Evaluating the Saudi Sixth-Grade Mathematics Textbook Through Lens of Cognitive Load Theory Principles

Nawaf Awadh k Alreshidi
Associate professor- Collage of Education – University of Ha'il

(**Received:** 16-09-2025; **Accepted**: 04-11-2025)

Abstract: The aim of this research was to evaluate the Saudi sixth-grade (first-semester) mathematics textbook content design through lens of cognitive load theory principles, including split-attention, problem completion, self-explaining and variability. A quantitative content analysis approach was used to gather numerical data from the textual content. The results showed that eighteen percent of fifty worked examples were affected by split-attention. No single worked example was followed immediately by problem completion or self-explaining activities. Six percent of worked examples were not followed immediately by problems of low variability, while ninety two percent of worked examples were not followed immediately by problems of high variability. No skills embedded in the worked examples were left without practice problems with high contextual interference.

Keywords: Cognitive load, split-attention, self-explain, worked examples, problem completion, variability.

***

تقييم كتاب رياضيات الصف السادس الابتدائي السعودي في ضوء مبادئ نظرية العبء المعرفي

نواف عوض خلاف الرشيدي
أستاذ مشارك – كلية التربية – جامعة حائل

(**تاريخ الاستلام:** 16-09-2025؛ **تاريخ القبول:** 04-11-2025)

مستخلص البحث: يهدف هذا البحث إلى تقييم تصميم محتوى كتاب الرياضيات للصف السادس الابتدائي السعودي (الفصل الدراسي الأول) في ضوء مبادئ نظرية العبء المعرفي، بما في ذلك: الانتباه المنقسم، وإكمال المشكلات، والشرح الذاتي، والتباين. وقد تم اختيار نهج تحليل المحتوى الكمي لجمع البيانات الرقمية من المحتوى النصي. وأظهرت النتائج أن ثمانية عشر بالمئة من 50 مثالاً عمليا تأثرت بالانتباه المنقسم. ولم يتبع ستة بالمئة من الأمثلة العملية مباشرةً مشكلات ذات تباين منخفض، بينما لم يتبع اثنان وتسعون بالمئة من الأمثلة العملية مباشرةً مشكلات ذات تباين مرتفع. ولم يتبع أي مثال عملي واحد إكمال المشكلة أو حتى أنشطة الشرح الذاتي مباشرةً. ولم تُترك أي مهارة مضمنة في المثال العملي دون ممارسة مع مشكلات ذات استدلالات سياقية عالية.

الكلمات مفتاحية: العبء المعرفي، الانتباه المنقسم، الشرح الذاتي، الأمثلة العملية، إكمال المشكلة، التباين.

(*) **Corresponding Author**:
Nawaf Awadh k Alreshidi
Associate professor- Collage of Education – University of Ha'il.

Email: n.alreshidi@uoh.edu.sa

(*) للمراسلة:
نواف عوض خلاف الرشيدي
أستاذ مشارك – كلية التربية – جامعة حائل - المملكة العربية السعودية.

البريد الإلكتروني: n.alreshidi@uoh.edu.sa

DOI: 10.12816/0062356

1. Introduction

Textbooks have long been widely used worldwide and continue to be the primary foundation of school curricula (Richards, 2014). Research has asserted the importance of various techniques that should be involved in the design of textbooks, such as integrating text with visuals (Mayer, 2009) and using worked examples, problem completion and self-explaining activities, and variability (Sweller et al., 2011). However, these techniques must be designed and presented in a way that can support effective learning. The effective design of such techniques in textbooks can be explained by cognitive load theory. Cognitive load theory (CLT), generated by John Sweller, is an instructional design framework grounded in the principles of human cognitive architecture (Sweller, 2019). It emphasises that instructional design should be presented with consideration of working memory limitations and unlimited long-term memory for learners (van Merriënboer & Sweller, 2010).

The theory works primarily with biologically secondary knowledge, which is the type of knowledge that is consciously acquired, such as reading, writing and arithmetic (Geary, 2007, 2008). Cognitive load, a central concept in CLT, refers to working memory resources, or the mental effort required to complete a certain cognitive task. It is a theoretical concept that explains the interaction between the cognitive abilities of the learner and the complexity of the information being processed (Kalyuga, 2009). Cognitive load is classified into three types: intrinsic cognitive load, extraneous cognitive load and germane cognitive load. Intrinsic cognitive load (ICL) is imposed by the complexity of the task, and extraneous cognitive load (ECL) is imposed by poor instructional design. Germane cognitive load (GCL) arises from using working memory resources to construct a schema in long-term memory (Jordan et al., 2020; Sweller, 2010, 2020; Sweller et al., 1998).

The total of these types of cognitive load combined must not exceed the working memory capacity; otherwise, learning can be hindered (Sweller et al., 2011). Therefore, instructional materials must be designed in such a way that the available working memory resources are efficiently used to maximise learning. This can be done by minimising extraneous load as negative and unproductive cognitive load while maximising germane cognitive load as productive and positive cognitive load (Sweller, 2019; Sweller et al., 2011). Several cognitive load effects have been presented for minimising extraneous cognitive load, such as the split-attention effect, the worked-example effect and problem completion, and for maximising GCL, such as the self-explaining effect and variability. These cognitive load effects are discussed in the following paragraphs, and the extent to which they are applied in the Saudi sixth-grade textbook content design is examined.

No previous study conducted in Saudi Arabia to evaluate the mathematics textbook for sixth-grade students has considered CLT. This study was intended to detect design problems, provide recommendations for improvement and pave the way for more studies in this domain.

Minimising extraneous cognitive load

Split-attention effect

The split-attention effect occurs when various sources of information that need to be integrated for learning are not integrated, including textual and pictorial details that are presented separately on the same page or over multiple pages (Castro et al., 2021; Nurjanah & Retnowati, 2018). This hinders learning when compared with spatially integrated sources (Ayres & Sweller, 2014; Florax & Ploetzner, 2010; Mayer & Fiorella, 2014). This is because ECL increases when learners must split their attention between various sources of information to integrate them mentally. This load is not necessary, and it diminishes learning. Therefore, various sources of information should be presented in an integrated manner when that information cannot be learned separately (Sweller, 2019).

Worked-example effect

A worked example (WE) is a problem with a complete step-by-step solution (Barbieri et al., 2023; Sweller, 2019). The worked-example effect occurs for novice learners, while its effect disappears as learners gain more experience. Rather than providing novice learners with problems, worked examples are recommended because presenting learners with problems likely forces them to use ineffective strategies, such as means-ends strategies (Sweller, 1988). For example, learners will identify the desired end state and current state of the problem and then generate random procedures in an attempt to bridge the gap between them and test their effectiveness repeatedly until they find the right procedures. This will cost the learner unnecessary effort (i.e. ECL). To reduce this burden, learners should initially be provided with a worked example to avoid unnecessary cognitive load and acquire problem-solving schemas first, and then they should be provided with related problems for practice. Hence, the worked-example effect occurs when it is presented to novice learners to reduce unnecessary cognitive load (i.e. ECL).

Problem-completion effect

The concept of problem completion is to present a problem with partial solution steps. Learners are expected to complete the rest of the problem solution steps based on the partial solution (Gupta & Zheng, 2020). This reduces student distraction and allows students to direct their attention to the steps of solving the problem (Mihalca et al., 2015). Providing part of the solution reduces the ECL (Sweller et al., 2011). At the same time, it motivates students to complete the solution steps (van Merriënboer & Sweller, 2005). Paas (1992) revealed that problem completion and worked examples are more effective and impose less ECL than traditional problems.

Maximising germane cognitive load

Self-explaining

Self-explaining is a mental process through which learners are encouraged to explain the solution steps of a worked example in their own words (Johnson & Mayer, 2010; Sweller et al., 2011). This can be done by establishing relationships between new knowledge and prior knowledge through self-explanation. This process induces GCL to construct cognitive schemas. However, when learners lack adequate relevant prior knowledge, the self-explaining effect may increase ECL (Chi et al., 1989; Cooper et al., 2001; Renkl, 1997; Sweller, 2019). It is also possible that self-explaining may be redundant when the student is able to explain the steps (Sweller et al., 2003). When using only one problem or worked example, students should be prompted to self-explain. However, when students are exposed to diverse examples, self-explanation may not be important because the variety motivates students to compare and contrast different problems, eliminating the need for self-explanation (Sweller, 2019).

Variability effect

The variability effect occurs when presenting worked examples or problems in different contexts. High variability is achieved by applying the same process in a variety of contexts, which involves changing the surface features of the problem (such as numbers) and the structure of the problem (i.e. the format of the questions); low variability is achieved by changing the surface features without changing the structure of the problem (see Paas & van Merriënboer, 1994). High variability improves knowledge transfer (Clark et al., 2006; Paas & van Merriënboer, 1994; van Merriënboer & Sweller, 2005) because it increases learners' likelihood of identifying and distinguishing relevant features from irrelevant ones (van Merriënboer & Sweller, 2005). This encourages learners to construct cognitive schemata, which is reflected in higher GCL (Sweller et al., 2011). However, when novice learners are exposed to complex cognitive domains, diversity or variance may lead to practices that hinder learning (Likourezos & Kalyuga, 2019). A special type of variability, contextual interference, is explained next.

Contextual interference

Low contextual interference focuses on a standardised training schedule in which one type of problem is mastered and then the learner moves on to another type of problem (e.g. B-B-B, C-C-C, A-A-A). High contextual interference focuses on a randomised training schedule in which different problems are put into practice in random order, that is, varied problems requiring different solving skills (e.g. C-A-B, B-A-C, B-C-A; Schmidt et al., 2011). Although high contextual interference requires more time and mental effort, it results in better retention and higher transfer of acquired skills compared to low contextual interference (De Croock et al., 1998; van Merriënboer et al., 2002b). High contextual interference stimulates the conscious abstraction of similarities and differences of different problem solutions. This requires control and effort, increasing GCL. Research has found that high contextual interference delays skill acquisition during training but produces greater knowledge transfer performance (De Croock et al., 1998; van Merriënboer et al., 2002b).

Cognitive load theory and instructional materials

Instructional materials are a source of cognitive load for learners (Sweller et al., 2011). Not designing and presenting these materials appropriately can result in an ineffective cognitive load, which consequently diminishes effective learning (Mayer, 2009). In education, the long-standing practice of using textbooks (Bezemer & Kress, 2009) emphasises the importance of continuously improving them to enhance learning outcomes (Kovac & Kepic Mohar, 2022); hence, several studies have been conducted from different perspectives to identify common problems in textbook design and the need to address them to optimise learning experiences. For example, Al-Saedi (2021) conducted a study in Saudi Arabia to evaluate the content of the sixth-grade textbook mathematics in light of the National Council of Teachers of Mathematics (NCTM) guidelines. Abdulhadi (2024) carried out a study in Palestine aiming to evaluate the sixth-grade mathematics textbook according to various criteria related to the book's elements (including form and artistic output of the book, educational objectives, book content, educational activities and evaluation) based on ideological, social, psychological and cognitive philosophy. Diwan and Ahmed) 2023(performed a study in Egypt to determine the ratios of the mental abilities of the Guilford model in the content of the mathematics book for sixth-grade primary school. To the best of the author's knowledge, no single study existed that had been conducted in Saudi Arabia to evaluate the sixth-grade mathematics textbook considering CLT. Internationally, few studies have examined textbooks, particularly in mathematics. For example, Nurjanah and Retnowati (2018) used CLT to analyse potential ECL, including four aspects – the redundancy of information, split attention, incoherence and the lack of signalling – presented in a seventh-grade mathematics textbook. The results showed that about 3.69% of the material presented in the textbook caused redundant information, 18.43% caused split attention, 3.69% was incoherent and 18.43% lacked signalling. In this study, the sixth-grade (first-semester) mathematics textbook was evaluated considering CLT principles, including split attention, problem completion, self-explaining and variability. The study aimed to answer the following questions:

To what extent is unproductive cognitive load design applied in the textbook?

To what extent is productive cognitive load design applied in the textbook?

2. Method

Study design and instrument of the study

The aim of this research was to evaluate the Saudi first-term sixth-grade mathematics textbook through lens of CLT principles, including split attention, problem completion, self-explaining and variability. A quantitative content analysis approach was implemented to gather numerical data from the textual content (Neuendorf, 2017). This approach was fulfilled using a structured checklist that measured the frequency of occurrence of eight design items that are covered in the four main CLT principles mentioned. The instrument was constructed based on a literature review of cognitive theory and was verified by three professors who were experts in the field in terms of measuring what the research aimed to measure and in terms of clarity in the coding rules and consistency. Some feedback was provided by the experts, and the author changed the instrument based on their assessments. To measure content analysis reliability, test-retest reliability was used to re-analyse the data with the author over the course of a month, which yielded an acceptable reliability score of 0.96.

Textbook description

The mathematics textbook for sixth-grade primary school students (for the first of three semesters during the year) includes 92 pages and was first published by the Saudi Ministry of Education in 2024. Table 1 shows that the textbook comprises three main units, encompassing a total of 50 worked examples. The textbook targets 12-year-old students.

Table 1: Mathematics textbook descriptive features

Unit	Title	Number of WEs	Pages
1	Algebra: Number patterns and functions	15	17–43
2	Statistics and graphs	10	56–81
3	Operations on decimal fractions	25	86–127
Total		50	92

Note: WE(s) refers to worked example(s).

The design of each unit in the book begins with preparation for the new unit, which reviews the relevant prior knowledge. Each topic begins with an activity that aims to guide students to discover new concepts. Students should read it and answer the relevant questions. This activity is followed by concepts and instructions. Then 2–4 worked examples are presented, each one followed by a problem as an assessment of students' understanding of the worked example. Presented after that are related problems intended to ensure the students achieve the learning objectives, followed by training (problems), then higher order thinking problems and then training for tests. Preparation for the next topic appears at the end of the topic section. Several visual designs accompany each topic.

Data collection

Data were collected using an eight-item structured checklist developed based on a literature review of CLT. The author measured eight items related to four main CLT principles: split attention, problem completion, self-explaining and variability (see Table 2).

Table 2: Structured checklist of cognitive learning theory principles

Principles	Description
Split attention	Various sources of information that need to be integrated for learning are not integrated
Problem completion	No problem completion followed WM immediately
Self-explaining	No self-explaining activities followed WE immediately
Variability	WE was not followed immediately by problems with low variability
	WE was not followed immediately by problems with high variability immediately
	WE was not followed by problems with low variability at a later stage of the instructional sequence
	WE was not followed by problems with high variability at a later stage of the instructional sequence
	WEs were not followed by high contextual interference

Note: WE(s) refers to worked example(s).

Split attention included one item – 'Various sources of information that need to be integrated for learning are not integrated' – which accounts for how many worked examples caused split attention. Problem completion included one item – 'No problem completion followed WE immediately' – which accounts for how many worked examples were not followed by at least one problem completion before presenting another worked example. Self-explaining included one item – 'No self-explaining activities followed WE immediately' – which accounts for how many worked examples were not followed by at least one self-explaining activity before presenting another worked example.

Variability included five items. 1) 'WE was not followed immediately by problems with low variability', which accounts for how many worked examples were not followed by at least one practice problem of low variability before another WE was presented. 2) 'WE was not followed immediately by problems with high variability', which accounts for how many WEs were not followed by at least one practice problem before another WE was presented. 3) 'WE was not followed by problems with low variability at a later stage of the instructional sequence, which accounts for how many worked examples were not followed by at least one practice problem of low variability within the whole topic. 4) WE was not followed by problems with high variability at a later stage of the instructional sequence, which accounts for how many worked examples were not by at least one practice problem of high variability within the whole topic. 5) 'WEs were not followed by high contextual interference', which accounts for how many worked examples were not followed by high contextual interference of practice problems within the whole topic.

The data were collected through a straightforward coding approach, where the author reviewed each worked example and the tasks that followed in the textbook and recorded every instance in which items related to CLT were identified. Each item was documented individually. To organise the analysis process, the author followed the same unit order as the textbook. The gathered data were then statistically analysed.

3. Results and discussion

Table 3 represents the frequency of occurrence of the eight investigated design items obtained via the structured checklist categorised into four main scales, including split attention, problem completion, self-explaining and variability.

Split-attention effect

Approximately 18% of the worked examples were negatively affected by split attention. They presented various sources of information that were not integrated, even though they needed to be integrated for learning. The results revealed that Unit 1 had the highest percentage (33%) of worked examples affected by the split-attention effect, followed by Unit 2 with 20% and Unit 3 with 8%, the lowest percentage. The split-attention effect occurs when various sources of information that need to be integrated for learning are not integrated, which includes textual and pictorial information presented separately on the same page or over multiple pages (Castro et al., 2021; Nurjanah & Retnowati, 2018). The example of the split attention displayed in Figure 1 shows that the presetting steps of the solution of the worked example split students' attention.

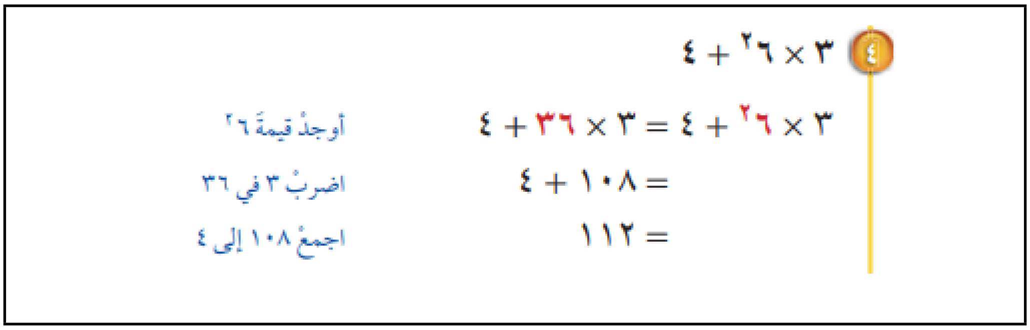

Figure 1: an example of split attention reported for Unit 1 (example N 4 /P 28)

The designer presents the steps of the solution as follows:

'$3 \times 6^2 + 4 = 3 \times 36 + 4$ find value 6^2'

The students here must split their attention horizontally to find out why 36 existed, and the statement 'find value 6^2' is an instruction that appears after the action was taken, which can confuse learners. The designer should place 36 under 6^2 vertically to avoid split attention and give the instruction (find value 6^2) one step before action is taken as follows:

'$3 \times 6^2 + 4$ find value 6^2
↓
$= 3 \times 36 + 4$'

As seen in Figure 1, the problem was first related to the inappropriate placement of the instructions. This problem existed throughout the textbook where procedures (i.e. actions) preceded instructions, which caused split attention between the instructions and the procedures. This must be changed to make instructions precede procedures by one step, which can help students understand what action would be taken next. When instruction comes first, the students will hold the instruction and check the next action, while if the instruction comes at the end of the action, the students will be forced to explain the action taken to understand it, but if they cannot, then they must return to the instruction, which causes split-attention. In addition, the problem also is that presenting mathematical statements horizontally while they should be presented vertically causes split attention. This problem also existed throughout the textbook. Improperly integrated sources will hinder learning when compared with properly spaced integrated sources (Ayres & Sweller, 2014; Florax & Ploetzner, 2010; Mayer & Fiorella, 2014) because ECL is increased when learners must split their attention between various sources of information to integrate them mentally. This load is not necessary, and it diminishes learning. Therefore, various items of information should be presented in an integrated source and in a proper way when that information cannot be learned separately (Sweller, 2019).

Table 3: The results

Principles	Description	Unit1			Unit2			Unit3			Total		
		N. WE	F	%	N. WE	F	%	N. WE	F	%	N. WE	F	%
Split attention	Various sources of information that need to be integrated for learning are not integrated	15	5	33%	10	2	20%	25	2	8%	50	9	18%
Problem completion	No completion problem immediately followed WM		15	100%		10	100%		25	100%		50	100%
Self-explaining	No self-explaining activities immediately followed WM		15	100%		10	100%		25	100%		50	100%
Variability	WE was not followed immediately by problems with low variability		0	0%		1	10%		2	8%		3	6%
	WE was not followed immediately by problems with high variability		14	93%		9	90%		23	92%		46	92%
	WE was not followed by problems with low variability at a later stage of the instructional sequence		0	0%		0	0%		0	0%		0	0%
	WE was not followed by problems with high variability at a later stage of the instructional sequence		2	13%		2	20%		0	0%		4	8%
	WEs were not followed by high contextual interference		0	0%		0	0%		0	0%		0	0%

Note: WE(s) refers to worked example(s), N refers to Number and F refers to frequence.

Problem completion

No 'problem completion' activities immediately followed the WEs. The design of the textbook did not take advantage of problem completion techniques, which are important for reducing ECL and for motivating students to complete the solution steps (van Merriënboer & Sweller, 2005).

Self-explaining activities

No self-explaining activities immediately followed the WEs. Self-explaining can induce GCL, which leads to connecting relevant prior knowledge to new information and results in constructing cognitive schema (Kalyuga, 2007; Rittle-Johnson & Loehr, 2017). In general, some studies conducted across the world indicated that mathematics textbook emphasise procedural knowledge over conceptual knowledge (see Namlı & Özçakır, 2024).

When using only one problem or worked example, students should be prompted to self-explain. However, when students are exposed to diverse examples, self-explanation may not be important because the variety motivates students to compare and contrast different problems, eliminating the need for self-explanation (Sweller, 2019). Most worked examples were followed immediately by a single practice problem, which is needed for self-explanation techniques. Many mixed practice problems were placed after 2-4 worked examples; however, these practice problems seemed to cause ECL because they practised many skills in different contexts (i.e. applying high contextual interference) while each skill was not practiced sufficiently before applying high contextual interference.

Variability

Six percent of the worked examples were not followed immediately by practice problems with low variability. There was at least one practice problem with low variability that followed each WE immediately for Unit 1, while Unit 2 represented the highest percentage with 10% of the WEs that were not followed immediately by practice problems with low variability.

Ninety-two percent of worked examples were not followed immediately by practice problems with high variability. Unit 1 represented the highest percentage with 93% of WEs that were not followed immediately by at least one problem with high variability, while the lowest percentage was for Unit 2 with 90%. Eight percent of worked examples were not followed by any high variability problems at all. The highest percentage of WEs that were not followed by at least one practice problem with high variability at all was Unit 2 with 20%, while the lowest percentage was Unit 3 with 0%. High variability improves learning transfer (Clark et al., 2006; Paas & van Merriënboer, 1994; van Merriënboer & Sweller, 2005) because it increases the learners' likelihood of identifying and distinguishing relevant features from irrelevant ones (van Merriënboer and Sweller, 2005). This encourages learners to construct cognitive schemata, which is reflected in higher GCL.

In terms of contextual interference, due to the lack of problems with high variability that immediately followed each worked example, low contextual interference was not applied, but high contextual interference was applied; after some examples addressing certain learning objectives, some problems were randomly presented. Although high contextual interference requires more time and mental effort, it results in better retention and higher transfer of acquired skills compared to low contextual interference (De Croock et al., 1998; van Merriënboer et al., 2002b). High contextual interference stimulates the conscious abstraction of similarities and differences of different problem solutions. This requires control and effort, increasing the associated cognitive load. Research has found that high contextual interference delays skill acquisition during training but is greater in knowledge transfer performance (De Croock et al., 1998; van Merriënboer et al., 2002b). However, in this textbook, it seems that each skill was not sufficiently practised before high contextual interference was applied. This was indicated by 92% of worked examples that were not followed immediately by practice problems with high variability. Therefore, it seems high contextual interference applied might cause too high a cognitive load. This needs to be investigated in future research.

Recommendations

- Present mathematical procedures vertically if presenting them horizontally causes split attention.
- Place instructions in the correct place; the instructions should precede the action by one step to avoid split attention.
- Provide self-explaining activities and problem completions where necessary.
- Worked examples should be followed by practice problems with low and high variability before proceeding to another example.
- Conduct more studies to evaluate mathematics textbooks at different educational levels and with more CLT principles.

Limitations

The study is limited to four CLT principles, including split attention, problem completion, self-explanation and variability. It is limited also to the first-semester sixth-grade mathematics textbook published by the Saudi Ministry of Education in 2024. The analysis of the textbook is limited to worked examples and the tasks that follow while the tasks presented before the worked examples were ignored.

4. Conclusion

The Saudi sixth-grade (first-semester) mathematics textbook was evaluated considering CLT, including split attention, problem completion, self-explaining and variability. Throughout the textbook, action was found to precede instructions, which causes split attention: that is, the students had to view the action and then go one step back to view the instructions to find out what procedures had been followed. Another finding throughout the textbook was that mathematical statements were presented horizontally when they should have been presented vertically. Presenting them horizontally forces students to switch their attention from the right side to the left side of the mathematical statements. However, if the statement is presented vertically, the action taken could be seen without switching attention between the different statements. The textbook design does not use self-explaining activities. This might indicate that the textbook focuses on procedural knowledge over conceptual knowledge. Most worked examples were followed by practice problems with low variability; however, no practice problems with high variability followed practice problems with low variability immediately. This does not support learning mathematics effectively and causes too high a cognitive load when later applying high contextual interference.

5. References

Abduahadi, Mansour, Ikram Talab, (2024) Evaluation of the Mathematics Textbook for the Sixth Grade in Palestine, Examining its Components and Foundational Principles from the Perspective of Teachers: Qualitative Study. Arab Journal of Educational and Psychological Sciences. 41 (1). 43-72

Al-Saedi, Hanan Ahmed (2021). evaluating content of the sixth-grade mathematics curriculum in the light of National Council of Teachers of Mathematics (NCTM). Journal of educational science, 7 (2), 339-374.

Ayres, P., & Sweller, J. (2014). The split-attention principle in multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd, rev. ed.) (pp.206- 226). New York: Cambridge University Press. doi: 10.1017/CBO9781139547369.011

Barbieri, C. A., Miller-Cotto, D., Clerjuste, S. N., & Chawla, K. (2023). A meta-analysis of the worked examples effect on mathematics performance. Educational Psychology Review, 35(1), 11.

Bezemer, J., & Kress, G. (2009). Visualizing English: a social semiotic history of a school subject. Visual communication, 8(3), 247-262. doi:https://doi.org/10.1177/1470357209106467.

Castro-Alonso, J. C., de Koning, B. B., Fiorella, L., & Paas, F. (2021). Five strategies for optimizing instructional materials: Instructor-and learner managed cognitive load. Educational Psychology Review, 33(4), 1379-1407. Retrieved from https://doi.org/10.1007/s10648-021-09606-9

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. Cognitive Science, 13, 145–182

Clark, R. C., Nguyen, F., & Sweller, J. (2006). Efficiency in learning: Evidence-based guidelines to manage cognitive load. San Francisco: Pfeiffer.

Cooper, G., Tindall-Ford, S., Chandler, P., & Sweller, J. (2001). Learning by imagining procedures and concepts. Journal of Experimental Psychology: Applied, 7, 68–82.

De Croock, M. B. M., Van Merriënboer, J. J. G., & Paas, F. (1998). High versus low contextual interference in simulation-based training of troubleshooting skills: Effects on transfer performance and invested mental effort. Computers in Human Behavior, 14, 249-267.

Diwan, Alaa Khalid, Ahmed, Baida Mohamed, (2023). The mental abilities of the Guilford model included in the mathematics book for the sixth grade of primary school. Journal of the College of Basic Education. Vol.29 (NO. 122) 2023, pp. 461-480.

Florax, M., & Ploetzner, R. (2010). What contributes to the split-attention effect? The role of text segmentation, picture labelling, and spatial proximity. Learning and Instruction, 20, 216-224. doi: 10.1016/j.learninstruc.2009.02.021

Geary, D. (2007). Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology. In J. S. Carlson, & J. R. Levin (Eds.), Psychological perspectives on contemporary educational issues (pp. 1–99). Greenwich, CT: Information Age Publishing.

Geary, D. (2008). An evolutionarily informed education science. Educational Psychologist, 43, 179–195

Gupta, U. and Zheng, R. Z. (2020). Cognitive Load in Solving Mathematics Problems: Validating the Role of Motivation and the Interaction Among Prior Knowledge, Worked Examples, and Task Difficulty. European Journal of STEM Education, 5(1), 05. https://doi.org/10.20897/ejsteme/9252

Johnson, C. I., & Mayer, R. E. (2010). Applying the self-explanation principle to multimedia learning in a computer-based game-like environment. Computers in Human Behavior, 26(6), 1246-1252.

Jordan, J., Wagner, J., Manthey, D. E., Wolff, M., Santen, S., & Cico, S. J. (2020). Optimizing lectures from a cognitive load perspective. AEM education and training, 4(3), 306-312.

Kalyuga, S. (2007). Expertise Reversal Effect and Its Implications for Learner-Tailored Instruction. Educational Psychology Review, 19(4), 509-539.

Kalyuga, S. (2009). Cognitive load factors in instructional design for advanced learners. New York: Nova Science Publishers, Inc.

Kovac, M., & Kepic Mohar, A. (2022). The changing role of textbooks in primary education in the digital era: What can we learn from reading research? CEPS Journal, 12(2), 11-27. doi:10.25656/01:25210; 10.26529/cepsj.1290

Likourezos, V., & Kalyuga, S. (2019). The Variability Effect in High and Low Guidance Instruction: A Cognitive Load Perspective. Mathematics Education Research Group of Australasia.

Mayer, R. E. (2009). Multimedia Learning (2 ed.). Cambridge: Cambridge University Press.

Mayer, R. E., & Fiorella, L. (2014). Principles for reducing extraneous processing in multimedia learning: Coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd , rev. ed.) (pp. 279-315). New York: Cambridge University Press. doi: 10.1017/CBO9781139547369.015

Mihalca, L., Mengelkamp, C., Schnotz, W., & Paas, F. (2015). Completion problems can reduce the illusions of understanding in a computer-based learning environment on genetics. Contemporary Educational Psychology, 41, 157–171. https://doi.org/10.1016/j.cedpsych.2015.01.001

Namlı, Ş., & Özçakır, B. (2024). Analysing the Tasks in Middle School Mathematics Textbooks According to the Levels of Cognitive Demand. Türk Akademik Yayınlar Dergisi (TAY Journal), 8(3), 477-502.

Neuendorf, K. A. (2017). The content analysis guidebook. Sage.

Nurjanah, A., & Retnowati, E. (2018). Analyzing the extraneous cognitive load of a 7th grader mathematics textbook. Journal of Physics: Conference Series. 1097, p. 012131. IOP Publishing. doi:10.1088/1742 6596/1097/1/012131.

Paas F. G. W. C., Van Merriënboer J. J. G. (1994) Variability of worked examples and transfer of geometrical problem-solving skill: A cognitive-load approach. Journal of Educational Psychology, 86, 122–133.

Paas, F. G. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: a cognitive-load approach. Journal of educational psychology, 84(4), 429.

Renkl, A. (1997). Learning from worked-out examples: A study on individual differences. Cognitive Science, 21, 1–29.

Richards, J. C. (2014). The ELT textbook. In International perspectives on materials in ELT (pp. 19-36). London: Palgrave Macmillan UK. Retrieved from https://doi.org/10.1057/9781137023315_2

Rittle-Johnson, B., & Loehr, A. M. (2017). Eliciting Explanations: Constraints on When Self-Explanation Aids Learning. Psychonomic Bulletin and Review, 24(5), 1501- 1510.

Schmidt, R. A., Lee, T. D., Winstein, C. J., Wulf, G., & Zelaznik, H. N. (2011). Motor control and learning: A behavioral emphasis. Human Kinetics.

Sweller , J. (2019). Cognitive load theory and Educational Technology. Education Technology Research Development, 1-16.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive science, 12(2), 257-285.

Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. Educational Psychology Review, 22, 123–138. https://doi.org/10.1007/s10648-010-9128-5

Sweller, J. (2020). Cognitive load theory and educational technology. Educational Technology Research and Development, 68(1), 1-16. https://doi.org/10.1007/s11423-019-09701-3

Sweller, J., Ayres, P. L., Kalyuga, S., & Chandler, P. (2003). The expertise reversal effect.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). Cognitive load theory. New York: Springer

Sweller, J., Van Merriënboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. Educational Psychology Review, 10, 251–296.

van Merrienboer, J. J. G., Schuurman, J. G., de Croock, M. B. M., and Paas, F. (2002b). Redi- ¨ recting learners' attention during training: Effects on cognitive load, transfer test performance and training efficiency. Learn. Instruct. 12: 11–37.

Van Merrienboer, J. J., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. Educational psychology review, 17, 147-177.

Van Merriënboer, J. J., & Sweller, J. (2010). Cognitive load theory in health professional education: design principles and strategies. Medical education, 44(1), 85-93. Retrieved from https://doi.org/10.1111/j.1365-2923.2009.03498.x