Cognitive Load while Learning and Teaching

To enhance the user experience

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Overview

- The project aims to augment the experience of teachers and students in the Indian education system by studying the cognitive load they experience while teaching and learning.
- The project focusses on redesigning of existing NCERT books and other visual aids by analysis of current system.
- The data has been collected through a wide range of interviews, tests and experiments on students and teachers.
- To enhance the accuracy of the data, the students were divided into 3 different categories based on their syllabus and its advancement. The 3 categories are:
  1. Classes 3 to 5
  2. Classes 6 to 8
  3. Classes 9 to 10

Mental Model

- The problem lies that in contrast to individual learning, there is limited well-researched, evidence-informed theory to guide collaborative learning.
- One consequence of this void is poor implementation and, thus, ineffective, inefficient and unsatisfying use of collaborative learning both for the teacher and for the learner.
- Another consequence is that, due to this poor implementation, teachers and learners waste precious resources (i.e., time,effort, money) on ineffective and inefficient learning and teaching inside and outside of the classroom (i.e., computer-supported collaborative learning; CSCL).
- Finally, this represents a severely missed chance for learners to acquire necessary work-life skills.

Contents

Cognitive Load Theory

> *"Since working memory has a limited capacity, instructional methods should avoid overloading it with additional activities that don't directly contribute to learning."*
>
> -John Sweller, Developer of Cognitive load Theory

- "Cognitive load" relates to the **amount of information** that **working memory** can **hold at one time**.

- **Cognitive Load Theory in Teaching and Learning**:

  Cognitive Load Theory shows us that **working memory** can be **extended** in two ways. First, the **mind processes visual** and **auditory information separately**.

  Auditory items in working memory do not compete with visual items in the same way that two visual items, for example a picture and some text, compete with one another.
  This is known as the "Modality Effect." So, for example, explanatory information has less impact on working memory if it is narrated, rather than added to an already complex diagram.

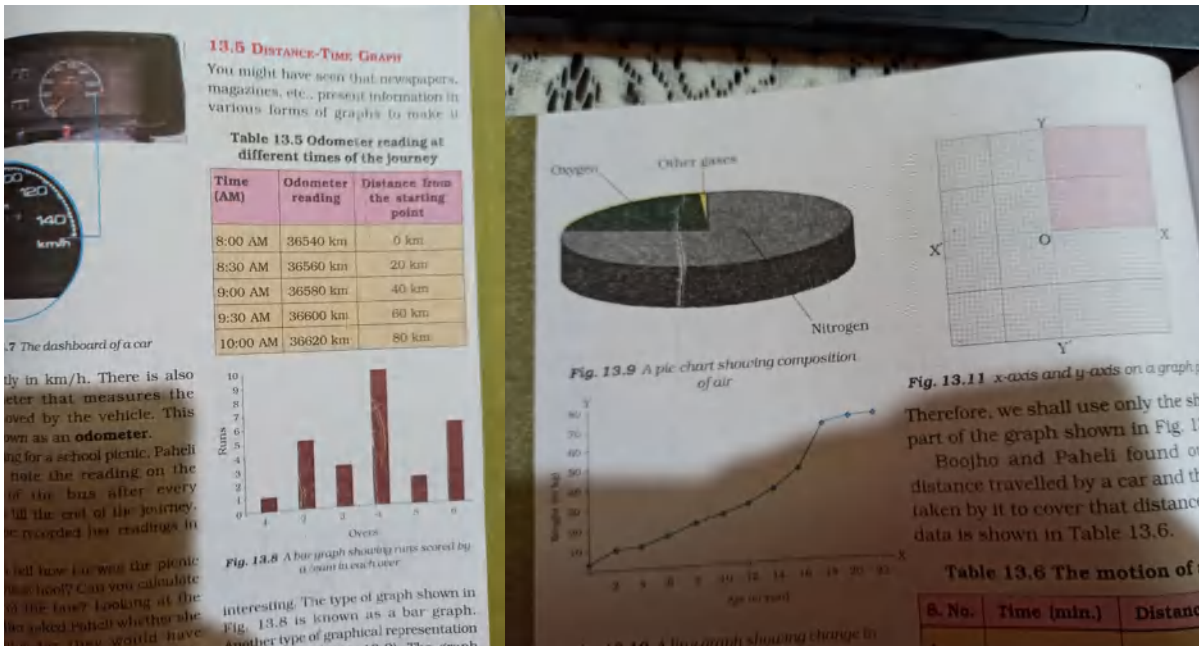
  Second, working memory treats an established schema as a single item, and a highly practiced "automated" schema barely counts at all. So, **learning activities** that **draw upon** your **existing knowledge expand** the **capacity** of your **working memory**.
  This means that **pre-training**, or teaching people prerequisite skills **before** introducing a more **complex topic**, will help them establish schemas that **extend** their **working memory**; and this then means that they can understand and learn more difficult information.

Analysis of the Current System

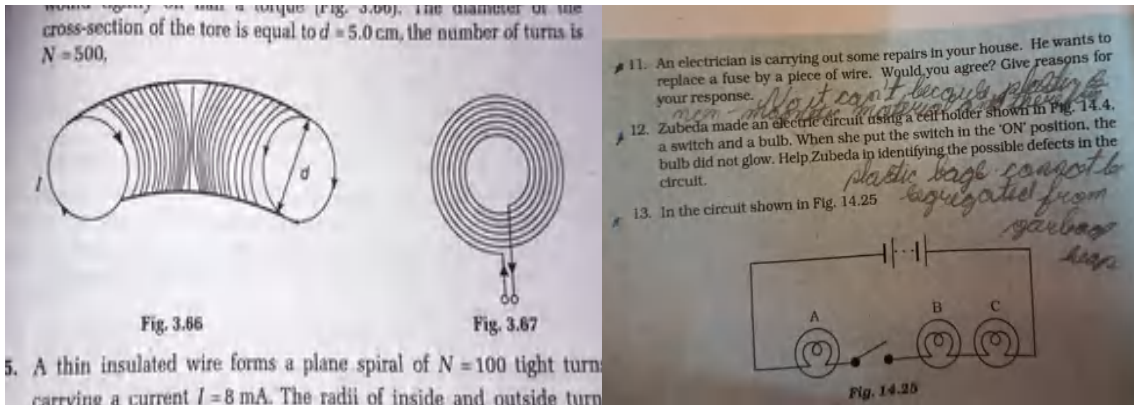
In books

When you have **multiple sources** of **visual information**, such as **diagrams, labels** and **explanatory text**, your **attention** is **divided** between them. This **adds** to the cognitive **load**, making it more **difficult** to **create new schemas**.
This split attention effect is reduced when you integrate visual information. Incorporate labels into diagrams, rather than placing them in a box to one side, or, if this isn't possible, focus in on one part first. If learners need to use a manual while working through a computer program, for example, allow them time to become familiar with the text first, before introducing the program.

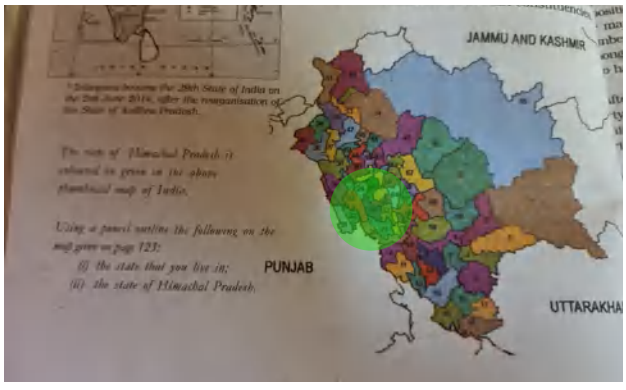
Following are few examples from the NCERT books:



The pages have statistical diagrams, text and images which confuse the makes it difficult to integrate the information.

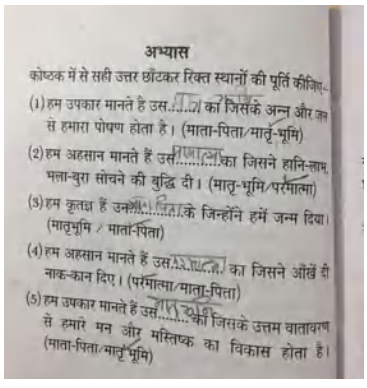


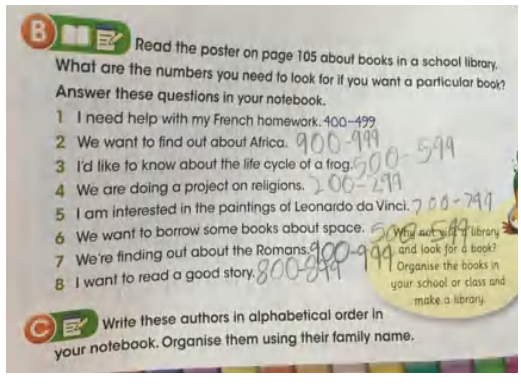
The diagrams are too basic and not illustrative.



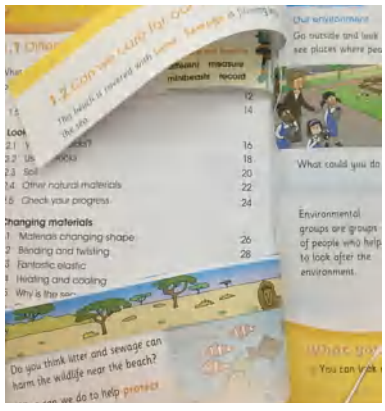
The labels of the diagram are not readable creating mental confusion.

Usage of books by the students: as the studies do not hold the attention of the student, they start doodling.

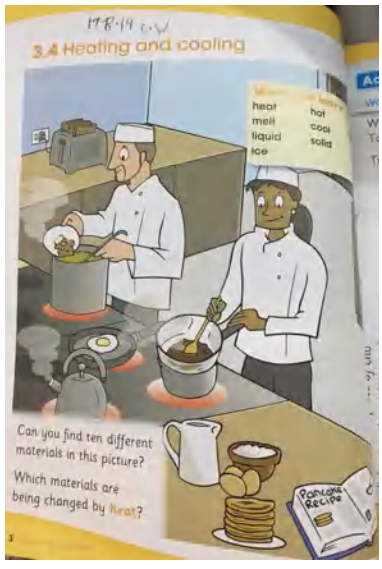




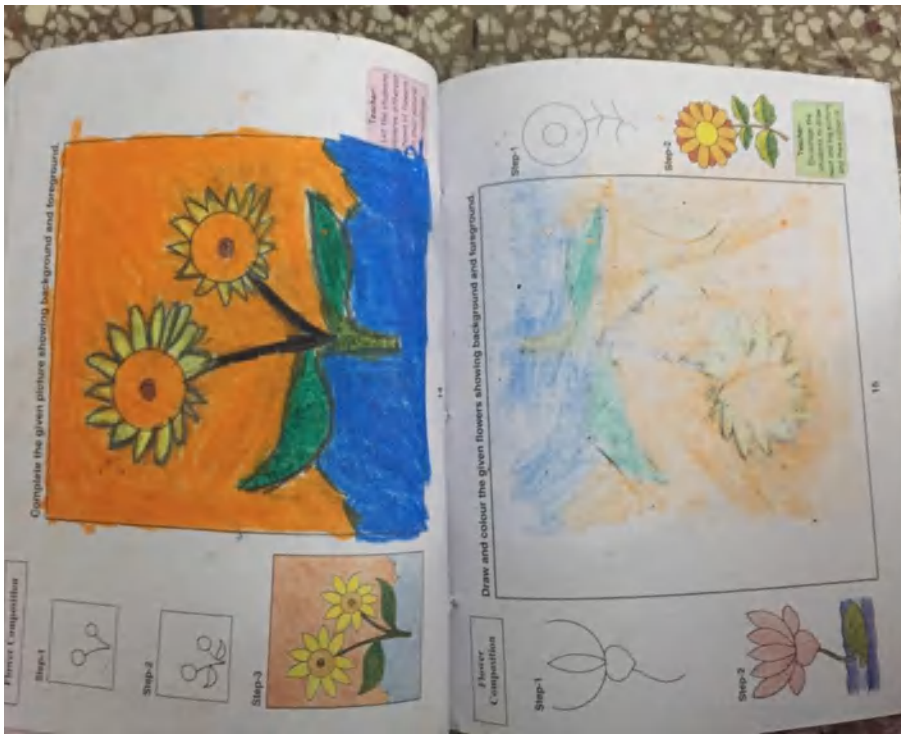
Insufficient space to write the answers to questions in the book



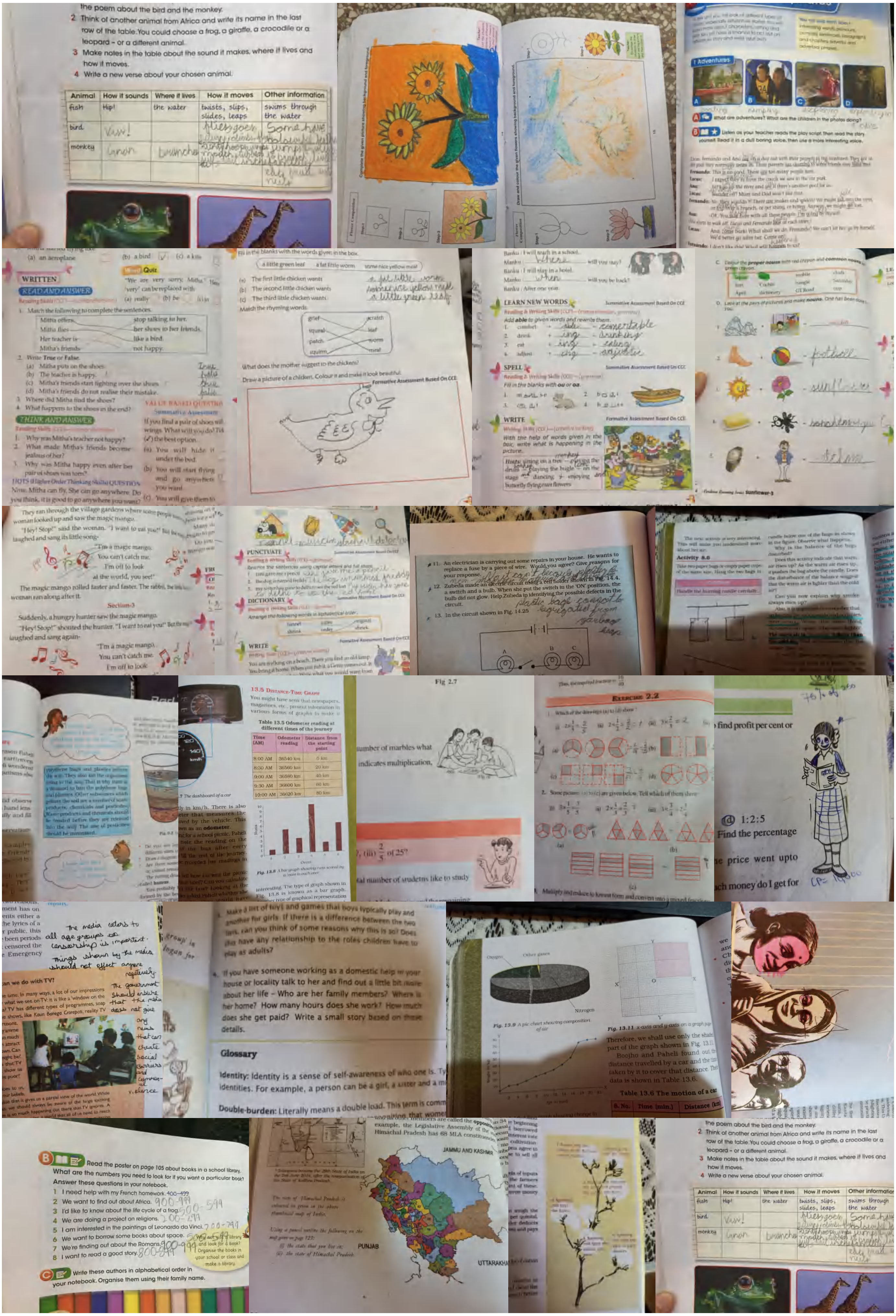
The books are re-used the next year for projects by cutting off of photographs.



Insufficient space to note down any notes. Here the student has marked the class work in a haywire manner resulting in forgetting about it eventually.




3.4 Heating and cooling
Can you find ten different materials in this picture?
Which materials are being changed by heat?
Look at these pictures.
Is the Sun high or low in these pictures?
Do you think it is morning, midday or evening?
Check your progress
Look at the picture.
Who is in day? Who is in night?
Activity 4.2
Can you see in the dark?
You will need:
Kiri wants to see what is in the box, but it is dark. She cannot see anything.
Kiri is using a torch. Now there is light in the box. She can see inside.
Can you see in the dark?
Try looking into a dark box yourself to find out.
Darkness
eez is in his bedroom.
quite dark in his bedroom but
re is some light.
n you see how light is getting in?
I can see in the dark!
भोलू भुलक्कड़
quick bad wind mess kind mud clear clean
2 Draw another table in your notebook with the heading 'Words with ly'. Fill it in with the words in the box, add of each one. Check you understand the meaning of
Words with y
Words with ly
thirsty
slowly
quickly
Language focus
When you add y to the end of a word you turn a noun int
Adjectives give you more information about a noun.
When you add ly to the end of some words you turn an a
adverb. Adverbs give you more information about a verb
3 What happens next?
Valuable Learning
Get Them Right
Language focus
Poem to play script
Breakfast
अभ्यास


the poem about the bird and the monkey.
2 Think of another animal from Africa and write its name in the last row of the table. You could choose a frog, a giraffe, a crocodile or a leopard – or a different animal.
3 Make notes in the table about the sound it makes, where it lives and how it moves.
4 Write a new verse about your chosen animal.
Animal | How it sounds | Where it lives | How it moves | Other information
fish | Hip! | the water | twists, slips, slides, leaps | swims through the water
bird
monkey
What are adventures? What are the children in the photos doing?
Listen as your teacher reads the play script. Then read the story yourself. Read it in a dull boring voice, then use a more interesting voice.
WRITTEN
READ AND ANSWER
Match the following to complete the sentences.
Write True or False.
THINK AND ANSWER
VALUE BASED QUESTION
Fill in the blanks with the words given in the box.
a little green leaf
a fat little worm
Match the rhyming words.
What does the mother suggest to the chicken?
Draw a picture of a chicken. Colour it and make it look beautiful.
Formative Assessment Based On CCE
LEARN NEW WORDS
SPELL
Fill in the blanks with ou or oa.
WRITE
PUNCTUATE
DICTIONARY
Arrange the following words in alphabetical order.
Section-3
Suddenly, a hungry hunter saw the magic mango.
"Hey! Stop!" shouted the hunter. "I want to eat you!" But the mango laughed and sang again-
"I'm a magic mango.
You can't catch me.
I'm off to look
11. An electrician is carrying out some repairs in your house. He wants to replace a fuse by a piece of wire. Would you agree? Give reasons for your response.
12. Zubeda made an electric circuit using a cell holder shown in Fig. 14.4, a switch and a bulb. When she put the switch in the 'ON' position, the bulb did not glow. Help Zubeda in identifying the possible defects in the circuit.
13. In the circuit shown in Fig. 14.25
Activity 8.6
13.5 Distance-Time Graph
Table 13.5 Odometer reading at different times of the journey
Time (AM) | Odometer reading | Distance from the starting point
8:00 AM | 36540 km | 0 km
8:30 AM | 36560 km | 20 km
9:00 AM | 36580 km | 40 km
9:30 AM | 36600 km | 60 km
10:00 AM | 36620 km | 80 km
Fig 2.7
Exercise 2.2
1:2:5
Find the percentage
Make a list of toys and games that boys typically play and another for girls. If there is a difference between the two lists, can you think of some reasons why this is so? Does this have any relationship to the roles children have to play as adults?
If you have someone working as a domestic help in your house or locality talk to her and find out a little bit more about her life – Who are her family members? Where is her home? How many hours does she work? How much does she get paid? Write a small story based on these details.
Glossary
Identity: Identity is a sense of self-awareness of who one is. Typically identities. For example, a person can be a girl, a sister and a m
Double-burden: Literally means a double load. This term is comm
Fig. 13.9 A pie chart showing composition of air
Fig. 13.11 x-axis and y-axis on a graph paper
Table 13.6 The motion of a car
Read the poster on page 105 about books in a school library.
What are the numbers you need to look for if you want a particular book?
Answer these questions in your notebook.
1 I need help with my French homework.
2 We want to find out about Africa.
3 I'd like to know about the life cycle of a frog.
4 We are doing a project on religions.
5 I am interested in the paintings of Leonardo da Vinci.
6 We want to borrow some books about space.
7 We're finding out about the Romans.
8 I want to read a good story.
Write these authors in alphabetical order in your notebook. Organise them using their family name.
JAMMU AND KASHMIR
PUNJAB
UTTARAKHAND

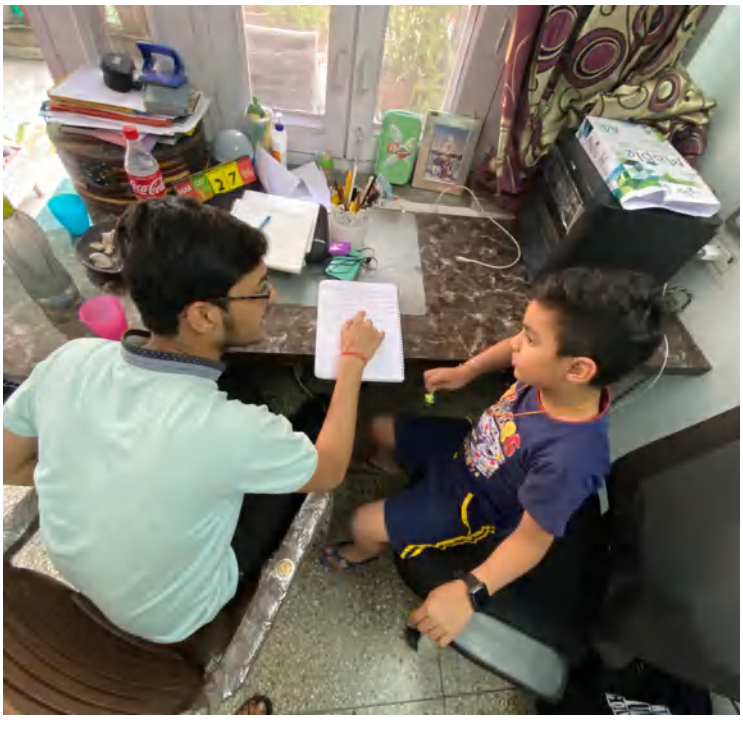
In Classrooms

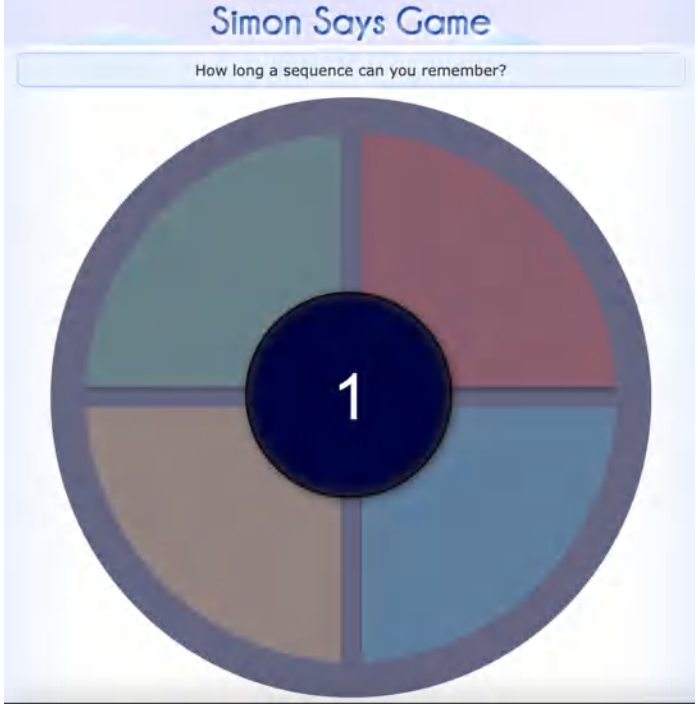
The number of students is quite large in a general classroom hence it is difficult for the teacher to pay attention to each student and make sure all of them are able to understand.
In a survey, it was observed that almost 50% students are not able to properly understand what is being taught in the class as the audio and visuals are not clear.
The visuals and audio have to be synced and topics have to be explained in a step by step manner so that the students are able to form the basic foundation of the topic to make its advanced stages easy to understand.

Tasks Conducted

We conducted various memory tests in forms of fun games on the kids to understand their memory capacity and the level of cognitive load they can sustain. A sample of 5 children (mean age = 8-10 years & 11-13 years) respectively from each category were used to conduct these tests.

1. We conducted the game of simon says: in this game, the player has to repeat what the screen does. For example: there are 4 different colours in the screen, one colour will glow for a second. After the colour glows, the player will be given 5-10 seconds to tap on that colour again. As you advance in the game, the number of colours that will glow after one by one increases and the user has to memorise them and repeat the pattern.





Result of tests:

1. **Situation A: Completely quiet** setup, where the student is the only player in the game
2. **Situation B: Random Noisy** setup, where the student is the only player in the game but someone is constantly disturbing him
3. **Situation C: Classroom Environment** setup, where the student is competing with another person and also being disturbed

Case A	The student was able to reach the 5th level of the game but wasn't able to complete it as he faced difficulty while remembering the order of the colours.
Case B	The student was able to reach the 5th level of the game but wasn't able to complete it as he faced difficulty in paying attention to the game as his attention was split between the surroundings and game.
Case C	The student was able to reach the 3rd level of the game only as he was in a competitve environment where he was experiencing stress while also being disturbed by another person.

Compared with conceptually similar response inhibition tasks,the game of Simon Says is particularly challenging for young children. However, possible reasons for this difference have not been systematically investigated.
Here we tested the relative influence of two dissociable characteristics of the standard Simon Says task:

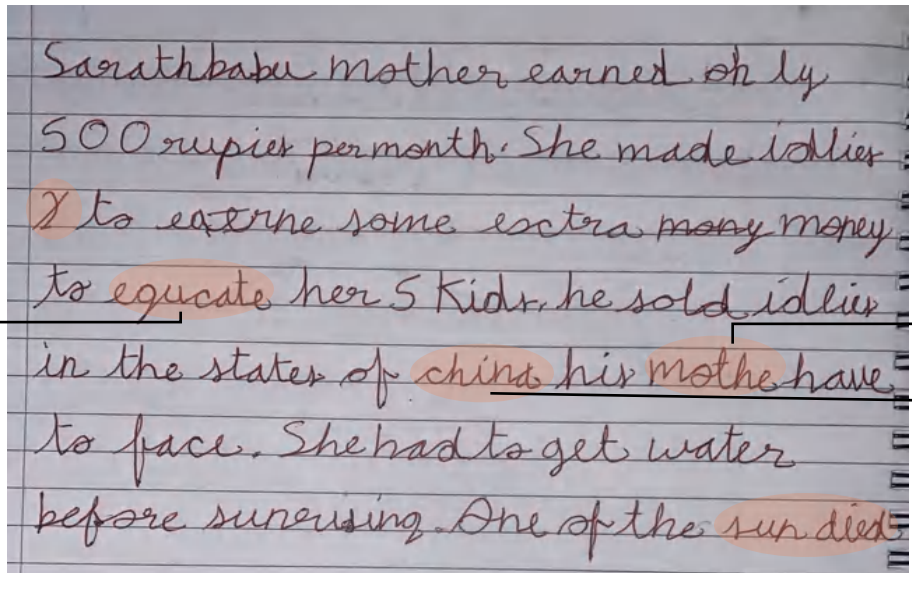
- Receiving both inhibition and activation commands from the same experimenter
- Seeing the experimenter perform the movement along with the commands.

2. We conducted a dictation game, where a paragraph was being dictacted the student and he had to write it down while simultaneously solving the simon says game.
   We then added the elements of disturbance and competition to test how the student responds to these added factors and performs the test.

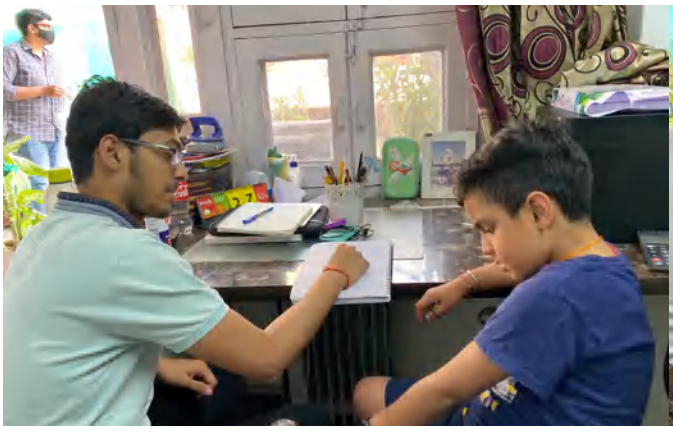
Result of tests:

1. **Situation A**: **Completely quiet** setup, where the student is the only player in the game
2. **Situation B**: **Classroom Environment** setup, where the student is competing with another person and also being disturbed

Case A	The student was able to write few lines without any error - spelling or missing out words.
Case B	The student was not able to write even one line without error. He ommitted a lot of words and a lot of spelling errors were observed.



Analysis revealed that children's performance was significantly worse on the one-task Simon Says compared with the multi-task game. The presence of the experimenters movements alongside their commands had a significant effect on children's performance. The requirement to respond to one person who is changing how different rules apply to similar actions appears to be an important determinant of the difficulty of Simon Says for young children. In terms of implications, inconsistency in how an adult applies rules to children's actions may be a detrimental social influence on the development of cognitive control during childhood.

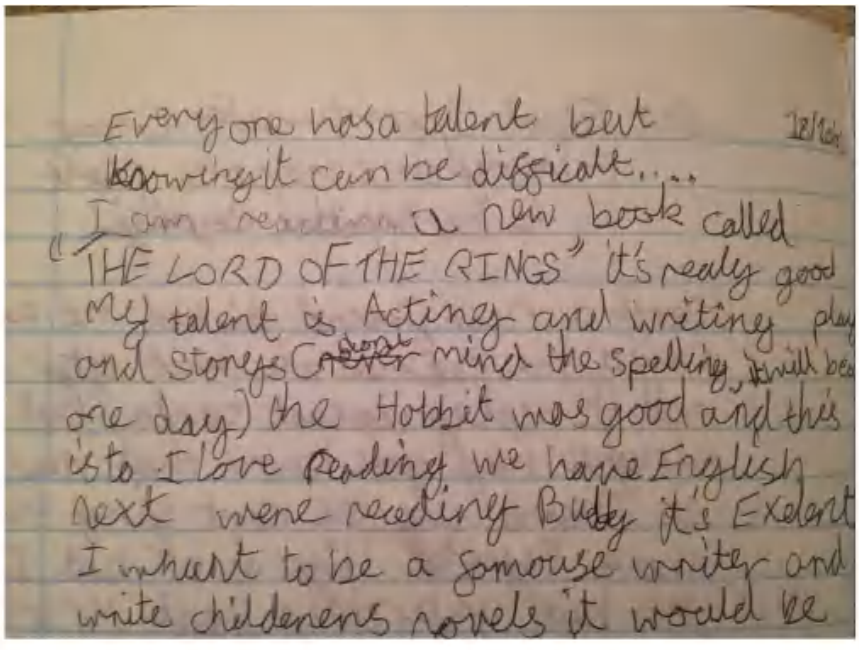





Reading and Learning Disorder

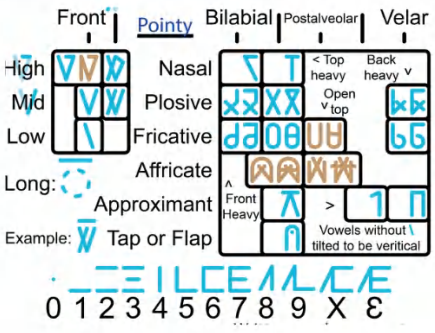
A student with an expressive language disability may have difficulty with the following tasks requiring written languages:

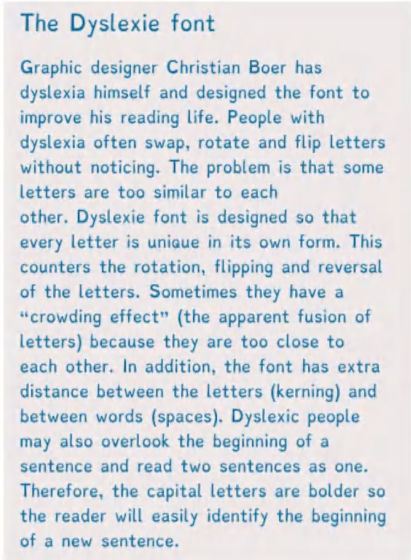
- Expressing themselves clearly and precisely
- While using a variety of sentence structures
- Mature syntactical patterns
- Using an appropriate range of words
- Organizing thoughts
- Useage of punctuation correctly
- Copying from the board, organizing written information note taking, handwriting, and spelling.
- Decoding unfamiliar words
- Understanding what is read
- Knowing the meaning of words read
- Maintaining an efficient rate of reading



Writing diability in children while learning, depicting the amount of cognitive load built during this process

Lack of rganizing written information & comprehension ability





Dyslexic fonts, for students suffering from the condition

While using sentence structures, and not able to keep up the rate of reading amongst the peers

Image source : Google

Insights kept in mind taking into account the mention special case for children :

- **Readable Fonts** : Use of sans serif fonts, such as Arial and Comic Sans, as letters can appear less crowded. Font size should be 12-14 point or equivalent. Inter-word spacing at least 3.5 times the inter-letter spacing. Avoiding text in uppercase /capital letters and small caps, which can be less familiar to the reader and harder to read.

- **Colour** : Use of single colour backgrounds. Avoiding background patterns or pictures and distracting surrounds. Sufficient contrast levels between background and text. Dark coloured text on a light (not white) background.

- **Layout** : Left align text, without justification. Multiple columns (as used in newspapers) were avoided. Use of white space to remove clutter near text and group related content. Break up the text with regular section headings in long documents and include a table of contents.

- **Structure** : Used formatting tools for text alignment, justification, indents, lists, line and paragraph spacing to support assistive technology users. Addition of extra space around headings and between paragraphs. Ensuring hyperlinks look different from headings and normal text.

- **Writing Style** : Sufficient use of images to support text. Flow charts are ideal for explaining procedures. Pictograms and graphics can help to locate and support. Use of active rather than passive voice and avoiding abbreviations where possible; always provide the expanded form when first used.

Dyslexia in Classroom

With an increasing rate on education and literacy, more emphasis has to be laid on providing aids to **children and adults** facing this condition, be it while reading, spelling or expressing their throughts on paper and acquiring adequate use of grammar.

Apart from there categories, **classroom teachers** might be paticularly confused while interacting with students whose constant unachievement could be considered as lack of effort and disinterest in the subject as well.This might dwell in with other genure of cognitive load (part of **cognitive load while teaching**). Class teachers need to have an understanding of the problems that the dyslexic child may have within the classroom situation.

The following items could provide useful guidelines for teachers and parents to follow and support :

1. **In classroom** : Of value to all children in the class is an outline of what is going to be taught in the lesson, ending the lesson with a resume of what has been taught. In this way information is more likely to go from short term memory to long term memory.
2. **Copying from blackboard** : Use different colour chalks for each line if there is a lot of written information on the board, or underline every second line with a different coloured chalk.
3. **Reading** : A structured reading scheme that involves repetition and introduces new words slowly is extremely important. This allows the child to develop confidence and self esteem when reading.
4. **Spelling** : Many of the normal classroom techniques used to teach spellings do not help the dyslexic child. All pupils in the class can benefit from structured and systematic exposure to rules and patterns that underpin a language.

Tasks Conducted (2)

We conducted a readability test in which we read same paragraphs in different fonts and noted down the time to read each of them and studied how the time taken varies and is indicative of the cognitive load the participants experienced. Result of the tests:

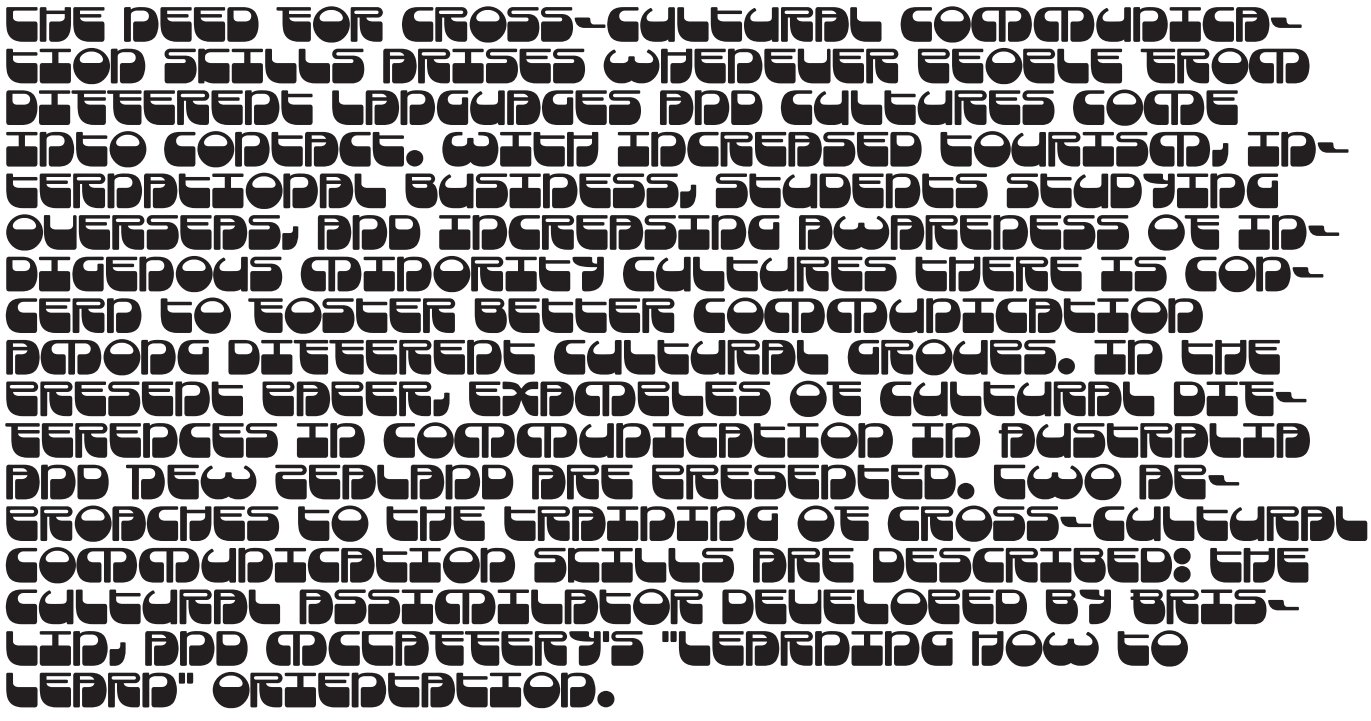
	Font 1: Times New Roman (s)	Font 2: Fritiga (s)	Font 3: Hipmotizna (s)	Font 4: Sans Forgetica (s)
1.	0:24.47	1:28.66	0:35.16	0:24.25
2.	0:20:12	0:58:37	0:34:84	0:25.09
3.	0:22.96	1:14.32	0:36.52	0:20.12
4.	0:25.08	1:21.79	0:35.16	0:23.67
5.	0:26.87	1:39.14	0:42.17	0:28.11
6.	0:20.87	1:27.73	0:36.41	0:19.81
7.	0:25.38	1:32.17	0:35.86	0:26.23
8.	0:21.76	1:07.92	0:31.52	0:23.48
Mean	**0:23.41**	**1:21.21**	**0:35.85**	**0:23.83**

Text used in the tests:

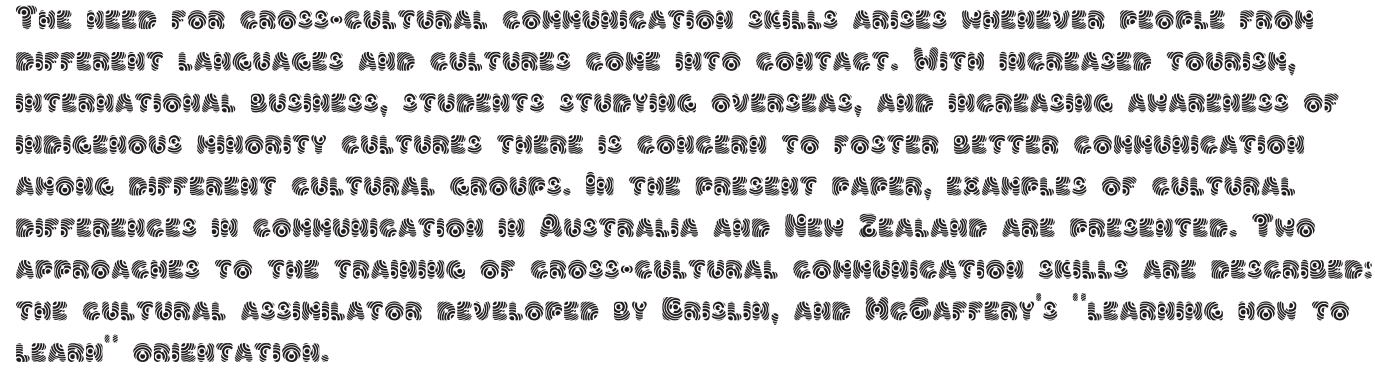
Font 1:

The need for cross-cultural communication skills arises whenever people from different languages and cultures come into contact. With increased tourism, international business, students studying overseas, and increasing awareness of indigenous minority cultures there is concern to foster better communication among different cultural groups. In the present paper, examples of cultural differences in communication in Australia and New Zealand are presented. Two approaches to the training of cross-cultural communication skills are described: the cultural assimilator developed by Brislin, and McCaffery's "learning how to learn" orientation.

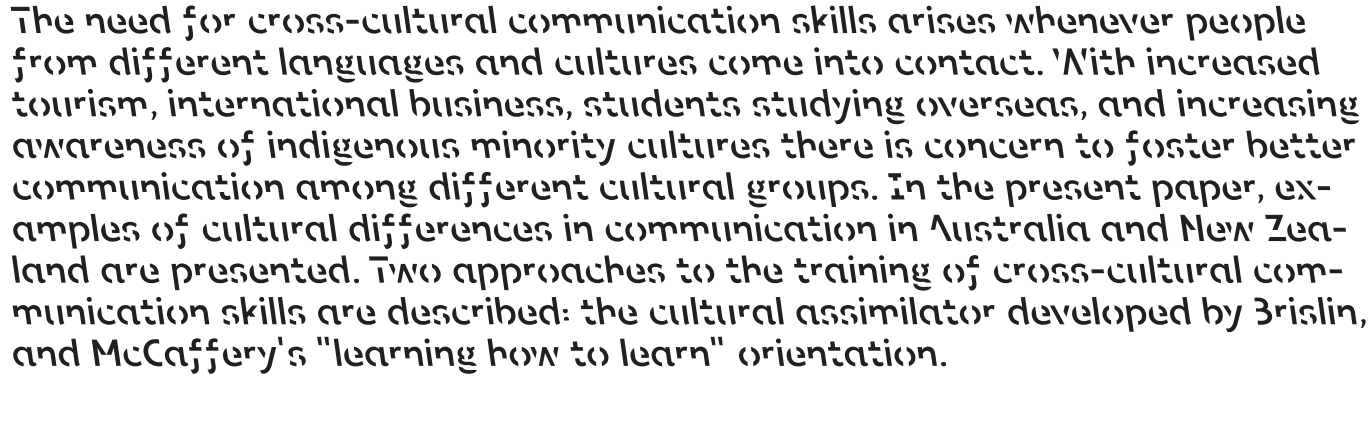
Font 2:



Font 3:



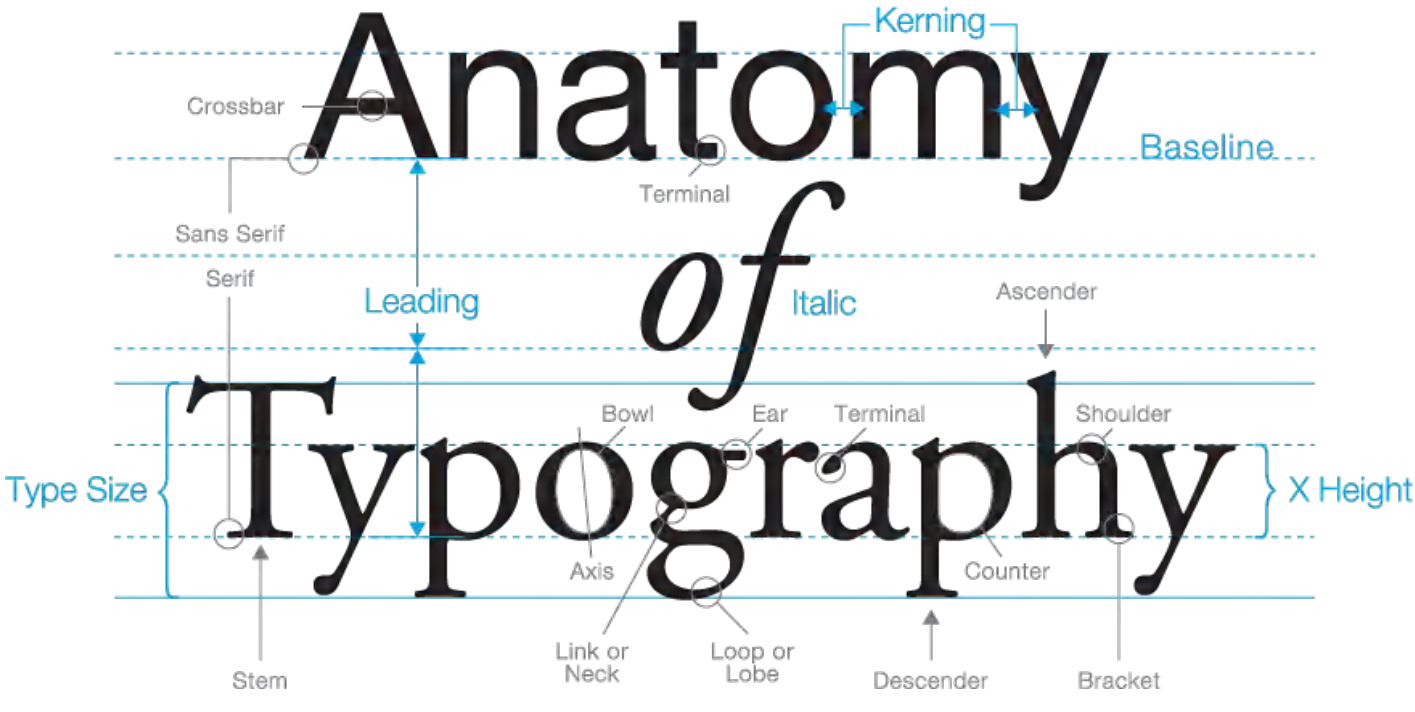
Font 4:



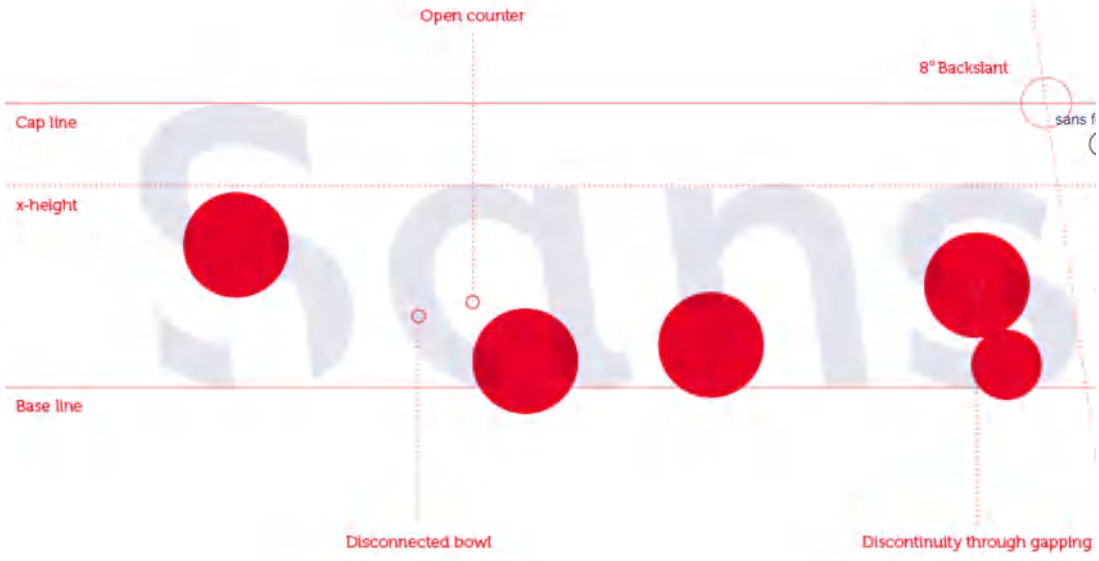
On analysing the test results, it was observed that the participants took the most time to read the font style fritiga followed by hipmotizna, sans forgetica and times new roman.

The time consumed to read the text is directly proportional to the difficulty faced in reading and understanding the text which implies that the user pays more attention to it due to increased input of effort. It is also observed that the difficult to read texts affect your memory and the information is retained in your memory for a longer period of time.

This signifies that the font style used in the book affects the cognitive load experienced by the user.



Sans Forgetica



Sans Forgetica is a font designed using the principles of cognitive psychology to help you to better remember your study notes.
It was created by a multidisciplinary team of designers and behavioural scientists from RMIT University.

The science of Sans Forgetica
Sans Forgetica is more difficult to read than most typefaces – and that's by design. The 'desirable difficulty' you experience when reading information formatted in Sans Forgetica prompts your brain to engage in deeper processing.

Science News *from research organizations*

Previously claimed memory boosting font 'Sans Forgetica' does not actually boost memory

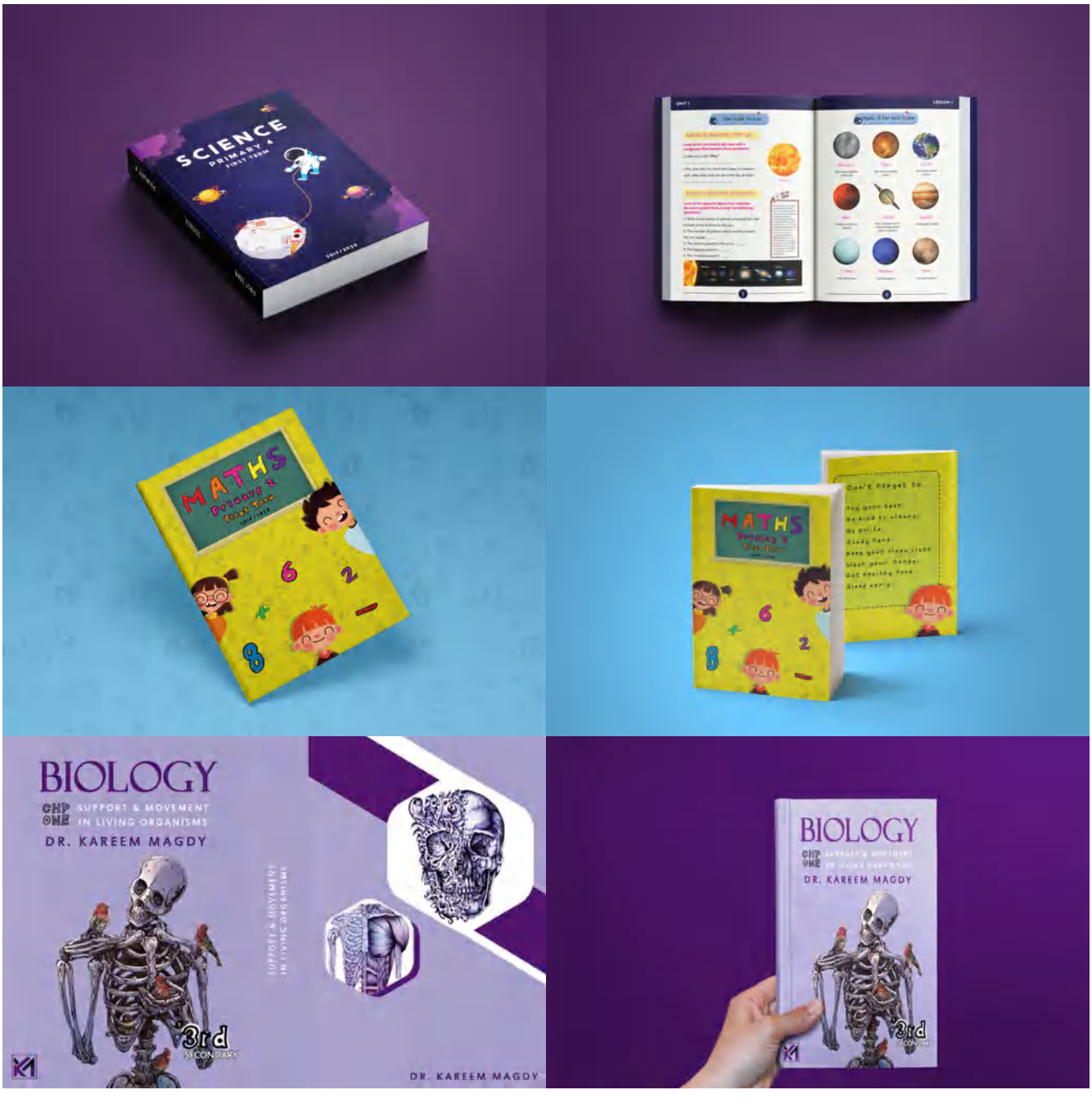
Date: May 28, 2020

Source: University of Warwick

Summary: It was previously claimed that the font Sans Forgetica could enhance people's memory for information, however researchers have found after carrying out numerous experiments that the font does not enhance memory.

Proposed Changes

- Books:
  The new book design mockups are made keeping in consideration all the problems we observed in our research. The new books are colourful and have vibrant illustrations to aid the students to understand the topic better and also to keep them interested in the studies.
  The books have a particular visual design which will avoid mental confusion and decrease the unnecessary load on their working memory.



Comparision

- The visual languages in the books are strikingly different. As we can observe, in the existing book sample, the activity is written in few monotonous paragraphs which makes the user lose interest in the subject and not conduct these activities whereas in the new book sample, the activity has been categorised in a systematic manner with more accurate diagrams which aids in understanding and interest in the topic.

Let us try to understand why phases of the moon occur. You have studied in Chapter 16 that the moon does not produce its own light, whereas the Sun and other stars do. We see the moon because the sunlight falling on it gets reflected towards us (Fig. 17.3). We, therefore, see only that part of the moon, from which the light of the Sun is reflected towards us.

Fig. 17.3 : Moon is visible due to reflected sunlight

Activity 17.2

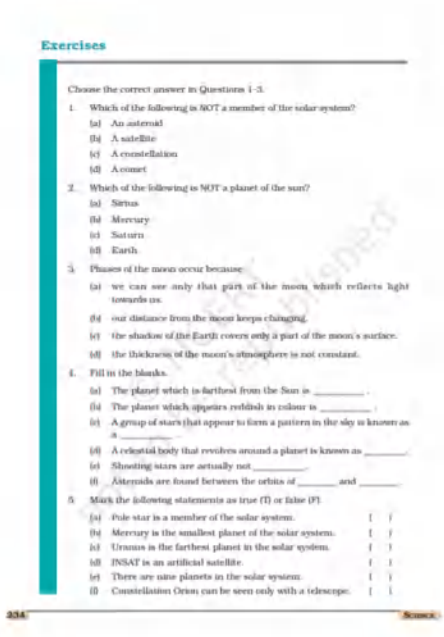
Take a big ball or a pitcher. Paint half of it white and half black.

Go out into the playground with two of your friends. Draw a circle of radius of about 2 m on the ground. Divide the circle into eight equal parts as shown in Fig. 17.4.

Stand at the centre of the circle. Ask a friend to hold the ball at different points of the circle. Ask her to keep the white portion of the ball always towards the Sun. If you are performing this activity in the morning then the white portion of the ball should be kept towards the east. If the activity is being performed in the afternoon then the white portion of the ball should be kept towards the west. In each case the line dividing the white and black portions is kept vertical.

Standing at the centre of the circle observe the visible white portion of the ball while your friend stands at the points on the circle marked earlier. Draw the shape of the white portion as you see it. Compare your drawings with the different phases of the moon as shown in Fig. 17.5.

Fig. 17.4: The moon appears different at different positions in its orbit



Exercises

Choose the correct answer in Questions 1-3.

1. Which of the following is NOT a member of the solar system?
   (a) An asteroid
   (b) A satellite
   (c) A constellation
   (d) A comet
2. Which of the following is NOT a planet of the sun?
   (a) Sirius
   (b) Mercury
   (c) Saturn
   (d) Earth
3. Phases of the moon occur because
   (a) we can see only that part of the moon which reflects light towards us.
   (b) our distance from the moon keeps changing.
   (c) the shadow of the Earth covers only a part of the moon's surface.
   (d) the thickness of the moon's atmosphere is not constant.
4. Fill in the blanks.
   (a) The planet which is farthest from the Sun is _____ .
   (b) The planet which appears reddish in colour is _____ .
   (c) A group of stars that appear to form a pattern in the sky is known as a _____ .
   (d) A celestial body that revolves around a planet is known as _____ .
   (e) Shooting stars are actually not _____ .
   (f) Asteroids are found between the orbits of _____ and _____ .
5. Mark the following statements as true (T) or false (F).
   (a) Pole star is a member of the solar system. [ ]
   (b) Mercury is the smallest planet of the solar system. [ ]
   (c) Uranus is the farthest planet in the solar system. [ ]
   (d) INSAT is an artificial satellite. [ ]
   (e) There are nine planets in the solar system. [ ]
   (f) Constellation Orion can be seen only with a telescope. [ ]

- **AR Visual Aid:**
  An application to convert all the 2D diagrams to 3D to aid the understanding of complex systems. The students often face this issue of not being able to imagine and visualise the system entirely which makes them lag and affects their mental health due to peer pressure.

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Future Prospects

Due to the sudden imposition of the lockdown, we had to stop our research abruptly.

Further, we will be continuing with the following:

1. To study and analyse of the Eye Tracking Pattern to understand how the placement of text affects the cognitive load.
2. Study of the cost of the production of each book and its effect on the environment
3. To conduct and analyse the response to reading difficult tests using EEG tests
4. The present study aimed to examine the modality and redundancy effects in learning in children with dyslexi a (of the same age group i.e 8-10 and 11-13 years old) in order to find out whether their learning benefits from written and/or spoken text with pictures. We'd planned a compared study time and knowledge gain in 8-13 year-old children with dyslexia and other typically reading peers in a within-subjects design. All children were supposed to be presented with a series of user-paced multimedia lessons in 3 conditions: pictorial information presented with

- Written text
- Audio examining
- Combined text and audio

After fulfilling these research aspects, we will be working on the analysis of the final outcome of our research and hence ideate on the ideal solution to solve this problem in the Indian Education System.

teacher: even if you ask me 100 times, I'll explain it to you

me: *ASKS 2nd TIME*

teacher: