Cognitive load in high school students during online learning amidst the Covid-19 pandemic: A qualitative study in Bantul, Indonesia

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ABSTRACT

The public doubts that learning can be meaningful and in-depth if done online. Moreover, the implementation of online learning still has weaknesses from upstream to downstream. This research focuses on the cognitive load in students when online learning begins to be carried out massively in Indonesia due to the Covid-19 pandemic. This qualitative study aims to identify high school students' experiences in Bantul while learning online during the pandemic. Data were collected for four months through observation, in-depth interviews, and documentation. The collected data were transcribed, coded, and analyzed for themes using cognitive load theory and learning technology. The results illustrate that high school students in Bantul experience extra effort in learning through online platforms due to the novelty of the online learning experience, distractions, subject matter presentation, and the impact of cognitive load on students' learning. This research enriches innovative strategies for managing online learning by learning technology science. It has contributions to the need to train teachers and students to carry out learning in an independent mode. Online learning, when managed by accommodating good theory and practice of learning technology, proves to be a strategic learning mode, especially amidst the challenges of the Covid-19 pandemic.

INTRODUCTION

Improving the quality of learning is one of the themes raised by researchers to investigate how learning in schools can improve based on considerations of learning conditions and learning methods (Reigeluth, 1993). Learning will always be based on learning objectives for students, so learning design has an essential position in learning success (Dick et al., 2015). Like an interrelated and binding chain, quality learning begins with managing students as raw inputs with various powerful methods to achieve targeted results. The learning outcomes are one of the benchmarks for the quality of learning.

Online learning was implemented massively in Indonesia during the Covid-19 pandemic. This situation makes the education community in Indonesia unprepared because the learning space is limited. Restrictions on access to face-to-face learning support have implications for adjusting all components to carry out online learning, posing problems and support (Afriansyah, 2020). This non-ideal situation changes things, from changing paradigms to implementing innovations (Trilisiana, 2020).

Online learning existed long before the presence of the Covid-19 pandemic. Open University is an institution in Indonesia that has implemented online learning for students who have difficulty reaching space and time. What was implemented by Open University, at first, was underestimated among Indonesian academics, but now online learning has become a trend that is welcomed with joy (Rahman et al., 2020).

Online learning research is studied based on the perspective of mental health (Fitria & Saputra, 2020; Isrokatun et al., 2022), eye health (Putri et al., 2021), and academic resilience (Hernawan et al., 2021). Besides academic stress, previous researchers examined the cognitive load during online learning using a quantitative approach (Thahura & Tutdin, 2021). A qualitative approach must be taken to strengthen cognitive load studies in online learning. Concerns during online learning on how well our students master learning objectives to the application level in the real world need to be proven. The level of understanding in scientific and social fields must not be enough to memorize information or procedures.

The concept of rote learning becomes irrelevant in deep learning (Marton & Säljö, 1976; Degeng, 2013). Deep learning (deep learning) grows on individual awareness to realize what he understands and does not just want to get the best grades from exam results (Jhala & Mathur, 2019) and makes individuals have the character of diligent learners (Anwar, 2017). Deep learning can be achieved through learning by creating (Fullan & Langworthy, 2014), project-based (Miller & Krajcik, 2019), and case-based to provide a real-world experience (Jhala & Mathur, 2019; Santosa et al., 2020). Deep learning should be realized in offline and online conditions because the primary key lies in pedagogical practice and not just technological sophistication (Chaeruman et al., 2019; Chaeruman et al., 2020).

The community doubts whether learning can be meaningful and in-depth if it is carried out online. Community complaints are captured qualitatively and quantitatively, occupying a latent position on human quality in learning. Students experience stress while studying at home online (Palupi, 2020; Muzakki, 2020). Stress occurs not only in students but also in Indonesian teachers and adults in the 'moderate' category due to the outbreak and social media fatigue (Yuwono, 2020). The subjective feelings of social media users appear as if they feel tired, bored, and less motivated due to too much content found on social media. These feelings are suspected to be due to the sizeable cognitive load received, while the ability to process information is still relatively lacking (Rahardjo et al., 2020).

Studying from home via mobile devices reaps distraction in cases common in students' lives. Students share devices with family members, have difficulty focusing on lessons, are distracted by social media activities while studying, help parents work at home, and have difficulty accessing the internet (Afriansyah, 2020). The challenges faced by Indonesian students are phenomena that occur everywhere. Previous work on identifying why students experience distraction was highlighted by Curum and Khedo (2021) regarding the causes of poor adaptation of dynamic content during online learning at the theoretical level. Learning through the internet at the surface level, which provides content knowledge, makes students not give more effort to in-depth understanding (Ahad et al., 2018).

Identifying what students feel during online learning is of interest, as is the issue of cognitive overload. What Rahmat and Hindriana (2014) did long before the pandemic, comparing concept-integrated learning strategies as an experimental class, they found a link between Intrinsic cognitive load (ICL) and Extraneous cognitive load (ECL) with a large Germane cognitive load (GCL). The greater the intrinsic load (the burden of processing information when working memory takes place), as well as the additional load (all irrelevant learning elements), will affect the magnitude of the German load (the load that allows students to focus consciously on understanding and recalling learning content).

There have been many studies outside that focus on measures of brain performance when processing learning materials, such as using hypertext (Antonenko & Niederhauser, 2010) which turns out to reduce the cognitive load and through subjective judgments after solving algebraic problems (Ayres, 2006). Research related to working memory capacity on extensive mental effort has also been carried out, which resulted in recommendations for episodic/distance learning with less comprehensive mental effort (Chen et al., 2018). This qualitative research focuses on the cognitive load and the extent to which high school students in Bantul carry out and interpret cognitive load when studying online during a pandemic.

Meaningful Learning Through Online Learning

Ideally, the 21st-century learning environment involves three essential components: learning strategies, learning contexts, and integrating technology, media, and learning materials (Smaldino et al., 2015). The learning strategy becomes a pedagogical aspect that reflects the direction of learning design based on contexts, such as face-to-face, online, and blended learning. Integrating technology, media, and learning materials supports these strategies. A smart learning environment (an innovative environment) can be implemented flexibly during a pandemic that penetrates the formal lines of education administration (Trilisiana, 2020). It is because online learning under certain conditions requires face-to-face meeting sessions with a touch of the psychological aspects of students.

Before the term online learning became popular, learning with the help of an internet connection was labeled as distance learning, online learning, e-learning, mobile learning, and asynchronous learning. The opposite context of online learning is offline learning which is interpreted as learning directly by interacting and face-to-face in the real world. Smaldino et al. (2015) compared online and offline distance learning and face-to-face instruction.

Specific characteristics of online learning have been linked to aspects of the personal characteristics of individual students. The more personal the learning design, the more positive the impact on learning performance (del Valle & Duffy, 2009; Smaldino et al., 2015). Individual adaptation is a requirement that underlies the development of a learning management system. No matter how sophisticated an e-learning system is, if it is not designed using pedagogy, such as paying attention to student characteristics and learning theory, learning through devices will be boring (Chaeruman et al., 2019).

In addition to considering a variety of personal characteristics, online learning must provide evocative online activities such as opportunities for discussion through online forums and chats, quizzes tailored to learning objectives, and assignments appropriate to performance loads (Surjono et al., 2019). Involving experience as an online learning activity will hone students' reasoning power (Santosa et al., 2020).

Cognitive Load Theory

The cognitive load developed since 1998 has three categories: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load Sweller et al. (2019). In simple terms, intrinsic cognitive load is the burden of processing information when working memory takes place, additional/foreign loads are all irrelevant learning elements, and Germane load allows students to focus their attention consciously to understand and recall learning content.

The instructional design discipline's main goals should be the cognitive load categories implicated in reducing extraneous load and increasing Germane load by developing scheme construction and automation (Orru & Longo, 2019). In other words, cognitive load theory recommends that extraneous load be reduced by reengineering learning activities when the intrinsic complexity of the task remains unchanged (Curum & Khedo, 2021). Simultaneously, as the extraneous cognitive load decreases, the scattered cognitive resources must balance the load. Reengineering the learning activities can reflect clear teaching so students can process class information more deeply (Bolkan, 2016).

METHOD

The method used in this study is qualitative. The type of qualitative research method used is phenomenology, an exploration of the general meaning of several individuals for their various life experiences related to concepts or phenomena (Creswell, 2015). Students as informants were selected purposively based on the appointment of key informants (teachers) using the same considerations as when selecting key informants. The number of informants was determined by a snowball, in the sense that interviews with informants were stopped if the data obtained was considered sufficient, in the sense that it was following the research objectives. This research involved four teachers and 30 high school students across Piyungan, Pundong, Sedayu, and Sewon districts.

The researchers could trace were five public schools located (the senior high schools) in four sub-districts in Bantul, namely in Piyungan, Pundong, Sedayu, and Sewon. There are a total of 19 public schools in Bantul in 17 districts. The selection of the area was based on the distribution of the Bantul area from all directions of the compass. School characteristics are relatively similar: public schools and implementing central and regional government policies regarding online learning during a pandemic.

Researchers monitored online learning at the school from an e-learning website used by teachers and students for four months, from June to October 2021. Researchers obtained special permission to participate in online learning spread across Whatsapp and Google Classroom chat groups in various fields of study, such as language, science, social, and sports. Researchers conducted in-depth interviews with teachers and students as key informants in this study. The students interviewed were in grades X, XI, and XII, with the highest number of class XI students at 76%. There were four teachers studied and 30 students. The students who were observed and interviewed were spread across various courses so that the researchers got stable data.

The research was conducted in schools in Bantul. The researchers started by working with schools with specific characteristics in common, such as similarities in online learning patterns or similarities in learning management. The number of schools was expanded according to the need to find data consistency/consistency. The choice of location in Bantul was due to the characteristics of being in an area with a moderate income category when compared to regencies and cities in DI. Yogyakarta. This assumption underlies the families in Bantul in the middle class in facilitating learning for their children.

Table 1. Techniques and Grid of Data Collection Instruments

No	Instrument Types	Activities/Topics
1	Online class observation sheet	Observations of online learning by teachers and students.
2	Individual performance observation sheet	Observation of student responses when practicing problem-solving skills such as working on questions and answering questions.
3	The key informant interview guide	School policies in Bantul regarding online learning during the pandemic, learning management patterns.
4	Informant interview guide	Students' perceptions (knowledge, feelings, and responses), online learning habits and activities, learning motivation, learning instructions, supporting facilities.
5	Sensitive issues written interview guide	what do teachers and students personally do?
6	Supporting documentation	Learning tools, activity photos, activity documents, and student achievement. Student works.

Primary data sources were obtained directly from key informants and informants who were then told and assessed based on their subjectivity regarding effort and cognitive load when learning online during a pandemic. Secondary data sources were obtained through documentation and literature, namely by documenting findings with a camera device, studying supporting documents

for school learning, and scientific books related to cognitive load problems in high school students. The validity of the data in this study is expressed as the level of research credibility. Such as data triangulation techniques, clarifying bias.

Table 1 shows the data collection technique used in this study was carried out using (a) involved/participating observation techniques adapted from Surahman et al. (2021) and can be seen in Table 2, (b) in-depth interviews with key informants and informants which were conducted formally and informally; and (c) documenting findings using camera equipment and sound recordings and studying supporting documents for learning in schools.

Table 2. Online Observation Protocol

Aspect	Observation activities
Teaching process	a. Learning Opening;
	b. Learning materials Delivery;
	c. Learning Closing;
	d. Lesson plan.
Student learning activity	a. Student response from teachers' feedback;
	b. Student interaction with friends and learning materials.
Learning assessment process	a. Assessment instrument;
	b. Assignments processes;
	c. Assignments method;
	d. Checking students' answers and progress;
	e. Providing feedback.
Distance learning platform reliability	a. Kind of online learning platform;
	b. Internet network power during the online learning;
	c. Digital devices control used.

Based on the data collection technique, the data collection instruments were determined, which consisted of online class observation sheets, individual performance observation sheets, key informant interview guides (deputy principals and teachers), informant interview guides (students), written interview guides on sensitive issues, as well as a documentation guide to support online learning activities.

Data analysis in this study is inductive, a comment that starts from the data obtained and then develops into assumptions (Creswell, 2015). Researchers always raise questions during data analysis as triggers, as shown in Table 3. These questions were born from inductive logic in qualitative research in general.

Table 3. The list of Research Trigger Questions

No.	Question
1	What themes usually arise from the responses and behavior of research subjects related to the research focus?
2	Are there any deviations from these themes?
3	Does finding after finding suggest additional data to be collected?
4	Do the themes found form patterns?
5	Do the patterns emerging from the qualitative data analysis corroborate the same findings?

RESULTS AND DISCUSSION

Results

This study raises several themes that the researchers succeeded in extracting based on the primary data explored during the research. The emerging themes are presented in Table 4. These themes are derived from the results of interview transcripts, field observation notes, and documentation.

Table 4. Emerging Themes

No	Emerging Themes	Description
1	Online learning destruction	a. Notifications of entertainment applications and games on Smartphone devices and computers; b. Family members at home asking for help and activities; c. From internal students (drowsy); d. Insufficient internet signal.
2	Online learning makes it difficult for students	a. Not able to learn independently; b. The teacher gives materials and assignments without adequate explanation; c. Chased by task deadlines.
3	Student extra effort	a. Repeatedly reading the material text; b. Watching other people's explanations (besides the teacher) via Youtube; c. Read other relevant material via Google; d. Follow tutoring; e. Ask seniors and teachers.
4	Cognitive load	a. Learning materials; b. Learning effectiveness; c. Learners capabilities.
5	Tasks that burden students	a. Make videos; b. Summarize; c. Do many questions.

Online learning platform

The research subjects had their first online learning experience since the pandemic. Both teachers and students are learning to adapt to new study habits during the COVID-19 pandemic. Teachers and students use Google Classroom, the Jogja Learning website, and the school's Learning Management System (LMS) to access course materials and assignments. The communication media used by teachers and students are WhatsApp and e-mail. Here are some LMS screenshots (Figure 1, Figure 2, Figure 3) of how online learning is facilitated for students.
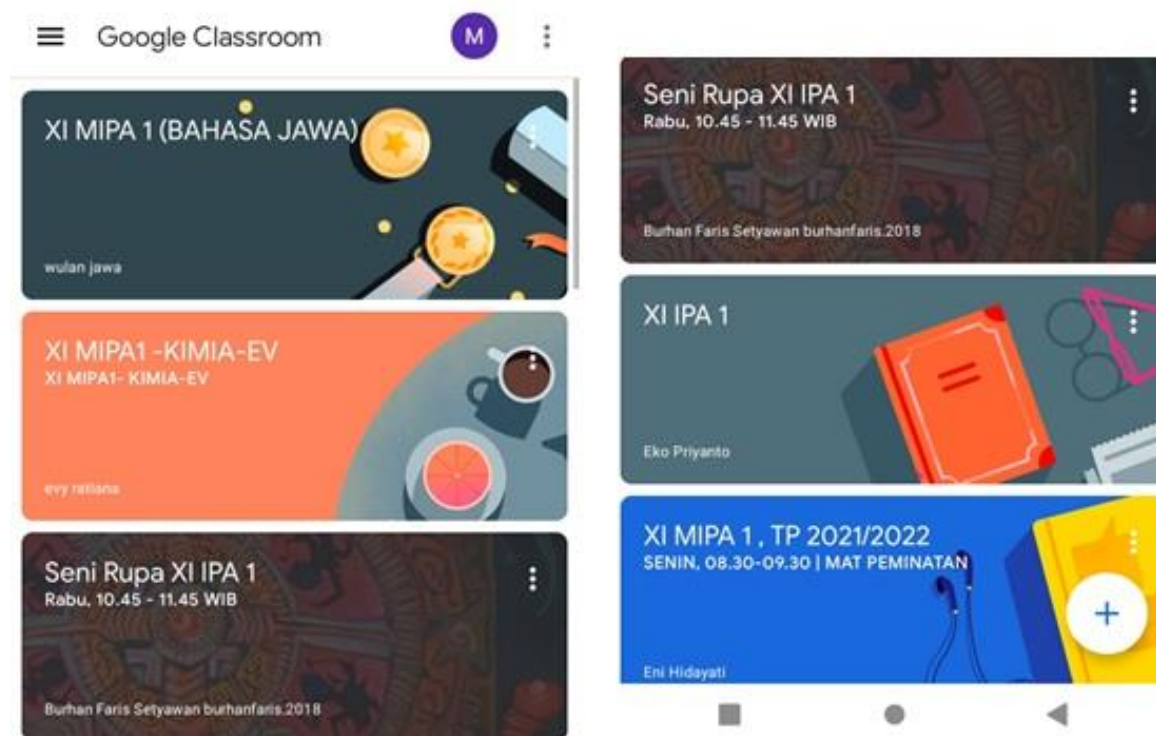

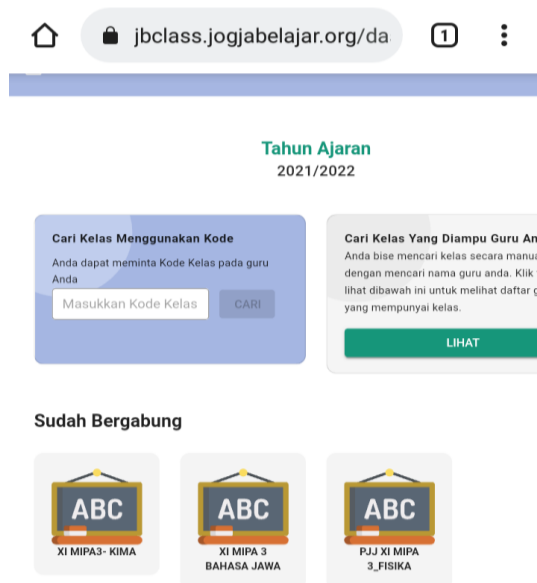Figure 1. The list of Subjects Created by Teachers Using Google Classroom

Figure 2. The list of Subjects Created by Jogja Belajar

Online learning is conducted face-to-face via the Zoom Meeting and Google Meet applications. Learning meetings are interpreted as providing comfort when the teacher greets and encourages students. Especially if the teacher explains the material and gives assignments without forcing students to complete them with a short deadline because students need time to understand both. Students feel comfortable when the teacher reminds them to do assignments according to the allotted time so they do not forget or get absent from assignments. Even though online learning activities are crowded, students are helped by notifications informing them of the latest activities, as seen in Figure 4.

Learning that students consider not to provide comfort when the teacher does not greet and immediately gives relatively many assignments to students. Tasks that are given and not explained confuse students, especially if no confirmation is given that the task is tucked into one subject matter. Students' perceptions are still oriented towards reading or listening to subjects if there are assignments or questions. The student's habit harms the teacher's assessment and the student's learning comfort.
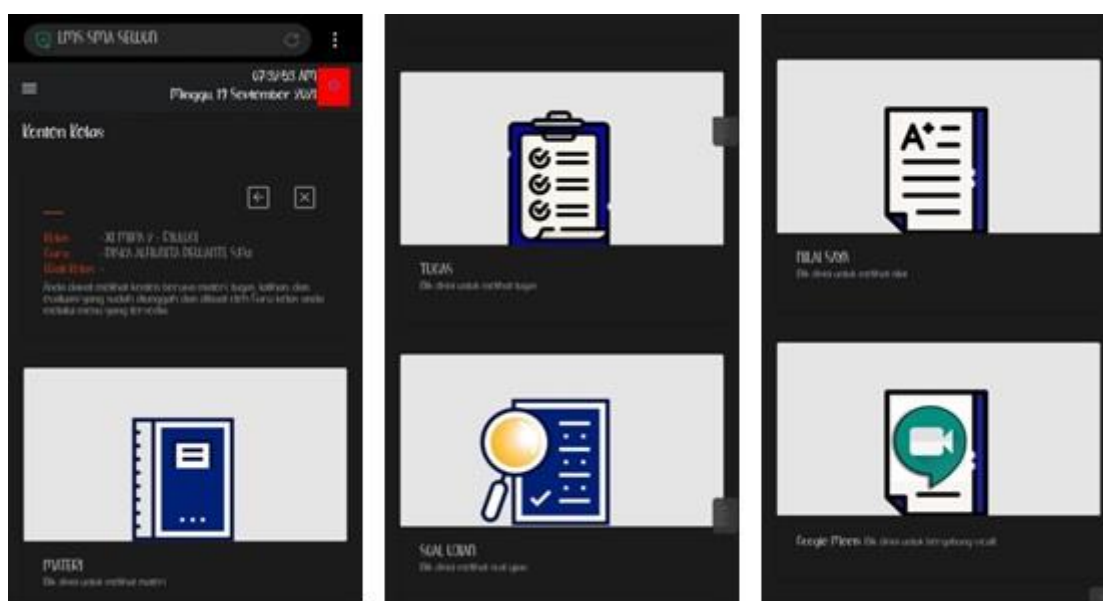

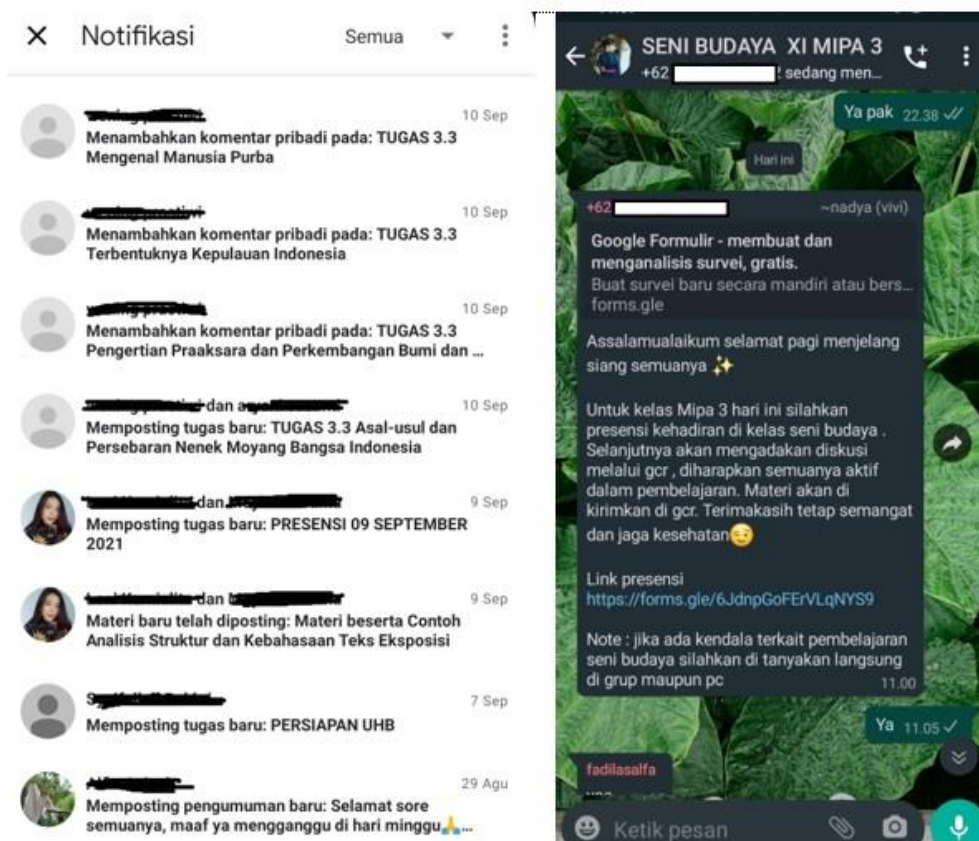Figure 3. School's Learning Management System

Figure 4. Notification of Assignments and Learning Activities

Students admit that studying during a pandemic is not easy. The difficulty that students experience is how to self-manage to explore independently. Mainly if the media for delivering learning messages from the teacher is limited to text format, students admit that when the teacher gives material text while explaining it via Zoom recorded in the video, it can make it easier for students to learn to understand. For students' understanding to continue to deepen, most students suggest giving practice questions. When media is presented in the independent learning process, students are happy and try to build motivation for learning enthusiasm. Conversely, students feel foreign to the lesson when learning messages are packaged in a limited format, such as text.

Another difficulty is the internet signal constraints. Even though students have received internet quota assistance to support online learning from the Ministry of Education and Culture, the student's domicile affects internet access speed. Infrastructure is still a technical obstacle that can be overcome in several ways in teaching-learning. Learning can be accessed with a delay so that students can repeat the subject matter as they like. Assignments and training can also be given for 1 or 2 hours or several days.

Online learning distraction and difficult

Online learning makes it easy for students to be distracted or distracted from their focus on education because students usually learn using mobile phones integrated with social networking applications that contain friendship and entertainment content. Students become less focused on online classes when they are more interested in chats in Whatsapp groups that discuss gossip; for example, students addicted to online games and open game applications more often than online learning applications.

The following online learning disruption comes from home. "Studying at home does not mean you can have more time to study" (FS, a student in the Piyungan area). Students having roles at home, such as children, brothers, sisters, nephews, or grandchildren, can be disrupted because parents ask students to look after younger siblings when they work, help parents trade, or ask for

other help. Students become exhausted because of this. When studying online, students need additional energy to focus, easily understand instructions, and learn from the teacher.

Except for three students, almost all students needed extra effort to understand and translate assignments from the teacher. It is not enough for students to read once. They must repeat it by accessing other varied learning resources (not depending on the teacher's source). Students do business by finding out from search engines such as Google, participating in additional online learning such as Ruang Guru, watching similar content from Youtube, and constantly asking teachers, friends, and older siblings so that students understand better.

Students feel enthusiastic about exploring the lesson as a follow-up to the teacher's teaching when the teacher implements learning using various delivery media. Students' favorites for further learning a subject are direct teaching strategies combined with problem-based learning. Students feel that teachers who explain through video conferencing and challenge students can encourage students to explore further material. Conversely, most students feel lazy to explore if the teacher's strategy encourages students to be free to study independently without being given clear directions. In addition to strategy, types of subjects or subject matter are also in the spotlight of students. Subject matter that students like tends to make them want to learn more deeply. Students like subjects that tend to be easy for students to master. Give examples to the teacher to make it easier for students to learn more.

Student cognitive load

Types of subject matter content can be in the form of concepts, theories, procedures, and facts. Each type of material has specific characteristics, so the material's presentation must be managed appropriately—presentation of the material in concepts and theories on the research subject classes, from general to specific. The teacher provides material through text, hyperlinks, voice notes, and video recordings or one of the four.

Teachers who present learning by organizing content from easy to difficult tend to be liked by students. Students admit that it is easier to understand the concept if given from the easiest and accompanied by examples. On the other hand, students find it challenging to learn an idea if it is not presented sequentially, let alone given examples and exercises. The sequence of learning activities is often inconsistent for the one-semester learning period. The teacher presents digital learning material that comes from material that others have developed. The smear results from everywhere were then adjusted to the semester learning plan. The deepening of the source material that the teacher has collected is not comprehensive, so students often find foreign terms or confusing content from sources that the teacher has not validated.

The weakness in the teacher's unpreparedness in providing digital resources that students need to study is the beginning of students' strenuous efforts in learning. New information becomes more difficult for students to understand because learning resources are not credible and learning strategies are inappropriate. Students read the text the teacher gave, but they use memorizing strategies rather than interpreting them. Students memorize, but it is not sure that they understand how to apply these concepts to conditions or problems in different contexts.

The presented learning material is too complex and perceived by students as confusing. For example, abstract material such as Mathematical formulas are trained with too frequent assignment schemes. The assignments given are in the form of answering multiple-choice and essay questions. Project-based assignments are not plentiful during online learning. Tasks that are too repetitive without adequate explanation are felt by students as a burden. Student recognition is as follows:

"I am often chased by assignment deadlines, so I do not understand the material." (DAT, students in the Sewon area); "I have difficulty translating subject matter during meetings when the teacher often gives assignments without explaining." (BAS, students in Sedayu area). The material packaged into text only makes students complain of confusion. Especially if the subject matter is relatively new to students and is presented with video media less relevant to student learning needs.

"My difficulty is not being able to summarize (determine what is important/less important) in the text given. Also, I cannot develop the material or examples of questions given in development, so when I find questions with HOT questions that have never been given an example,

I find it difficult to work on it." (FR, students in the Pundong area); "There are teachers who only provide material in text only so that we as students have trouble and look for our references to pursue the material, and there are some teachers who rely on YouTube videos from other people, as a result, we are also in trouble because the material from Youtube is different from the assignments given by the teacher." (FS, a student in the Piyungan area)

It is because students have to put more profound mental effort into understanding the material, especially in ambiguous statements and poorly explained content. Moreover, screen displays such as Google Classroom, Whatsapp, and Jogja Belajar Site are unfamiliar to students.

The cognitive load on students comes from three essential elements related to learning materials, learning effectiveness, and students' abilities. Learning materials have the characteristics of different learning objectives. Old material students have mastered initial knowledge ready to be used as a bridge to learning new things. In general, teacher research subjects know this learning principle, but teachers find it difficult to translate it into online learning activities. Like the confession of teacher "A" who found it challenging to introduce new formulas to students simply because he could not use the whiteboard feature when sharing screens via Zoom. Interactivity in synchronous meetings is minimal when the material presentation is displayed because the teacher only relies on textual presentation.

The type of material will be easy to understand, depending on the interactivity elements that strengthen the material. The material in a schematic or flowchart should be presented in a detailed drawing. In the cases found in this study, there was learning in the classroom where the teacher presented pictures, but minimal information directly referred to the parts of the picture. This makes it difficult for students to guess the picture accurately because the interactivity of the elements in the image presentation is unsuitable.

The learning method used in some cases is appropriate. For example, the teacher facilitates students to listen to a speech, so the teacher makes learning activities to listen to the podcast of an Indonesian artist, between learning objectives and learning activities appropriately connected. In other cases that are not suitable, it is shown that there is no connection between the learning objectives and the strategies used by the teacher. Like in one school where teachers do not carry out synchronous meetings, do not provide video experiments, and only provide textual material to achieve the learning objectives of chemical reactions.

Even so, the characteristics of students' abilities determine how burdened the students are in processing information. In the case of a child considered intelligent by his environment, the child can understand new learning because he may have good initial knowledge. The speed of processing information cannot be separated from intelligence and past experiences that are inherent in every student. As the researchers found, in the same class, the materials and learning methods were the same, there were variations in students who acknowledged that learning was relatively easy to follow, and some felt very difficult.

Students then make an additional effort to understand the lesson. The learning that stimulates students to learn more deeply to explore advanced knowledge is highly recommended. However, the extra efforts made by students due to the confusion of the material presented by the teacher made students experience dizziness and fatigue. Students choose learning alternatives by following tutoring packages outside of the school program.

Cognitive management in online learning systems is vital because cognitive features such as concentration levels, learning abilities, and learner attitudes are general attributes that must be maintained when interacting with learning content on digital devices.

Discussion

Based on the recognition and meaning of students from online learning experiences, a phenomenon was found that students experienced a variation in cognitive load. Working memory in students' cognitive experiences a high load on inefficient schema construction. Information presented without regard to the characteristics of working memory can increase the extraneous load, forcing students to give extra effort to stay focused, concentrated, and motivated in learning (Sweller et al., 2019). For online learning to be easy, educators must pay attention to differences in

student perceptions and learning modalities in processing information (Surahman & Surjono, 2017; Chaeruman et al., 2020). To minimize excessive working memory performance.

Information processing theory recommends involving various human senses to experience a pleasant learning environment (Curum & Khedo, 2021). A fun learning environment and learning elements are more helpful in assimilation during the learning process. Linking students' past skills and experiences with new learning plans leads to a significant and enjoyable knowledge transfer.

Learning becomes directionless when online learning is still not designed and implemented according to learning design principles. Simple things such as giving clear study instructions can make it easier for students to go through learning (Bolkan, 2016). Online learning conditions indeed became emergency learning during the Pandemic, but that does not mean that the quality of learning is difficult to reach, as long as learning is by the proper development procedures (Dick et al., 2015; Mayer et al., 2003; Miller & Krajcik, 2019).

The phenomenon of students being burdened in presenting material in text only without pieces of explanation almost evenly occurs because the application of online learning principles has not been fully implemented. Cognitive Information Processing (CIP) theory focuses on how students react to surrounding conditions and process incoming information while considering their knowledge to store new facts in memory (Mayer et al., 2003). Students can activate selective attention by selecting and processing only important information while ignoring irrelevant information. In addition, the theory states that learning materials must be organized and cut to increase working memory capacity in online learning systems.

Online learning experienced by students is difficult to remember because most of the material presented is text that students have to read repeatedly. Based on information processing theory, learning content should be designed to address essential details (Mayer et al., 2003; Curum & Khedo, 2021), for example, by adding hierarchical diagrams, flowcharts, concept maps, and many other techniques available to support the delivered online learning content. Furthermore, ending each learning session with multiple-choice questions or a self-assessment can help remember the topics studied.

Subject matter will be stored in long-term memory after the learner's memory captures the physical characteristics of the information (images) and encodes the auditory learning elements presented (Curum & Khedo, 2021). Teachers who give learning material with various modalities tend to make it easier for students to retain. Teachers who provide assignments with adequate explanations allow students to learn again and explore more deeply through their understanding to increase their knowledge retention.

In addition to presenting material, complex learning methods such as problem-based learning can increase student participation in learning (Mukti et al., 2023). This method is not difficult to apply in online learning as long as the learning sequence is designed to be a flipped classroom (Chaeruman et al., 2020). Students are enabled to make connections at any online learning opportunity.

Cognitive management in online learning systems is essential because cognitive features such as concentration levels, learning abilities, and learner attitudes are common attributes that must be maintained to properly adapt learning content on mobile devices (Curum & Khedo, 2021).

Learning effects of high students' cognitive load and recommendations

Holding students' full attention when studying online through small screen devices is usually tricky. Furthermore, the faulty design of learning materials leads to high cognitive load and negatively impacts online learning experiences. A relevant recommendation for this problem is the Split Attention principle which states that individuals learn more when information is presented in multiple forms (Mayer & Moreno, 1998). The learning material presented can be in the form of textual, images, animation, or verbal. It can encourage students to process information quickly. However, too many different learning materials presented under one interface can lead to confusion, attention shifts, and poor student performance (Curum & Khedo, 2021).

Instructional content that is too complicated can burden students with working memory because the same type of information is presented in an overlapping format that is not synergistic.

For example, material sufficiently presented with pictures does not need to be explained in detail in a textual form. This cognitive load effect is called the redundancy effect. The recommendation to avoid the redundancy effect is that the teacher provides only learning materials that students need to remember.

Giving assignments without explanation and guidance turns out to be difficult for students to complete assignments. This results in a total student cognitive load, so students expend additional effort to complete the task. Recommendations on this issue can take advantage of the sample effect. By giving examples, students can easily use their analytical abilities, especially during independent learning, when they get tasks to solve (Chen et al., 2018).

The presentation of material in online learning screens is sometimes in the form of more interactive detailed presentations. For example, pieces of information are presented in an animated format. If it is excessive, the presentation can burden students cognitively. Therefore, online learning designs should facilitate learning by providing learning elements that are not complex.

However, this study has limitations in not measuring the level of cognitive load statistically representing senior high schools in Bantul, which may be used for future research. Some of the meanings of the research subjects have not been explored more specifically related to the elements forming cognitive load on students. This research still opens the surface of cases researchers in the Bantul area can reach.

CONCLUSION

The online learning experience during the Covid-19 pandemic has been covered in the cognitive load that occurs in high school students in four areas in Bantul, namely, Piyungan, Pundong, Sedayu, and Sewon. Digest from experience during online learning awards major student themes such as online learning disorders and cognitive effort. Online learning without careful planning can attack students, especially in the discrepancy between the characteristics of learning materials, learning methods, and student abilities. The thesis regarding cognitive load when learning to dare has occurred at the high school level. The reasons for the occurrence of cognitive load are recognized based on the recognition and experience of students as subjects who are experiencing courageous learning for the first time. Teachers not used to learning dare to experience difficulties in formulating digital material presentations, so teachers tend to use other learning resources that can be accessed easily via the internet. Cognitive levels among students have not been accommodated in every step of the instructional strategy. Differences in perception resulting from differences in cognitive and socio-cultural levels determine how much working memory can work. Working memory can be burdened when the learning menu does not match cognitive effects such as the principle of split attention, redundancy, the impact of giving an example, and the effect of a more detailed explanation.

Suggestions from researchers are addressed to education policymakers, teachers, and scientific development. The facts and causes of cognitive load on students during online learning become news that deserves to be exposed to the public, so it becomes a concern for education policymakers to form training programs for teachers in designing online learning. Teachers need to acquire knowledge and skills in designing and implementing courage lessons that do not place too much cognitive burden on students. Further research can be developed regarding concrete learning principles in cellular learning.

REFERENCES

Afriansyah, A. (2020). Covid-19, *Transformasi pendidikan dan berbagai problemnya.* Retrieved 22 Juli 2020, https://kependudukan.lipi.go.id/id/berita/53-mencatatcovid19/838-covid-19-transformasi-pendidikan-dan-berbagai-problemnya

Ahad, M.A., Tripathi, G. & Agarwal, P. (2018). Learning analytics for IoE based educational model using deep learning techniques: architecture, challenges and applications. *Smart Learn. Environ*. 5, 7. https://doi.org/10.1186/s40561-018-0057-y

Antonenko, P. D., & Niederhauser, D. S. (2010). The influence of leads on cognitive load and learning in a hypertext environment. *Computers in Human Behavior*, 26(2), 140–150. https://doi.org/10.1016/j.chb.2009.10.014

Anwar, M. K. (2017). Pembelajaran mendalam untuk membentuk karakter siswa sebagai pembelajar. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, 02(2), 97-104. https://doi.org/10.24042/tadris.v2i2.1559

Ayres, P. (2006). Using subjective measures to detect variations of intrinsic cognitive load within problems. *Learning and Instruction*, 16(5), 389–400. https://doi.org/10.1016/j.learninstruc.2006.09.001

Bolkan, S. (2016). The importance of instructor clarity and its effect on student learning: facilitating elaboration by reducing cognitive load. *Communication Reports*, *29*(3), 152–162. https://doi.org/10.1080/08934215.2015.1067708

Chaeruman, U.A. (2013). Merancang blended learning yang membelajarkan. *Paper seminar.* 28 November 2013. Available at: https://scholar.google.co.id/citations?user=6gTiQPcAAAAJ&hl=id&oi=sra

Chaeruman, U.A., Bintoro, T., Hartoto, & Maudiarti S. (2019). How do teachers perceive modern instruction? An online survey to pre-service and in-service teachers. Advances in social science. *Education and Humanities Research*, volume 372, 242-246 http://creativecommons.org/licenses/by-nc/4.0/

Chaeruman, U.A., Wibawa, B. & Syahrial, Z. (2020). Development of an instructional system design model as a guideline for lecturers in creating a course using blended learning approach. *International Journal of Interactive Mobile Technologies (iJIM)*, 14(14), 164-181. https://doi.org/10.3991/ijim.v14i14.14411

Chen, O., Castro-Alonso, J.C., Paas, F. et al. (2018). Extending cognitive load theory to incorporate working memory resource depletion: Evidence from the spacing effect. *Educ Psychol Rev* 30, 483–501. https://doi.org/10.1007/s10648-017-9426-2

Chen, O., Retnowati, E., & Kalyuga, S. (2018). Effects of worked examples on step performance in solving complex problems. *Educational Psychology*, https://doi.org/10.1080/01443410.2018.1515891

Creswell, J. W. (2015). *Penelitian kualitatif & desain riset: Memilih di antara lima pendekatan (edisi ketiga)*. (Translation Ahmad Lintang Lazuardi). Thousand Oaks: SAGE.

Curum, B., & Khedo, K.K. (2021). Cognitive load management in mobile learning systems: Principles and theories. *J. Comput. Educ*. 8, 109–136. https://doi.org/10.1007/s40692-020-00173-6

Degeng, I.N.S. (2013). *Ilmu pembelajaran: Klasifikasi variabel untuk pengembangan teori dan penelitian*. Bandung: Kalam Hidup.

del Valle, R., Duffy, T.M. (2009). Online learning: Learner characteristics and their approaches to managing learning. *Instr Sci* 37, 129–149. https://doi.org/10.1007/s11251-007-9039-0

Dick, W., Carey, L., & Carey, J. (2015). *The systematic design of instruction eighth edition*. New Jersey: Pearson.

Fitria, P. A., & Saputra, D. Y. (2020). Dampak pembelajaran daring terhadap kesehatan mental mahasiswa semester awal. Jurnal Riset Kesehatan Nasional, 4(2), 60–66. https://doi.org/10.37294/jrkn.v4i2.250

Fullan, M., & Langworthy, M. (2014). *A rich steam: How new pedagogies find deep learning*. London: Pearson.

Hernawan, A. H., Lestari, T., & Permatasari, E. (2021). Studi evaluasi pembelajaran daring dan pengaruhnya pada resiliensi akademik mahasiswa. *EduHumaniora*, *13*(2), 104–111. https://doi.org/10.17509/eh.v13i2.35304

Isrokatun, I., Rahayu, M., & Dewi, W. (2022). Pengaruh pembelajaran daring terhadap kesehatan mental peserta didik di masa pandemi COVID-19. *Jurnal Basicedu, 6*(1), 834-851. doi:https://doi.org/10.31004/basicedu.v6i1.1987

Jhala, M., Mathur, J. (2019). The association between deep learning approach and case based learning. *BMC Med Educ* **19,** 106. https://doi.org/10.1186/s12909-019-1516-z

Marton, F., & Säljö, R. (1976). On qualitative diferences in learning: I—Outcome and process. *British Journal of Educational Psychology*, 46(1), 4–11. https://doi.org/10.1111/j.2044-8279.1976.tb02980.x

Mayer, R. E., & Moreno, R. (1998). A split-attention efect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology*, 90(2), 312–320. https://doi.org/10.1037/0022-0663.90.2.312

Mayer, R. A. (2003). Elements of a science of e-learning. *Journal of Educational Computing Research*, 29(3), 297–313. https://doi.org/10.2190/YJLG-09F9-XKAX-753D

Miller, E.C., Krajcik, J.S. (2019). Promoting deep learning through project-based learning: a design problem. *Discip Interdscip Sci Educ Res* **1,** 7. https://doi.org/10.1186/s43031-019-0009-6

Mukti, S.C, Zulfiati H. M, Amin S, Sulaimon J.T. Applying Problem-Based Learning for boosting the Primary Students Participation in Learning Science in Indonesia 2023:60–7. https://seminar.ustjogja.ac.id/index.php/ICoTPE/article/view/869/511

Muzakki, A. (2020). "Kasihanilah, beban kami berat!": Analisis digital media ethnography terhadap tantangan akademik dan sosial-ekonomi mahasiswa atas pembelajaran di masa pandemi Covid-19. *The Sociology of Islam,* Vol. 1, No. 1, 1-31.) http://jurnalfisip.uinsby.ac.id/index.php/JSI

Orru, G., & Longo, L. (2019). The evolution of cognitive load theory and the measurement of its intrinsic, extraneous and germane loads: a review. *Human Mental Workload: Models and Applications, 23–48.* https://doi.org/10.1007/978-3-030-14273-5_3

Palupi, T.N. (2020). Tingkat stres pada siswa-siswi sekolah dasar dalam menjalankan proses belajar di rumah selama pandemi Covid-19. *JP3SDM*, Vol 9(2), 18-29. https://ejournal.borobudur.ac.id/index.php/psikologi/article/view/716

Putri, A. K., Reynanda, S. A., & Raisa, R. R. (2021). Pengaruh pembelajaran daring terhadap kesehatan mata di masa pandemi. *Jurnal Komunitas Kesehatan Masyarakat*, *3*(2), 26-38 https://www.academia.edu/75772020/Pengaruh_Pembelajaran_Daring_Terhadap_Kesehatan

Rahardjo, W., Qomariyah, N., Mulyani, I., & Andriani, I. (2020). Social media fatigue pada mahasiswa di masa pandemi COVID-19: Peran neurotisisme, kelebihan informasi, invasion of life, kecemasan, dan jenis kelamin. *Jurnal Psikologi Sosial*, Special Edition COVID-19. https://doi.org/10.7454/jps.2021.16

Rahman, G., Nurfajriani, & Jahro, I. S. (2020). Tren penelitian pendidikan proses pembelajaran daring selama pandemi Covid 19. *Prosiding Seminar Nasional Kimia Berwawasan Lingkungan*, 31–37. http://jurnal.kimia.fmipa.unmul.ac.id/index.php/prosiding/article/view/986

Rahmat, A. & Hindriana, A.F. (2014). Beban kognitif mahasiswa dalam pembelajaran fungsi terintegrasi struktur tumbuhan berbasis dimensi belajar. *Jurnal Ilmu Pendidikan*, Jilid 20, Nomor 1, 66-74. http://journal.um.ac.id/index.php/jip/article/view/4379

Reigeluth, C.M. (Ed.). (1993). *Instructional-design theories and models, volume II*. Hillsdale, New Jersey: Lawrence Erlbaum Associates Publishers.

Santosa, F. H., Negara, H. R. P., & Bahri, S. (2020). Efektivitas pembelajaran Google Classroom terhadap kemampuan penalaran matematis siswa. *Jurnal Pemikiran dan Penelitian Pendidikan Matematika (JP3M)*, *3*(1), 62-70. https://doi.org/10.36765/jp3m.v3i1.254

Smaldino, S.E., Lowther, D.L., Mims, C. & Russell, J.D. (2015). *Instructional technology and media for learning eleventh edition.* New Jersey: Pearson.

Surahman, E., & Surjono, H. (2017). Pengembangan adaptive mobile learning pada mata pelajaran biologi SMA sebagai upaya mendukung proses blended learning. *Jurnal Inovasi Teknologi Pendidikan, 4*(1), 26-37. https://doi.org/10.21831/jitp.v4i1.9723

Surahman, E., Sulthoni, & Pratama, U. N. (2021). Online observation protocol to supervise online learning and its sample report BT - *Proceedings of the 7th International Conference on Education and Technology (ICET 2021)*. 6–12. https://www.atlantis-press.com/proceedings/icet-21/125964508

Surjono, H. D., Muhtadi, A., & Trilisiana, N. (2019). The effects of online activities on student learning outcomes in blended learning environment. *Proceedings of the 2019 3rd International Conference on Education and Multimedia Technology (ICEMT)*, 107-110. https://doi.org/10.1145/3345120.3345167

Sweller, J., van Merriënboer, J.J.G. & Paas, F. Cognitive architecture and instructional design: 20 years later. *Educ Psychol Rev* 31, 261–292 (2019). https://doi.org/10.1007/s10648-019-09465-5

Thahura, F., & Tutdin, Z. (2021). Peran efikasi diri terhadap beban kognitif dan stress akademik mahasiswa selama pembelajaran daring di masa pandemi. *Jurnal Kajian Psikologi dan Konseling, 12*(2), 981-987. https://doi.org/10.24114/konseling.v19i2.30433

Trilisiana, N. (2020). Lingkungan belajar cerdas demi kebermaknaan pembelajaran di saat Pagebluk. Dalam: Herwin, Kusumawardani, E., Nurmalasari, Y., Purwandari, E. (eds.) *Inovasi dan Transformasi Pendidikan Bermakna di Era New Normal.* FIP UNY, Yogyakarta.

Yuwono, S.D. (2020). Profil kondisi stres di masa pandemi covid-19 sebagai dasar intervensi dalam praktek mikrokonseling. *Ristekdik (Jurnal Bimbingan dan Konseling)*, *5*(1), 132:138. http://jurnal.um-tapsel.ac.id/index.php/Ristekdik/article/view/1787