another recognized method to reduce intrinsic cognitive load is chunk learning method. In this method, rather than serve learning topic as a full big subject, it is better to separate them into smaller sizes to make it easier to chew and help students more concentrate to each smaller subject [7]. Because of its nature, chunk learning considered not only help learner concentrate better because of cognitive load reduction, furthermore it also gives the opportunity for the learner to look back and revisit the previous knowledge easily, thus the knowledge not just stay in working memory, but it has its way to the long-term memory, consequently it increases the retention, retrieval, and comprehension [10][11][12]

On the other side, to enhance cognitive load optimization, educators need to address the need and characteristics of the learner. Young learners today mostly consist of gen Z who born after 2000, therefore, to reduce extraneous cognitive load, the best learning media would be something they are familiar and comfortable with and that would be technology, the smart phone to be precise [13]. Millennials are the first generation who adapt with smart phone from the early stage, while gen Z start using it even earlier. Thus, while millennials love technology and expect their educator use technology to convey the message in a way that they are mostly comfortable, gen Z learner would demand that approach even more. Students more excited using the technology with video in it and seems to repeatedly access and learn from it even during their leisure time [14].

Having said that, some researchers argue that the use of technology in learning environments could bring some negative effects. In fact, for simple task such as note-taking during lecture, Mueller argues that using technology such as notebook could decrease the good learning experience and retention which in return give worsen result rather than do it traditionally [15]. This phenomenon due to the situation where the speed of note taking is slower, thus one need to push their brain to concentrate and process the information before handpicking the one need to be included in note taking.

Another research found that excessive use of smart phone can be associated with decreasing academic result while the reason has not discovered yet [16][17][18]. Yet, they still admit that smartphone has a potential to enhance learning experience, since the study link better achievement with the habit of information seeking using technology.

On more neutral side, some researchers pointed out that the intensity of technology become a distraction and interfere the learning process relates to learner's impulsive behaviour and habitual technology use [19]. And the solution of digital distraction is not removing technology from the learning process. Studies event show that after a certain of time student develop anxiety while apart from technology, this phenomenon may be due to the FOMO (Fear of Missing Out) nature of gen Z [20][21][22]. This anxiety can be seen as a distraction by itself. Without the existence of technology, studies found that learner could still distracted not by technology but by their own mind [23][24]. Hence, it cannot be stated if technology bring a good or bad influence, the grey area created based on the usage of it [25]. Rather than eliminate the usage of technology, it is better for educator to creatively encourage supportive habit regarding technology among their students.

While researchers still argue on the influence of technology in learning process, the involvement of technology in learning inevitably must happening when the pandemic of Covid-19 push authority to close down schools due to safety reason. The only way to let students keep learning was to use technology from their own home and stay connected with the educator. The pandemic brings the transformation in learning process come a lot faster than expected [26]. Ready or not, at that time, educators must employ technology to keep the education process functioning. It was like a moment of trial and error, at the beginning most educators maintain their traditional style and merely move the real physical classroom to digital platforms. Attitude play important role to the success of technology adaptation on learning process; therefore, it is important to encourage educators to successfully help students learn better by spend more time and frequently try to learn more about the technology [27].

While screen time spend by young gen Z accused as being the purpose of their inefficient cognitive control [28], by pandemic era the screen time would be raised more since all learning activities would be conducted on screen. Young adolescence already known for their exposure to screen time. Their motivation behind that mostly connected with FOMO, they need to connect with people and contents, thus their need of social media and other thing that offered using their smart technology is real [29]. Smart phone is essential since it offer an easy no commitment leisure time for young people [30]. Social media play a big role in the lives of millennials and gen Z since they have a sharing habit, they like to share the good or the bad or inspirational or other stuff. Study shows in learning environment, students happily sharing study related stuff without any compliment or instruction [31].

On learning delivery method point of view, video as education tools had been proven suitable to convey learning materials [32]. Different types of videos bring different influences though, the voice over type bring longer retention but burdened more on cognitive load, while craftly video with a combination of pictures, animation and verbal explanations tend to reduce cognitive load [33].

Combining the social media necessity in young learner's daily life and the suitability of video as learning method, the outcome of the combination is a social media which have video as the main content. One name of certain social media which recently gain popularity during Covid-19 pandemic as potential media to spread valid health information [34][35], has come to our attention, which is TikTok.

TikTok is a social media which allow its user to share and enjoy video content. The main characteristic of this media is the limitation of its video which started as 1 minute maximum to 3 minutes and 10 minutes recently [36]. With more than 1 billion users in around 150 countries, which 60 percent of them consist of gen Z, and great engagements (multiplied view and interaction compared to the number of viewer), this media is suitable for the likeness of young people recently. Approximately 67 percent teens said to use TikTok with screen time around 26 hours a month or 95 minutes a day. Frequency of usage in a day is around 8 times per user. And interestingly, this phenomenon led to a new habit as well as discovered that almost half of gen Z start to use social media such as TikTok or Instagram as if they are search engines.

One main characteristic of TikTok that differentiate it than other platforms is the short video content and fluid interaction. As known for shorter attention span, gen Z employ a rush nature in learning or searching on information [36]. They are not the most patient client. Thus, the concept of short video is very much comfortable for them, and because of the fluid interaction, this video can be sequentially arranged or responded with relevant one through the interaction, not only by the creator but also by the audiences [34].

Moreover, because of the shifting role of this video social media platform as a place to search for information followed by the massive content creator which sharing knowledge and not merely fun entertainment substance and following the sudden pandemic Covid-19 time when students suddenly been halted from the traditional learning set-up. The platform itself then adapt by promoting the hashtag #learnontiktok to encourage content creator and user creating a learning environment on TikTok to help students keep learning during the pandemic [37]. It is interesting to note that the activity on social media which young people do to keep in touch and interact with their social environment or just for having fun [38], the activity which many adults condemn as a waste of time, a distraction of learning activities, then becoming the part of learning activity itself.

Since the popularity of video podcasting as a learning delivery method, video has been widely used as many studies support the effectiveness of video in learning [32]. Podcasting which started as an audio tutorial, was elaborate into a full video with visual and audio recently [39].

While it is gaining popularity since the concept favourable to young people from millennials and gen Z, not all kind of video podcasting is a good one, for example one educator could simply recording its learning session and upload it as a podcast, this minimal effort type of video is considered as a bad and potentially ineffective podcast. Podcast of one bulk long session is considered as a bad and might raise an ineffective full of boredom learning session. Therefore, it is important to carefully design and spend more time to crafting a good effective podcast for educational matter.

III. Research Methods

The structure of research methods applied in this research shown in Fig. 1. This study attempted to propose a new adoption on chunking learning through social media video sharing. Prior of the development, audience analysis through interview to specific targeted audience which are high school students from 11th grade has been conducted to capture the recent problem and audience's choice and characteristic toward media. The development phase follows would keenly design of chunking structure of nervous system learning material followed by preparing the assets required and implementation process on developing short animation videos in sequence.

After the development of the media, 30 respondents from high school students join in learning process using the media build earlier. Pre-test and post-test have been conducted as well as part of the evaluation process. Anderson-Darling normality test which suitable for small sample [40][41] conducted to check the normality of data collected both in pre-test and post-test, and sequentially followed by t-test to examine the influence of media build on nervous systems learning.

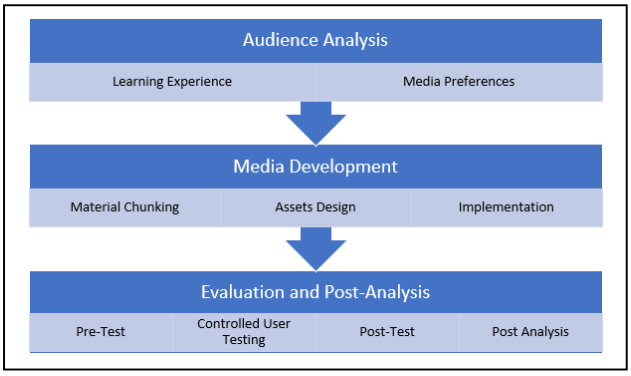

Fig. 1. Research Methods

IV. Result and Discussion

To get a picture about student's behaviour on nervous system learning process inside and outside formal education setup, some interviews had been conducted with respondents from the targeted audience of high school students from XIth stage (based on Indonesia school system). The selection target audience based on the stage where Nervous System included in high school curricula. Additional interview had been conducted to further dig on high school students experience and problems in learning process, especially during the pandemic time frame. The number of overall respondents reach 34 respondents from high school students from different stages with most students are from XIth stage.

Based on the interview, it had discovered that most students are struggling in the setup of learning process during pandemic era. There are rules based on government's policy in response to the situation regarding the spread of Covid-19 or school policy that not allowing the traditional face to face learning setup. Although sometimes, the school allowed to have an on-site study, limited time and participants allowed prevent the normal practice to take place. Another obstacle found is because of the quick spreading virus, thus for precaution reason, a student who show symptoms of Covid-19 infection suggested to stay at home and learn by themselves. At the beginning of the pandemic era, where learning process shifting to online learning, some schools give a short online video conference or meeting to convey the lecture, followed by self-study. Online learning provided from the teacher mostly came in the form of online meeting (synchronous), a voiceover video (asynchronous), or a recording of a class learning session (hybrid). Most students don't like this arrangement since they were not familiar with both online conference/meeting or self-study behaviour. Many parents complained to the teacher since they were not familiar with these arrangements as well. Educators, government, and society doubtful about the effectiveness of this arrangement. However, interestingly, after the student allowed to return for on-site learning at school, student's behaviour and mindset apparently had change through this time. Some students stated that they prefer the previous arrangement since the on-site learning is too long and they are bored. On the other hand, they admit that sometimes it is helpful to meet the teacher at school because some topic can be explained better.

On different perspectives, students learn many things, from gaming trick, life hack to science or math topics at their leisure time from videos in the form of YouTube or TikTok videos. Specifically on the nervous system learning, students

feel the content is too long on traditional arrangement which raise the requirement of a summary to help them learn. Moreover, the traditional learning method is not quite effective to help them fully grasp the whole concept, they cannot imagine and understand how nervous system work, therefore some of them need to find another video which have better visualization in the form of animation or infographics. At the end, they were convinced that nervous system topic is a hard topic to learnt, this finding was evident in the result of the test conducted to check their understanding of nervous system, as shown in Fig. 2 which show a very low number of students can answer most of the question, one six of students cannot answer any of the questions and more than half students can only answer less than half the questions correctly. Anderson-Darling normality test conducted on the data findings give the result of p-value of 0.03981 which indicate an abnormality distribution (Fig. 3).

To facilitate learning on nervous system for these young gen Z learners, these findings should be considered:

- Bulky content is hard to chew. As stated by students, nervous systems content is plenty, one of the reasons of their failure to understand this content even with the help of video presentation is the length of the content, the video presentation itself has the length of 20 – 40 minutes each. Previous research which shows student success while learning using a short summary over lengthy text support this judgement [9]. Consequently, the content should be chunked into bite size. The length of the video should be as short as possible.
- Video content should be presented in an interesting yet informative way. As point out previously, a good visualization on important message could enhance successful message delivery and in the end increase learning rate as well [9]. Moreover, to help reduce the cognitive load, the content could be associated with everyday life.

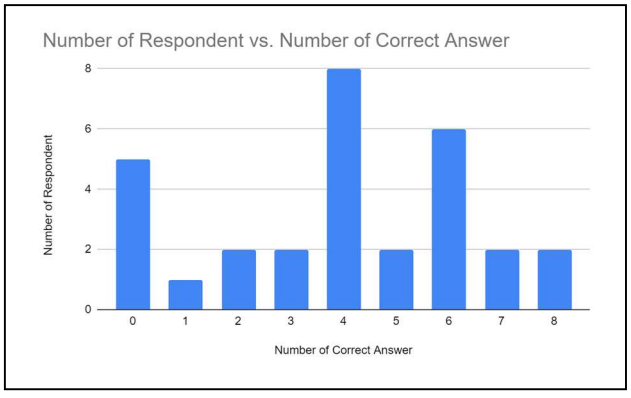

Fig. 2. Students Nervous System Test Result Before the Experiment

```
> ad.test(data_biologi$pretest)

        Anderson-Darling normality test

data:  data_biologi$pretest
A = 0.77209, p-value = 0.03981
```

Fig. 3. Anderson-Darling normality test on pre-test result

- Young learner can learn during their leisure time [14] and enjoy socializing using their social media [30]. The content of the video should be compatible with social media setting and while some social media make it possible to make a sequencing video indirectly, however it is more useful to create a learning content that can be accessed and understood separately.

Based on the analysis previously, we design and implement sequences of video of nervous system which can be consumed individually. Each video only covered a simple topic with the super short length of around 60 – 95 seconds. For each video, the opening would be a bizarre fun fact to grab their attention, such as the length of neuron in one body is almost as length as Java Island, or the fact that our body contain electricity as shown in Fig. 4.

This attention grabber created to make the learner curious and keep on viewing the video. On every end part of the video there is another attention grabber for the next video to make them continue learning the next part.

Another important substance of the video is the explanation of the theory with a visualization and animation to help the students grab the understanding better. The explanation itself would be conveyed verbally using some short text like text used in an infographic. Some of the explanations use daily phenomenon such as burning feeling when our hand close to fire as shown in Fig. 5.

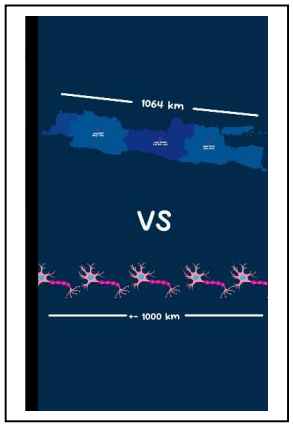

Fig. 4. Opening and Attention Grabber

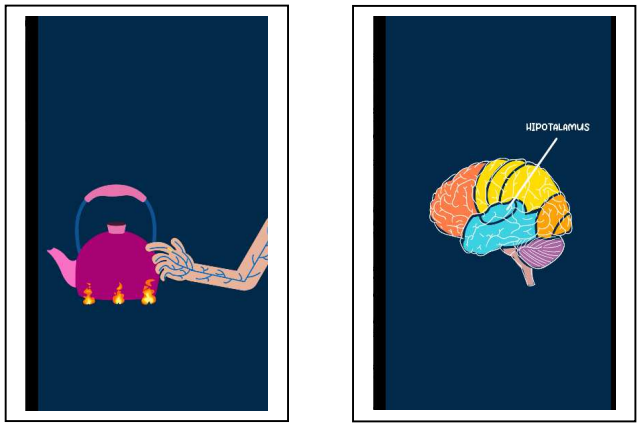

Fig. 5. Daily Life Reference Explanation

Following the implementation, these videos shared to 30 high school students from the XIth stage to evaluate the outcome. These are the same students has been tested previously on the theory of nervous system. After they learn from the videos, they take the post-test to check if there any improvement on their knowledge regarding the nervous system. The result of the post-test shown in Fig. 6 which indicate a huge leap of understanding based on the number of correct answers. All students can answer more than half questions correctly. Anderson-Darling normality test then conducted to test whether the data were normally distributed. It was found that p-value = 7.023e-08 and it can be concluded that it failed to reject null hypothesis, which means the data has been normally distributed as seen in Fig. 7.

From pre-test and post-test data, a comparison was made with the t-test with the null hypothesis no significance difference on the usage of chunk learning video and the alternate hypothesis is the usage of chuck learning can improve students' understanding of nervous system. The result of paired t-test show p-value = 4.967e-09 (Fig. 8), since it is now greater than 0.05 therefore it was valid to reject null hypothesis which means there was evident that the solution gives significance different result on student's understanding on nervous system. This result in line with the previous finding on the short learning time span of gen-Z previously [36] and that the effectiveness of learning method depend on the length of the media usage, whether it is a conventional or a modern media [9].

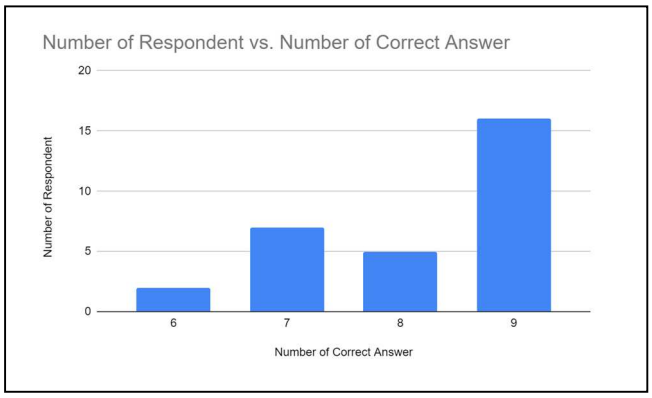

Fig. 6. Students Nervous System Test Result Before the Experiment

```
> ad.test(data_biologi$posttest)

        Anderson-Darling normality test

data:  data_biologi$posttest
A = 3.0598, p-value = 7.023e-08
```

Fig. 7. Anderson-Darling normality test on post-test result

```
> t.test(data_biologi$pretest,data_biologi$posttest,data=data_biologi,paired=TRUE)

        Paired t-test

data:  data_biologi$pretest and data_biologi$posttest
t = -8.1899, df = 29, p-value = 4.967e-09
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 -5.248843 -3.151157
sample estimates:
mean difference
          -4.2
```

Fig. 8. Students Nervous System Test Result Before the Experiment

V. CONCLUSION AND SUGGESTION

The super short animation video of chunked learning material on nervous system proved to be an effective solution to improve the understanding of nervous system. This result may be due to the insertion of daily phenomenon in the explanation which may reduce more cognitive load. Reduction of cognitive load had promoted as well by creating the chunk separated small topics and present it in a very short video which suitable for the latest social media trending platform in gen Z in the form of TikTok, YouTube Shorts, or Instagram Reels that encourage learner to learn this video on their leisure time which giving less pressure on the brain.

Having said that, this research has not examined the effect of excessive number of videos due to the chunky process. Would the number of videos reduce effectiveness of learning? If so, which is better between reducing length of each video or reducing the number of videos. Further research should be conducted to address this issue.

REFERENCES

[1] P.J. Lewis, "Brain Friendly Teaching-Reducing Learner's Cognitive Load," *Acad. Radiol*., vol. 23, no. 7, pp. 877-80, Jul. 2016, doi: 10.1016/j.acra.2016.01.018.

[2] S.N.H. Hadie, H.A. Manan, A. Hassan, Asma, Z.I.M. Ismail, S. Bahri, and A.F.A. Rahim, "Creating an engaging and stimulating anatomy lecture environment using the Cognitive Load Theory-based Lecture Model: Students' experiences," *Journal of Taibah University Medical Sciences*, vol. 13, no. 2, 2018, doi: 10.1016/j.jtumed.2017.11.001.

[3] J. Leppink, A.van den Heuvel, "The evolution of cognitive load theory and its application to medical education," *Perspect Med. Educ.*, vol. 4, pp. 119–127, 2015, doi: 10.1007/s40037-015-0192-x

[4] J. Leppink, "Cognitive load theory: Practical implications and an important challenge," *Journal of Taibah University Medical Sciences*, vol 12, no. 5, pp. 385-391, 2017, doi : 10.1016/j.jtumed.2017.05.003.

[5] J. Sweller, "The evolution in cognitive load theory," in Efficiency in learning, R. Clark, F. Nguyen, J. Sweller, Eds., San Francisco, CA: Pfeiffer (Wiley), 2006; pp. 313–329.

[6] A. Hurhish, A and M. Sterlikova, "Sustaining connections: in-class learning and game-based learning in ELT.," *Grail of Science*, No. 12-13, pp. 476–480, 2022, doi : 10.36074/grail-of-science.29.04.2022.083

[7] G.A. Miller, "The magical number seven, plus or minus two: some limits on our capacity for processing information," *Psychol Rev.*, vol. 63, no. 2, pp. 81– 97, 1956.

[8] J. Jordan, J. Wagner, D.E. Manthey, M. Wolff, S. Santen, and S.J. Cico, "Optimizing Lectures From a Cognitive Load Perspective," *AEM Educ. Train,* vol. 4, no. 3, pp. 306-312, Oct. 2019, doi: 10.1002/aet2.10389.

[9] M. Richard, B. William, B. Alexandra, M. Rebecca, and T. Lene, "When Less is More: Meaningful Learning from Visual and Verbal Summaries of Science Textbook Lessons," *Journal of Educational Psychology*, vol. 88, no.1, pp. 64-73, 1996, doi: 10.1037/0022-0663.88.1.64.

[10] F. Gobet et al., "Chunking mechanisms in human learning," *Trends in Cognitive Sciences*, vol. 5, no. 6, pp. 236–243, Jun. 2001, doi: 10.1016/S1364–6613(00)01662-4.

[11] D. Koufogiannakis and N. Wiebe, "Effective methods for teaching information literacy skills to undergraduate students: a systematic review and meta-analysis," *Evidence Based Library and Information Practice*, vol. 1, no. 3, 2006, pp. 3–43. doi: 10.18438/B8MS3D

[12] J. Leppink, "Cognitive load theory: practical implications and an important challenge," *Journal of Taibah University Medical Sciences*, vol. 12, no. 5, pp. 385–391, 2017, doi: 10.1016/j. jtumed.2017.05.003

[13] A. O. Manuel, G. Ramiro, M. José, and B. Frederico, "The social impact of technology on millennials and consequences for higher education and leadership," *Telematics and Informatics*, vol. 35, no. 4, Oct. 2017, doi: 10.1016/j.tele.2017.10.007.

[14] O. R. Leonardo, I. Osamu, A.T. Khaled, G. Antonio, and D. Fernandes, "Delivery of a urology online course using Moodle versus didactic lectures methods," *International Journal of Medical Informatics*, vol. 84, no. 2, Feb. 2015, doi: 10.1016/j.ijmedinf.2014.11.001.

[15] P. Mueller P and D. Oppenheimer, "The pen is mightier than the keyboard: advantages of longhand over laptop note taking," *Psychol Sci*, vol. 25, no. 6, pp. 1159–1168, Apr. 2014, doi: 10.1177/0956797614524581

[16] F. Daniel and G. Alexandra, "Cell phone usage and academic performance: An experiment," *Computers & Education*, vol. 117, Feb. 2018, doi: 10.1016/j.compedu.2017.10.006

[17] S.E. Domoff, R.P. Foley, R. Ferkel, "Addictive phone use and academic performance in adolescents," *Hum. Behav. & Emerg. Tech*, vol. 2, no. 2, pp. 33– 38, Sep. 2019, doi: 10.1002/hbe2.171

[18] C. Su-Yen and T. Jeng-Yi, "College Female and Male Heavy Internet Users' Profiles of Practices and Their Academic Grades and Psychosocial Adjustment," *Cyberpsychology, behavior and social networking*, vol. 13, no. 3, pp. 257-262, Jun. 2010, doi: 10.1089/cyber.2009.0023.

[19] L. Chen, R. Nath, and Z. Tang, "Understanding the determinants of digital distraction: An automatic thinking behavior perspective," *Computers in Human Behavior*, vol. 104, Mar. 2020, doi: 10.1016/j.chb.2019.106195

[20] L.R. Elliott-Dorans, "To ban or not to ban? The effect of permissive versus restrictive laptop policies on student outcomes and teaching evaluations," *Computers & Education,* vol. 126, pp. 183-200, Nov. 2018, doi: 10.1016/j.compedu.2018.07.008

[21] J.S. Mendoza, B.S. Pody, S. Lee, M. Kim, and I.M. McDonough, "The effect of cellphones on attention and learning: The influences of time, distraction, and nomophobia," *Computers in Human Behavior*, vol. 86, pp. 52–60, 2018, doi: 10.1016/j.chb.2018.04.027

[22] N.A. Cheever, L.D. Rosen, L.M. Carrier, and A. Chavez, "Out of sight is not out of mind: The impact of restricting wireless mobile device use on anxiety levels among low, moderate and high users," *Computers in Human Behavior*, vol. 37, pp. 290–297, 2014, doi: 10.1016/ j.chb.2014.05.002

[23] C.A. Was, R.B. Hollis and J. Dunlosky, "Do students understand the detrimental effects of mind wandering during online learning?," *Computers & Education*, vol. 135, pp. 113–122, 2019, doi: 10.1016/j. compedu.2019.02.020

[24] E.F. Risko, D. Buchanan, S. Medimorec and A. Kingstone, "Everyday attention: Mind wandering and computer use during lectures," *Computers & Education*, vol. 68, pp. 275-283, 2013, doi: 10.1016/j.compedu.2013.05.001

[25] A.J. Dontre, "The influence of technology on academic distraction: A review," *Hum. Behav. & Emerg. Tech.*, vol. 3, pp. 379– 390, 2021, doi: 10.1002/hbe2.229

[26] B. Kang, "How the COVID-19 Pandemic Is Reshaping the Education Service," *The Future of Service Post-COVID-19 Pandemic*, vol. 1, pp. 15–36, Feb. 2021, doi: 10.1007/978-981-33-4126-5_2.

[27] U. Öner, "Factors Associated with Technology Integration to Improve Instructional Abilities: A Path Model," *Australian Journal of Teacher Education*, vol. 43, no. 4, pp. 30-50, 2018, doi: 10.14221/ajte.2018v43n4.3.

[28] L. Marciano, A.L. Camerini, and R. Morese, "The Developing Brain in the Digital Era: A Scoping Review of Structural and Functional Correlates of Screen Time in Adolescence," *Front. Psychol*., vol. 12, Aug. 2021, doi: 10.3389/fpsyg.2021.671817.

[29] M.A. Throuvala, M.D. Griffiths, M. Rennoldson, and D.J. Kuss, "Motivational processes and dysfunctional mechanisms of social media use among adolescents: A qualitative focus group study," *Computers in Human Behavior*, vol. 93, pp. 164-175, 2019, doi: 10.1016/j.chb.2018.12.012

[30] M. Allaby and C.S. Shannon, "I just want to keep in touch : Adolescents' experiences with leisure-related smartphone use," *Journal of Leisure Research*, vol. 51, pp. 245 – 263, 2019.

[31] B. Edith, B. Smadar, and A. Christa, "Students, Social Network Technology and Learning in Higher Education: Visions of Collaborative Knowledge Construction vs. the Reality of Knowledge Sharing," *The Internet and Higher Education*, 2020, doi: 10.1016/j.iheduc.2020.100787.

[32] D. Pablo et al., "Learning from text and video blogs: comprehension effects on secondary school students," *Education and Information Technologies*, vol. 27, 2021, doi: 10.1007/s10639-021-10819-2.

[33] C. Chih-Ming and W. Chung-Hsin, "Effects of different video lecture types on sustained attention, Emotion, cognitive load, and learning performance'" *Computers & Education*, vol. 80, 2014, 10.1016/j.compedu.2014.08.015.

[34] C., Geoffrey, D. Sean, and G. Michael, "Is TikTok The Next Social Media Frontier for Medicine?," *AEM Education and Training*, vol. 5, 2020, doi: 10.1002/aet2.10532.

[35] B. Doyle. "TikTok statistics." Wallaroo Media. https://wallaroomedia.com/blog/social-media/tiktok-statistics (accessed October 26, 2022).

[36] A. Szymkowiak, B. Melović, M. Dabić, K. Jeganathan, and G.S. Kundi, "Information technology and Gen Z: The role of teachers, the internet, and technology in the education of young people," *Technology in Society*, vol. 65, 2021, doi : 10.1016/j.techsoc.2021.101565

[37] F.O. Angel, F. Carlos, and F. Stalin, "TikTok and Education: Discovering Knowledge through Learning Videos," in *Eighth International Conference on eDemocracy & eGovernment*, 2021, pp. 172-176, doi: 10.1109/ICEDEG52154.2021.9530988

[38] P. Escamilla-Fajardo, M. Alguacil, and S. López-Carril, "Incorporating TikTok in higher education: Pedagogical perspectives from a corporal expression sport sciences course," *Journal of Hospitality, Leisure, Sport & Tourism Education*, vol. 28, 2021, doi: 100302. 10.1016/j.jhlste.2021.100302

[39] P. Stephanie, "The Power of Podcasting: Perspectives on Pedagogy," *Journal of Instructional Research*, vol. 5, pp.4-7, doi: 10.9743/JIR.2016.1.

[40] T. Islam, "Normality Testing- A New Direction," *International Journal of Business and Social Sciences*, vol. 2, no. 3, pp. 115-118, 2011.

[41] J.L. Romeu, "Anderson-Darling: a goodness of fit test for small samples assumptions." RAC START https://web.cortland.edu/matresearch/AndrsDarlSTART.pdf (accessed November 16, 2022)