Designing for Children
- With focus on 'Play + Learn'

Paper Presented *under the theme:*
Design of school textbooks and other learning materials

DESIGNED TO PROPEL : Using Visual Design to Promote Meaningful Learning in Constructivist Classrooms in K-5 Schools

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Abstract

Meaningful learning occurs when the learned knowledge is fully understood by the individual in a manner that it can be manipulated and applied to a variety of situations and contexts. Leflore (2000) says that learning can be enhanced if attention is paid to the way course material is designed.

This study focuses on examining the link between visual design of textbooks and learning. Our approach is based on a study of the theories of learning to identify key parameters that can inform strategies for visual design of textbooks to promote meaningful learning.

In this, our work is underpinned by the **constructivist theory of learning** where a learner is actively engaged in constructing knowledge by formation of 'schemas' i.e. mental models of organising knowledge (Plass & Brunken, 2012). We refer to the **cognitive load theory** which has its foundation in constructivism, to understand how cognitive resources can be used efficiently during learning. Finally, we draw from **Gestalt Theory** which explains "pattern seeking" in human perception, and thereby offers a scientific framework to designers for visually structuring and organising content (Graham, 2008), to improve usability and enhance user experience.

Keywords: meaningful learning, visual design, textbooks, constructivism, schema-acquisition, cognitive load, gestalt theory

1. Introduction

Primary schools across the globe use a variety of teaching-learning materials of which printed textbook is most widely used. The dominating presence of textbooks in present day indian classrooms is also highlighted by NCERT in a 2006 report published by National Focus Group on 'Curriculum, Syllabus and textbooks'. The report also recommends innovation in textbooks and other materials being used in schools, based on a child's learning requirement. As one of the most important factors that influence classroom learning, the content in textbooks must be critically examined and carefully selected, and thoughtfully presented (designed) in the way it maximises learning. (Ball & Cohen, 1996 and Leflore, 2000).

"Visual design" is the use of elements such as imagery, colour, typography, etc. to communicate a message in a user-friendly manner. Visual design influences the way we perceive information and make meaning (Haugen, 2010). Therefore, visual presentation of learning material determines the way learners interact with, perceive and interpret the content.

A closer look at majority of textbooks being used in the country brings out several gaps; often the basic principles of visual design are overlooked in the process of content presentation and instructional design. According to Nobel Laurette, Herbert Simon (1988), Design is "concerned with how things ought to be" to attain intended goals. While there is substantial work on application of design to enhance usability and improve user experience of various products, we need to look specifically into effective implementation of design in creating textbooks that promote meaningful learning.

This establishes the need for this study. The present paper explores the application of visual design in textbooks, with a focus on applying Gestalt's Laws, to aid active construction of knowledge by learners.

As a prelude to this study we held discussions between teachers, curriculum creators and design experts (who had reviewed the books), to identify the gaps in communication vis-s-vis intended learning outcomes. We then began by literature review of learning theories, and principles of visual and instructional design. Thus, curriculum and design experts worked together to come up with a research-based, comprehensive design strategy that integrated knowledge of learning theories and principles of visual design, to identify visual design elements that can meet the requirement of constructivist learning process.

2. Literature Review

2.1 Learning Theories

Learning is a process that brings change and development of a person's knowledge, understanding and competences through experience and practice. According to Dewey, some experiences are merely passive affairs, pleasant or painful but not leading to learning (Solits. n.d.). Meaningful learning occurs when the individual is able to recognise links between all the pieces of a concept, idea or theory, and can manipulate and apply the learned knowledge to a variety of situations and contexts, in future. In his theory of meaningful learning, Ausubel states that this involves integrating new information into the old knowledge structure. (Subsumption Theory (David Ausubel)).

Over the years, different theories of learning have emerged that explain the process of learning. These can be broadly classified under: Behaviorism, Cognitivsm, Constructivism and Humanism.

Presidium Schools, which was selected for this study due to convenience sampling, use constructivist curriculum. We therefore delve deeper into the study of "Constructivist theory" to understand the mechanisms of meaningful learning.

Constructivist Theory of Learning suggests that knowledge cannot be simply transmitted to learners; learners need to "actively construct knowledge in their own minds". As per constructivists, the process of learning starts with individuals perceiving new experiences. They make sense of the perceived information based on their existing mental-models about the subject and in the process update the existing mental-models.

Piaget called these mental models "**schema**". Schema are conceptual structures or maps of knowledge by means of which principles are organised and information is stored in long term memory. In Piaget's view, a schema includes both a category of knowledge and the process of obtaining that knowledge. (Plass & Brunken, 2012 and Sigelman & Rider, 2011). Therefore, learners constantly "construct" and reconstruct (or upgrade) their own *patterns* of knowledge. (Olesugun, 2015).

In order for the schema to be formed, cognitive processing of information takes place in the human brain with memory playing a significant role. Drawing from the Modal model of memory, this process of cognitive processing for learning can be explained as mentioned in Figure 1.

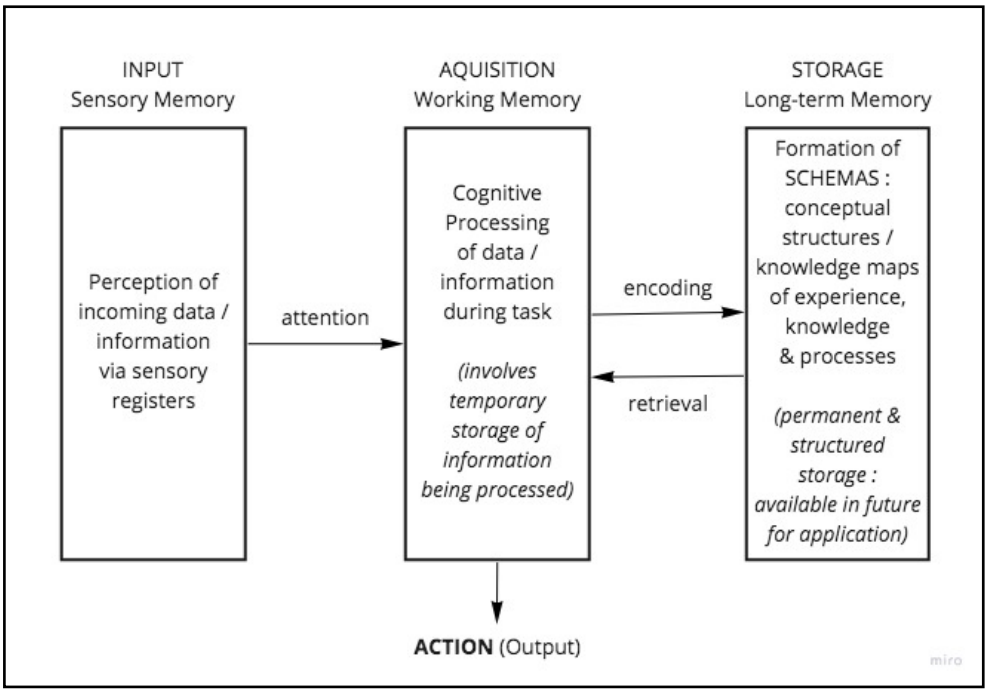

Figure 1: Cognitive Processing & Memory, self created, adapted from Hockley, 2002

Cooper (1990) defines **cognitive load** as the level of 'mental energy' required to process a given amount of information. If the cognitive load is too high the working memory of the learner will not be able to hold the information for long enough to transfer it to long term memory; in such a case schema are not constructed effectively and are not retrievable for future application.

To conclude, Plass & Brunken (2012) summarise the fundamental tenets of Constructivist theory of learning:

- Schema acquisition is the building block of learning and skilled performance.
- Schema acquisition requires attention directed to problem states and their associated solution moves.
- Learning is enhanced when learners attend to schema acquisition.
- Other cognitive activities must remain limited to avoid imposing a heavy cognitive load that interferes with learning.

2.2 Gestalt Theory

Essentially belonging to the field of psychology, Gestalt theory presents a scientific method of explaining cognitive perception as it relates to “pattern seeking” and “meaning-making” in human behaviour (Graham, 2008). Since constructivism proposes that learning begins with perception of information and proceeds with the search for meaning through *patterning;* the theory becomes relevant to this study.

The theory explains the relationship between the whole and parts of a perceptual field; Highlighting our tendency towards “grouping”, theorists over a period of time were able to identify a set of general underlying principles behind the way humans *group things* in a perceptual field for meaning-making.

2.2.1 **Gestalt’s Laws of Grouping** (Moore & Fitz, 1993 and Pinna, 2010)

i. **Proximity:** Units that are close to one another, even if the shapes, sizes, and objects are radically different, will appear as a group.

Figure 2.1

ii. **Similarity:** Units which resemble each other in shape, size, color, or direction will be perceived together as part of a homogenous group.

Figure 2.2

iii. **Continuity:** Perceptual organisation tends to preserve smooth continuity rather than yielding abrupt changes- other things being equal, humans tend to continue a shape or form beyond its terminal point

Figure 2.3

iv. **Closure:** Closed areas, seem to be “self-sustaining, stable organisations”. If the area is not closed, readers search in the local context to see what the area belongs to and fill in the gaps to complete it.

Figure 2.4

Note : Figures 2.1-2.4 are self created

v. **Figure-Ground Segregation:** Individuals effortlessly distinguish between the figure in a field of view and the ground against which it is seen; a figure is a shape that is perceived as being in front of or surrounded by homogenous background (ground).

vi. **Simplicity:** Individuals unconsciously try to simplify what they perceive based on expectations that are formed because of previous experiences; viewers will simplify a complex visual into a form that they can understand.

Visual Design, with the use of elements such as imagery, colour, typography, etc., influences the way we perceive information and construct meaning (Haugen, 2010). Gestalt theory provides a way to understand visual ‘configurations’, thus forming a significant base for visual designers to structure and organise content visually, and to communicate the intended message in a user-friendly manner (Graham, 2008).

2.3 Link between Learning and Visual Design of textbooks.

Herbert Simon (1988) defines **Design** "as courses of action aimed at changing existing situations into preferred ones". Leflore (2000) proposes that designers of course material, can enhance learning by paying attention to how learners interact with and interpret the material. Learning theories can provide sound design guidelines for this purpose.

In a constructivist classroom, teaching practices, including presentation of course material, should provide learners with experiences that aid acquisition of schema and encourage active and learner-centred construction of knowledge (Honebin, 1996). Subsumption Theory (David Ausubel) states that meaningful learning requires well organised, relevant knowledge structures and conceptually clear subject matter to be presented.

Leflore (2000) recommends that providing learners with *pictorial view of the concepts* (visual organisers) in addition to textual explanations helps them in understanding "complex concept and sub-concept relationships". Baker and Dwyer while examining the instructional effectiveness of "visualisation vs. no visualisation", via a meta-analytic procedure, found that visual presentations enhance student achievement (d =0.71) (Hattie, 2009).

Cooper (1990, 1998) recommends that instructional material should be designed to reduce working memory load and direct cognitive resources towards "activities that are relevant to learning rather than to processes that are an adjunct to learning". With its foundation in constructivism, the Cognitive load theory, has been used to develop several effective instructional strategies for designing learning materials.

Haugen (2010) puts forth a strong case for using design as a powerful tool that allows designers to control the message that is communicated, as well as, in what order the information is received. As explained earlier in section 2.2, **Gestalt theory** offers a framework to visual designers for structuring and organising content visually.

Application of the Gestalt Laws of grouping can aid leaner's process of perception and meaning making by establishing relationships between different visual elements on the page of a textbook. This would aid them in comprehending concepts, processes and tasks. Our hypothesis is that this would facilitate schema acquisition by providing cues for patterning, and direct cognitive load and attention towards the instructional goal, thereby making way for meaningful learning.

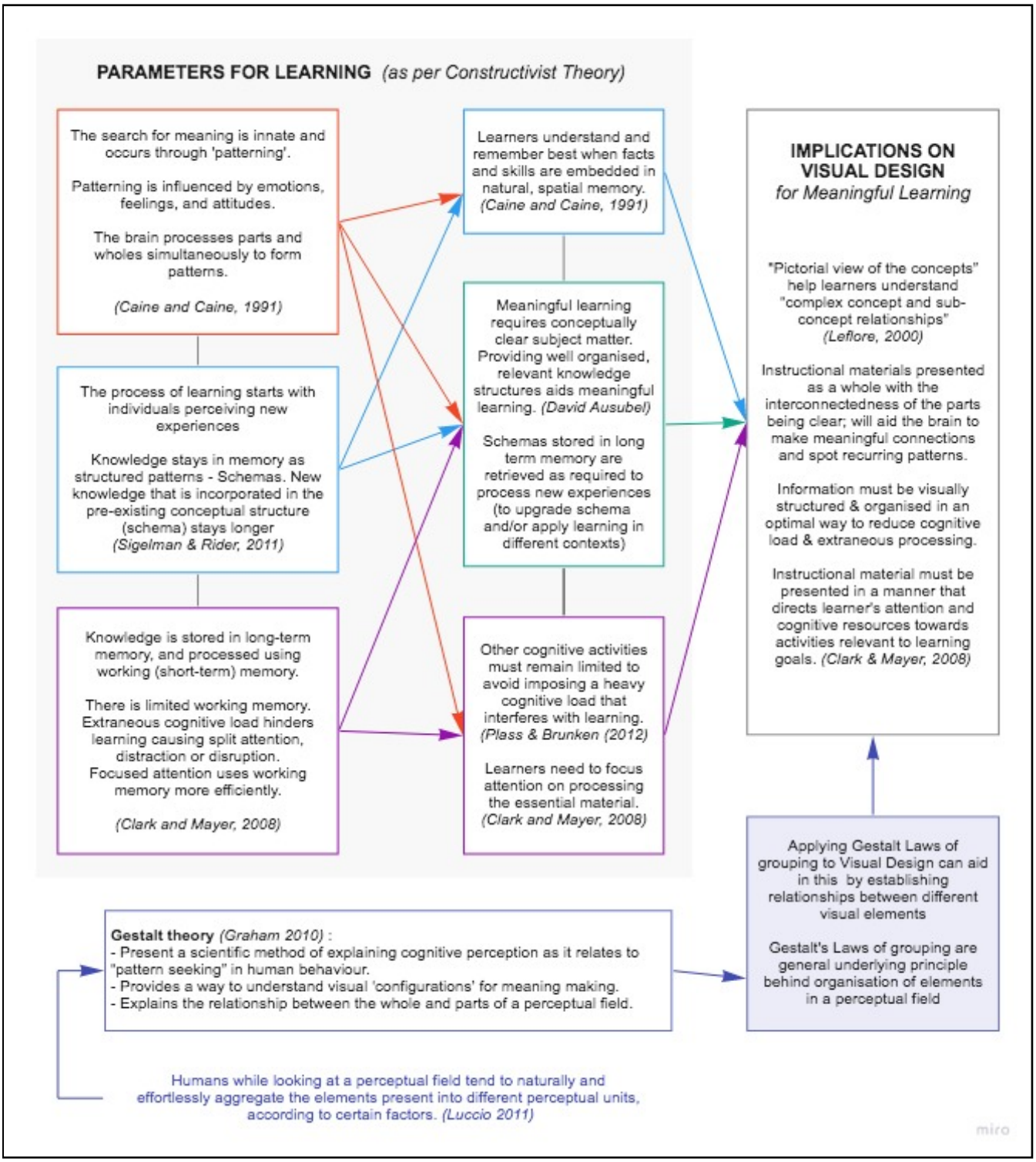

Figure 3 : Link Between Learning and Visual Design, self created

3. Research Methodology : This is an exploratory & conclusive study.

3.1 Mapping of Research Methodology

Data Type	Collection Method	Purpose	Details / Tools
Secondary Data	Review of Literature	• Understanding the relevant Learning Theories • Understanding visual design principles • Exploring the link between Learning and Visual Communication	• Sources: Textbooks Research Journals Research Papers
Primary Data	Questionnaire Method	• Exploring the link between Learning and Visual Communication.	• Research tool : Structured questionnaire • Sampling Technique: Convenience Sampling & Probability Sampling • Target Population: School Teachers
Data Analysis		• Analysis and conclusion of the study • Evaluating the impact of textbook design based on Gestalt's laws, on learning.	• Percentage Method

Table 1. self created

3.2 Approach to Data Collection

We start by evaluating the existing design of text book to identify gaps in visual design vis-s-vis learning goals (see Section 4). For this we selected Chapter on Addition in Math book of Grade-1 *(see Annexure-1)*.

This chapter was re-designed *(see Annexure-2)*, without altering the content, with application of Gestalt's laws, using parameters that aid meaningful learning in a constructivist classroom (Literature Review: Link between Visual Design and learning).

A questionnaire was then used to evaluate the impact of new design on learning. Data was collected, in the form of written opinion/ feedback/ citing reasons, through **6 questions,**

covering **3 distinct areas** of content presentation : picture reading task (Q.1), examples (Q. 3 &4) and writing tasks (Q.2,5&6). (see Annexure-3)

3.3 Sampling for the Study

In selecting sample unit, it was decided that the school should have the following:

- minimum 400 students enrolled in primary school classes.
- minimum 50 teachers teaching Math in Grade 1
- a pedagogical approach to learning
- the practice of creating their own content and books

Based on these criteria and convenience sampling, Six Presidium Schools in NCR were selected as sample group for this study.

Summary of Sample Design for the Study			
Population	Primary Schools in Delhi, NCR		
Sampling Unit	Presidium Schools in Delhi, NCR		
Elements	Teachers teaching Math in Grade 1 at Presidium Schools Curriculum experts and Teacher trainers in Primary section of Presidium Schools		
Sampling Size	**Group**	**Sample size**	**Comments on Data**
	Total Sample list	81	Combined list of teachers teaching Math in Grade 1 (71), team of curriculum experts and teacher trainers for Primary section (10), in Presidium Schools, across NCR.
	Total Responses Received	36	33 teachers + 3 curriculum experts/ teacher trainers
	Total Responses after Data Cleaning	32	Complete Questionnaires in all aspects- 29 teachers + 3 curriculum experts/ teacher trainers
Extent	Delhi/NCR		

Table 2. self created

4. Evaluation of Existing Design : Chapter on Addition, Math Textbook, Grade-1

A review of the existing design evidences that general principles of visual design have been often ignored, violated or diluted. Some of the more significant observations, in context of this study, are listed in table 3. This evaluation is based on identified parameters for meaningful learning (Literature Review).

Evaluating the Existing Design			
	Observations (Existing Design)	**Refer to ***	**Impact on learning**
I.	The content is not always sufficiently supported by representation of the underlying principles and the process (intermediate steps involved).	* Images 'b,c,f'	Does not support conceptualisation. The learner will depend on the teacher for detailed explanation
II.	Class identities are often not created clearly: in the urge to make the design more colourful/ attractive, formation of concept is compromised upon.	* Image 'a'	Creates difficulty in formation of concept and increases cognitive load; more processing will be required in the working memory.
III.	Related text and visuals are often organised in a manner which makes it difficult to make quick connections.	* Images 'c,d,f'	Leads to *extraneous processing (*cognitive processing that is unrelated to the instructional goal) and *cognitive overload*. (Clark & Mayer, 2008) The learner will depend on the teacher to receive explanation.
IV.	Organisation of the work space (in practice tasks) is not always efficient.	* Images 'c,d,e'	
V.	The worked examples at the beginning of each task/section are not highlighted.	* Images 'a,c,f'	Becomes difficult for the teacher to draw attention of individual learner to the correct place, while teaching in a group
VI.	The use of imagery in the design is at time "decorative" and not significantly "functional" as they do not aid in comprehension of the text / conceptual content.	* Image 'b'	Extraneous graphics can cause distraction or disruption, especially learners with low ability (Sanchez and Wiley in Clark & Mayer, 2008)

Table 3. self created

Note : * Refer images given below this table.
These are taken from the Existing Design (Annexe-1). These are only some examples of the observations made; they are representative of the current design approach

LET'S DO IT

Write numbers for every picture.

1. 3 birds are sitting together. 4 of their friends come and join them. How many birds are there now?

[3] birds and [4] more birds make [7] birds.

2. 3 glasses of juice are on one tray and 2 glasses of juice on another. How many glasses are there in all?

[ ] glasses and [ ] more glasses make [ ] glasses.

Image ‘a’, From Pg. 49

FUN AT HOME

You played some games in the classroom. Now play a game with your parents. Take two dice and 50 kidney beans in a bowl. Roll both the dice and take out the number of kidney beans shown on both the dice. Tell the total number of kidney beans taken out. Take turns with your parents to do the same. Every correct answer fetches you one point. The one who gets ten points first, wins the game.

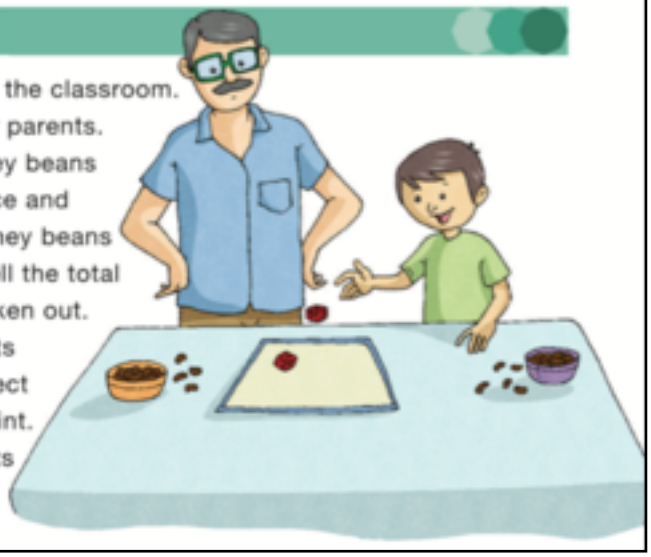

Image ‘b’, From Pg. 50

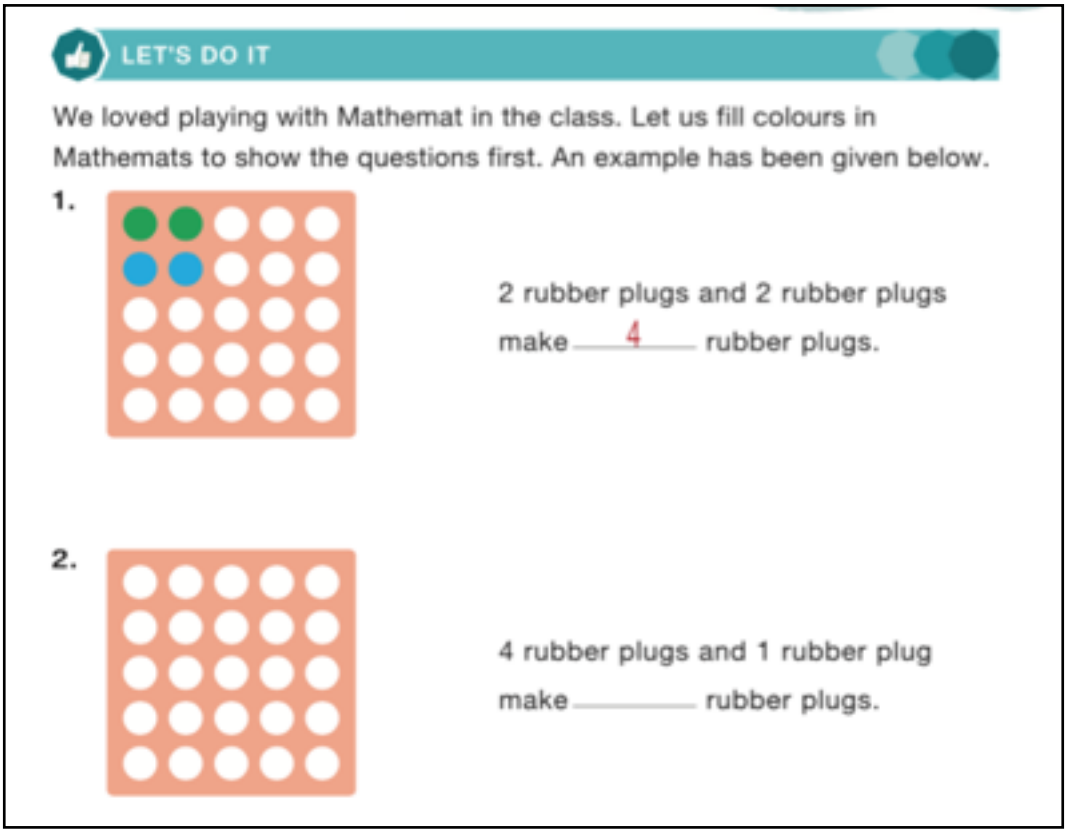

Image ‘c’, From Pg. 50

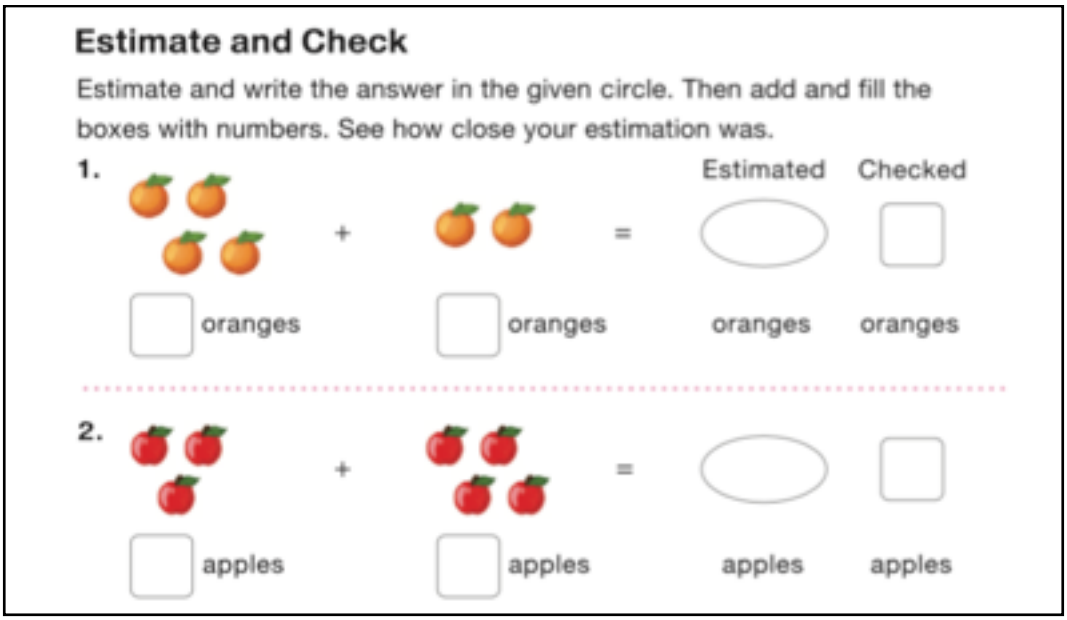

Image ‘d’, From Pg. 53

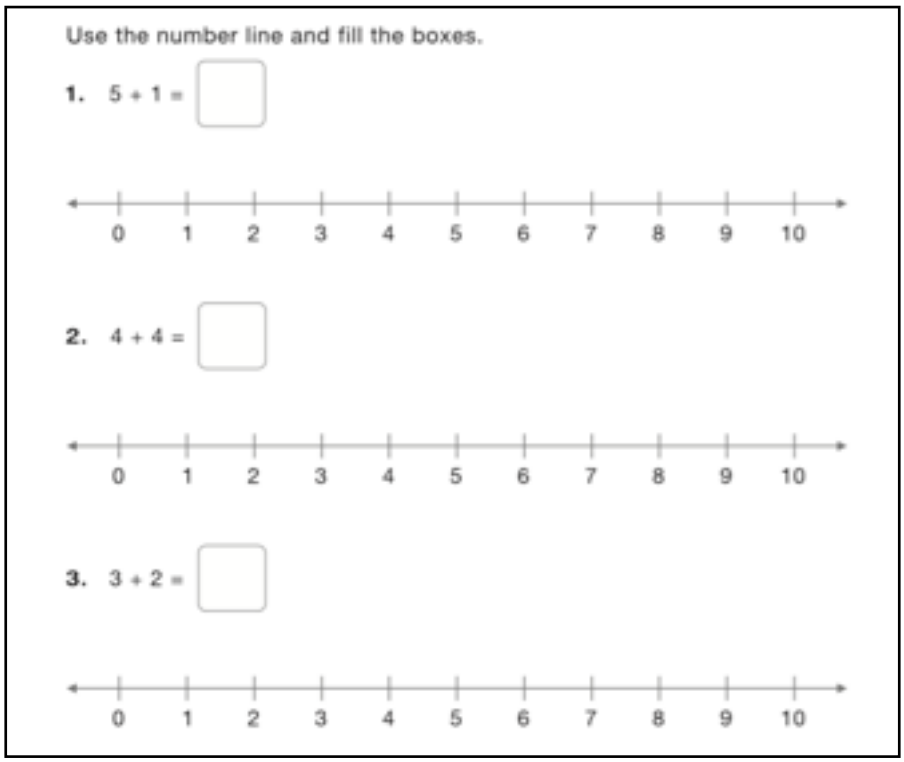

Image ‘e’, From Pg. 54

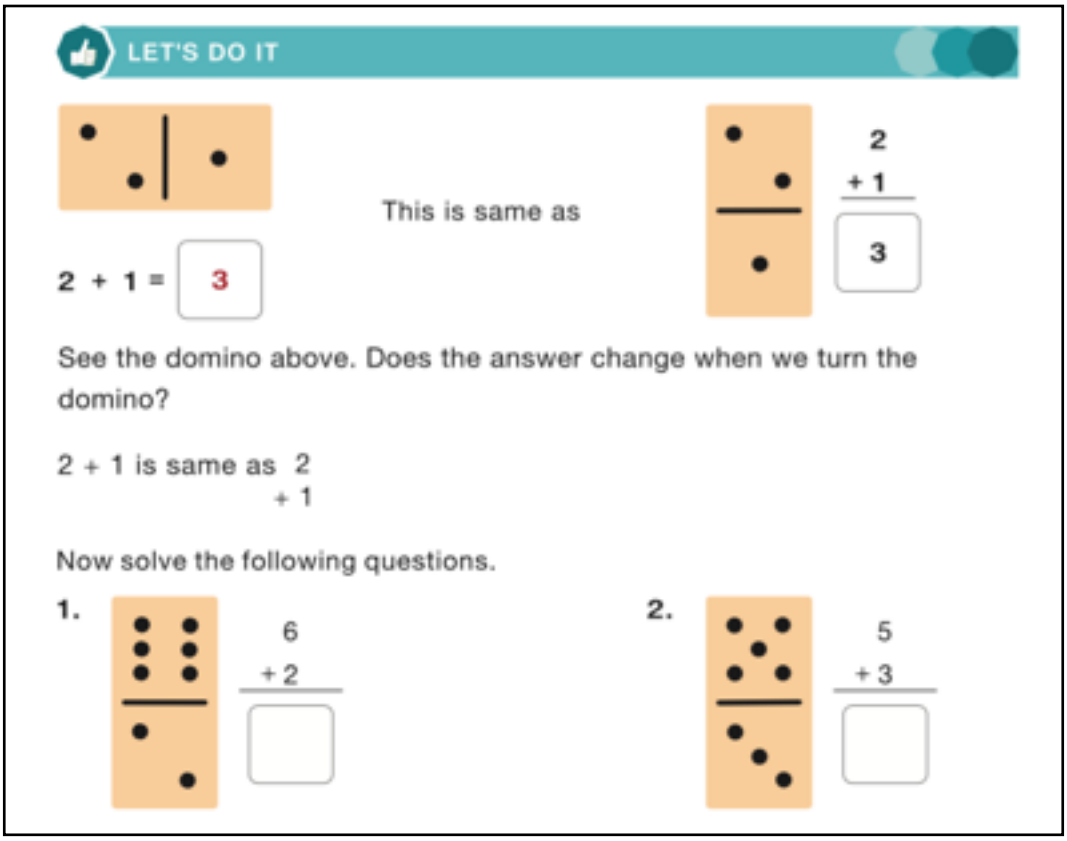

Image ‘f’, From Pg. 58

5. Exploring impact of Visual Design on Learning : Qualitative Data

5.1. Process of Data Analysis

Step 1: Data received was filtered using **repeating keywords and/ or attributes**

Step 2: Based on most frequently occurring words **response groups** were created of words that implied the same meaning/ were used in same context. The groups were **bundled under categories.**

Step 3: Data was then **mapped** as per these categories for each respondent.

Step 4: Frequency of occurrence was calculated, for each of the 3 areas of content presentation (example, writing task, picture reading task)

Step 5: **Cross tabulation** of the Data Category-wise

5.2. Data Analysis

The data received from the 32 respondents was filtered using repeating keywords and/ or attributes which were further bundles under broader categories:

Categorisation of comments occurring in responses collected		
Key words / Attributes	**Category**	
- Enables correlation of elements - Visual/ Symbolic presentation / Creates mental picture of concept/ process - Simplifies understanding / Makes comprehension easy - Gives clarity of concept	Construction of knowledge through Visual representation of Concept.	**A**
- Good utilization of space/ visual arrangement / page layout - Organized / grouping / distinction of sections - Gives clear instructions / Easy to follow or repeat - Enables/ Encourages sequential working of practice task - Helps child work independently - Clarity / Readability	Organising work-space to create ease of working.	**B**
- Highlighted / Gives Emphasis / Retain Attention - Big and Bold Text / Pictures / colour Helps to focus/ Gain attention	Drawing attention to instructional goal by using strong signals.	**C**
- Creates Interest / Excitement/ Encourages child to work on task - Attractive (due to colours/ illustrations)	Engagement & enthusiasm through aesthetics.	**D**
Miscellaneous comments that do not fit into any of the other categories defined		**E**

Table 4 : Categories of comments, self created

Tabulation of Qualitative Feedback on New Design

		Occurrence of Positive Remarks on New Design						
Category*	**Areas of Content Presentation —->**	Examples *(Q.3&4)*		Writing Tasks *(Q.2,5&6)*		Picture Reading *(Q.1)*		**Total (row)**
	Key words / Attributes	**No.**	**%**	**No.**	**%**	**No.**	**%**	
A	Enables correlation of elements	7	22%	19	59%	0	0%	26
	Visual/ Symbolic presentation / Creates mental picture of concept/ process	10	31%	13	41%	4	13%	27
	Simplifies understanding / Makes comprehension easy	8	25%	15	47%	8	25%	31
	Gives clarity of concept	6	19%	12	38%	7	22%	25
	Long term memory retention	3	9%	2	6%	1	3%	6
B	Good utilization of space/ visual arrangement / page layout	3	9%	4	13%	5	16%	12
	Organised / grouping / distinction of sections	4	13%	12	38%	2	6%	18
	Gives clear instructions / Easy to follow or repeat	5	16%	18	56%	1	3%	24
	Enables/ Encourages sequential working of practice task	0	0%	2	6%	3	9%	5
	Helps child work independently	2	6%	2	6%	0	0%	4
	Clearly visible / Readable	14	44%	15	47%	7	22%	36
C	Clearly Highlighted / Gives Emphasis / Retain Attention	21	66%	6	19%	3	9%	30
	Big and Bold text / picture/ colours helps to focus/ Gain attention	15	47%	16	50%	5	16%	36
D	Creates Interest / Excitement/ Encourages child to work on task	13	41%	9	28%	3	9%	25
	Attractive (due to colors/ illustrations)	21	66%	14	44%	6	19%	41
E	*Miscellaneous comments that do not fit into any of the other categories defined*	9	28%	8	25%	2	6%	19

Table 5.1 : Data Analysis-1

Calculation of percentage is out of 32 i.e. total number of responses received

Cross Tabulation of Qualitative Data Collected

	Occurrence of Positive Remarks (32 Respondents)							
Areas of content presentation —–>	**Examples** (Q.3&4)		**Writing Task** (Q.2,5&6)		**Picture Reading** (Q.1)		**Total for each category** (row)	
Category* :	No.	%	No.	%	No.	%	No.	%
A	34	24%	61	37%	20	35%	**115**	**32%**
B	28	20%	53	32%	18	32%	**99**	**27%**
C	36	26%	22	13%	8	14%	**66**	**18%**
D	34	24%	23	14%	9	16%	**66**	**18%**
E	9	6%	8	5%	2	4%	**19**	**5%**
Total No. for each Area (column)	**141**		**167**		**57**			

Table 5.2 : Data Analysis-2

Calculation of percentage is out of total no. of occurrences in that particular ***area***

Note:

* *Refer to Table 4 for detailed description of each category, in Tables 5.1 & 5.2 (above), and Figures 4.1, 4.2 & 4.3 (below)*

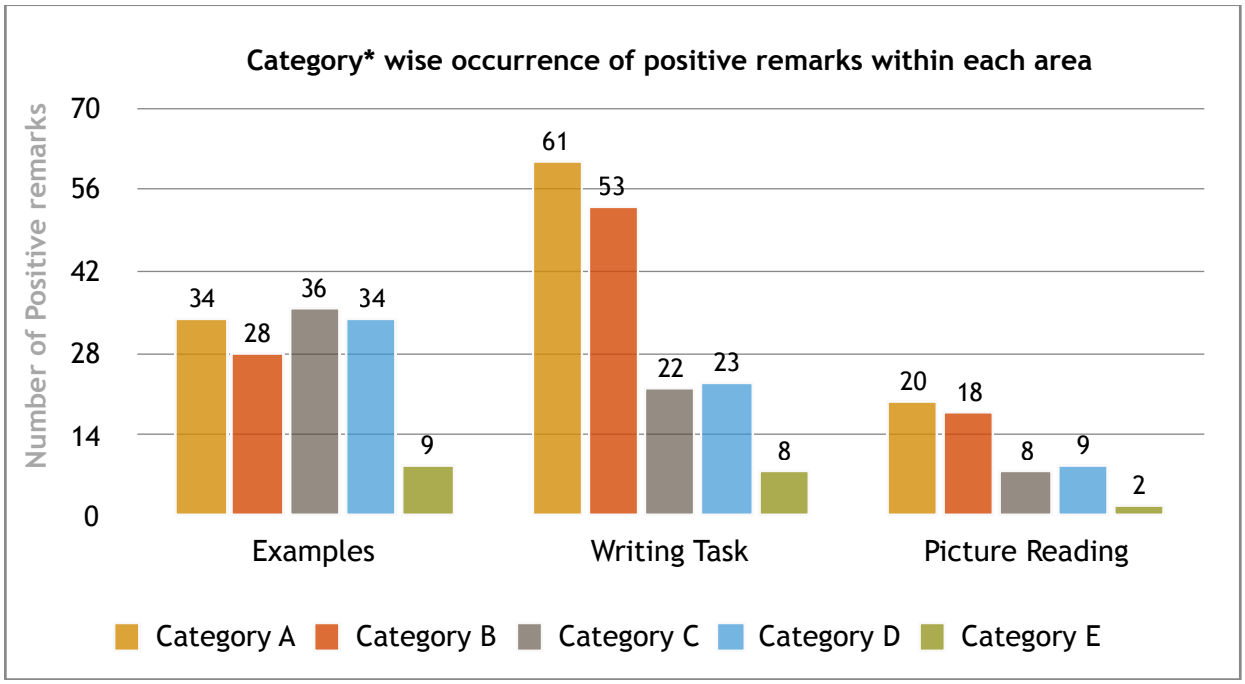

Figure 4.1. Summary of Qualitative Feedback on New Deign, Data Analysis-1

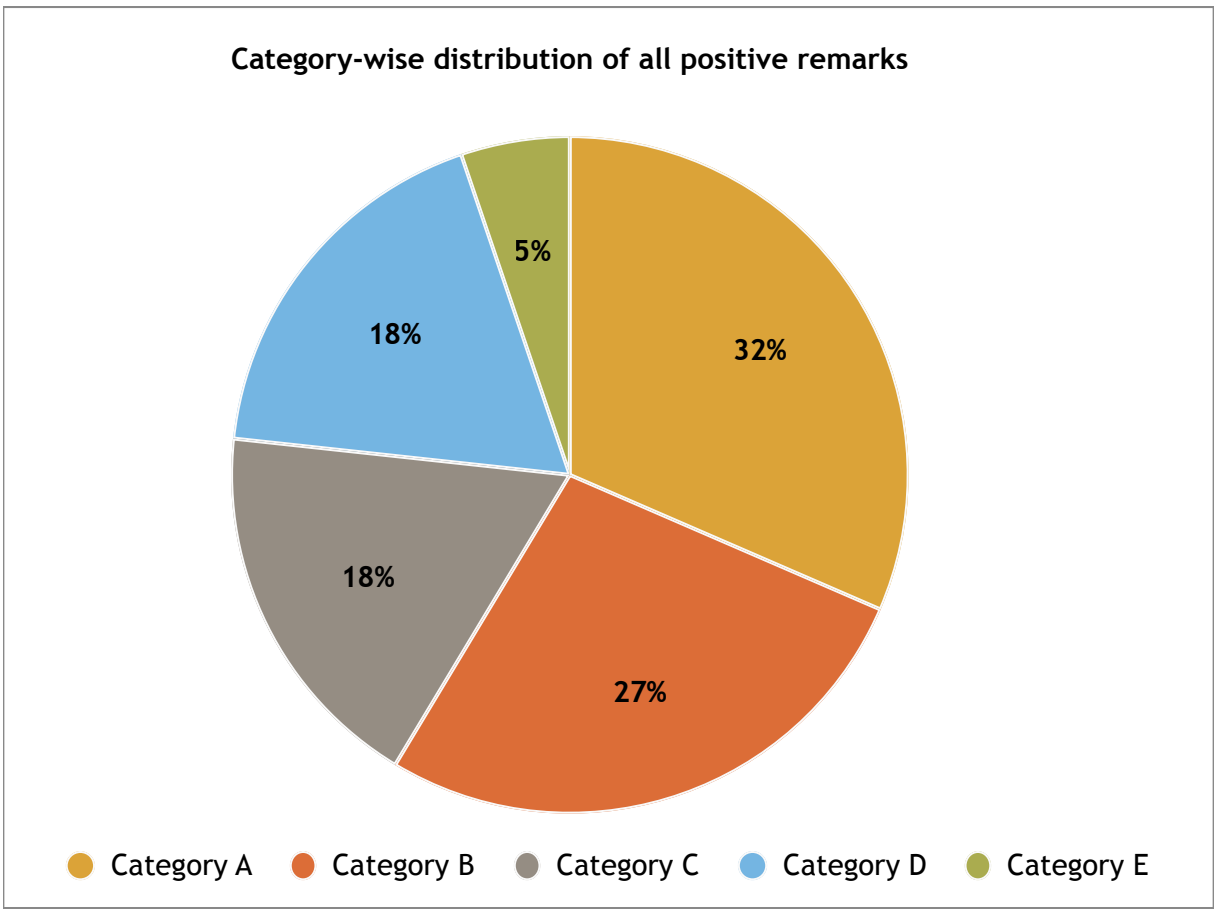

Figure 4.2. Summary of Qualitative Feedback on New Deign, Data Analysis-2

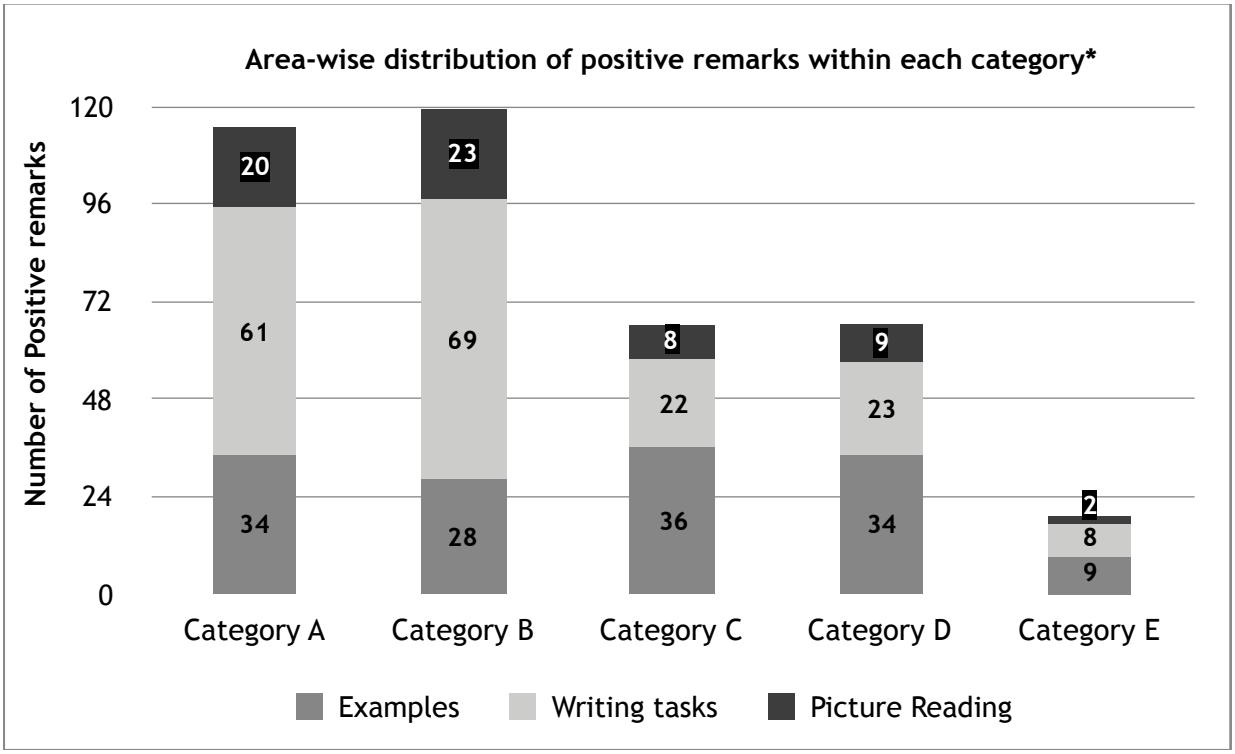

Figure 4.3. Summary of Qualitative Feedback on New Deign, Data Analysis-3

6. Conclusions and Recommendations

All 32 respondents agree that the New Design has improved usability of the instructional material and promotes meaningful learning. Based on findings of this study, we conclude:

"Visual representation of the content propels active construction of knowledge" (indicated through 32% of total positive remarks in Category A): This helps create mental pictures of the concept / process and relationship between its elements, leading to acquisition of schema. Colour and spatial arrangement (using Gestalt's laws of similarity and proximity) can be powerful tools to create visual groupings (class identities) in this context.

"Organised work-space reduces extraneous cognitive load, frees and directs cognitive resources towards the learning goal" (indicated through 45% of total positive remarks in Categories B & C**): An organised work-space, that is simple and straight-forward creates ease of working by communicating what has to be done and how. Aligning related text and visuals together, creating visual separation and distinction of different sections and problems, highlighting important elements, and eliminating irrelevant elements, can be simple strategies to achieve this (using Gestalt's laws of proximity, closure and figure-ground segregation). Further, ease of engaging with materials enable the five-year olds to work independently and motivates them to stay engaged.

** *Note : Here "Drawing attention by using strong signals" is being considered a part of "organising work-space".*

The above two core findings have unambiguous implications for visual design of instructional materials for meaningful learning. We recommend the following:

- **Maintaining consistency and continuity in visual representation** of concepts and procedures (using law of continuity) reinforce existing mental-models (schema) and allow learners to actively update them. This facilitates what Dewey calls "continual reorganisation, reconstruction and transformation of experience" for meaningful learning (Solits. n.d.).
- **Simplifying communication while retaining detailed representation** of the interconnectedness between parts of a concept or process, for more efficient meaning-making.

7. Limitation of the Study

1. The study limits its scope in terms of addressing the application of only the Gestalt's law of Grouping; Other aspects of visual design (such as illustrations/ symbolism/ colour theory/ typesetting/ etc.) have not been addressed here.
2. The study limits its scope in terms of testing the hypothesis in context of only one Grade and only one subject; namely Grade 1 and Mathematics.

3. The study limits its scope in terms of taking a case study method by collecting response in a group of schools, namely the 6 Presidium schools in NCR.
4. The study limits its scope to target audience i.e. students of Grade-1.

Epilogue

The findings from this study were taken into account while redesigning all the textbooks being used as part of the curriculum, for better engagement and learning. Other design strategies in conjunction with learning theories have also been used subsequently. These books have been and are being used by thousands of children across the country, and have brought considerably better engagement and meaningful learning to them.

Acknowledgement

We would like to thank the following for their contribution to our study:

- The management and teaching staff of the participating schools, as well as the publisher and its team of curriculum developers, for supporting us in the data collection for this study.
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Annexe 1 : EXISTING DESIGN of Unit on Addition in Math Book for Grade 1

Single Digit Addition

LET'S TALK

Picture Reading

What is happening in the pictures given below?

LET'S DO IT

Write numbers for every picture.

1. 3 birds are sitting together. 4 of their friends come and join them. How many birds are there now?

3 birds and 4 more birds make 7 birds.

2. 3 glasses of juice are on one tray and 2 glasses of juice on another. How many glasses are there in all?

_____ glasses and _____ more glasses make _____ glasses.

3. 3 candies are on one tray and 3 candies on another. How many candies are there in all?

_____ candies and _____ more candies make _____ candies.

NOTE FOR PARENTS

These tasks help children infer the meaning of addition and develop vocabulary related to that.

FUN AT HOME

You played some games in the classroom. Now play a game with your parents. Take two dice and 50 kidney beans in a bowl. Roll both the dice and take out the number of kidney beans shown on both the dice. Tell the total number of kidney beans taken out. Take turns with your parents to do the same. Every correct answer fetches you one point. The one who gets ten points first, wins the game.

LET'S DO IT

We loved playing with Mathemat in the class. Let us fill colours in Mathemats to show the questions first. An example has been given below.

1.

2 rubber plugs and 2 rubber plugs make 4 rubber plugs.

2.

4 rubber plugs and 1 rubber plug make _____ rubber plugs.

3.

6 rubber plugs and 2 rubber plugs make _____ rubber plugs.

4.

3 rubber plugs and 5 rubber plugs make _____ rubber plugs.

5.

9 rubber plugs and 1 rubber plug make _____ rubber plugs.

6.

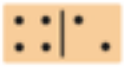
5 rubber plugs and 4 rubber plugs make _____ rubber plugs.

NOTE FOR PARENTS

Interacting with materials and pictures helps children form new concepts easily.

FUN AT HOME

Do you remember that we played with dominoes in the class? Let us match the cards with their correct answers now.

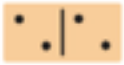


4 and 2 make 6

These are addends. This is the sum.

6

1.



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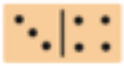
2.



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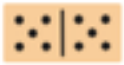
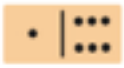
3.



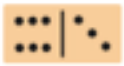
4

4.



7

5.



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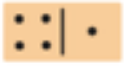
6.



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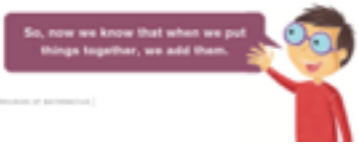


LET'S DO IT

Estimate and Check

Estimate and write the answer in the given circle. Then add and fill the boxes with numbers. See how close your estimation was.

			Estimated	Checked
1.	☐ oranges	☐ oranges	oranges	oranges
2.	☐ apples	☐ apples	apples	apples
3.	☐ bananas	☐ bananas	bananas	bananas
4.	☐ cherries	☐ cherries	cherries	cherries

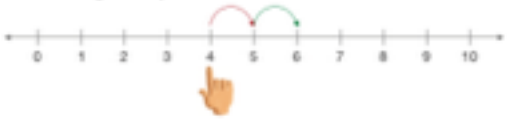
NOTE FOR PARENTS

Help children estimate the answers by just looking at the pictures for a moment. Let them check their answers later.

FUN AT HOME

Count On to Add

We use our fingers or objects for addition. Let us now use number line to add.



To add 4 and 2, first point your finger to 4, and then move it 2 steps forward. You will reach 6. That is the answer.

Use the number line and fill the boxes.

1. 5 + 1 = ☐

2. 4 + 4 = ☐

3. 3 + 2 = ☐

4. 1 + 5 = ☐

5. 3 + 3 = ☐

6. 8 + 2 = ☐

7. 6 + 3 = ☐

8. 7 + 1 = ☐

LET'S TALK

Adding Zero

Once there lived a man called Zero. He loved gifting zeroes to everybody. He would swing his fist in the air and say, 'Hey, I have a surprise for you', and give zero. Once he met Anu and said, 'Hi, you have 2 chocolates.
Let me give you some more.' Then he opened his fist but there was nothing.

Zero laughed aloud.

Did Zero give any chocolate to Anu?

How can we write this as a number?

Let us see.

2 + ☐ = 2

Did the number change? Why?

LET'S DO IT

Let us see what happens when we add zero to a number.

1. 4 + 0 = ☐
2. 5 + 0 = ☐
3. 6 + 0 = ☐
4. 7 + 0 = ☐
5. 2 + 0 = ☐
6. 9 + 0 = ☐
7. 1 + 0 = ☐
8. 0 + 0 = ☐

LET'S TALK

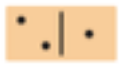
Did the numbers change when you added zero to them?

Talk about the reasons for what you find out.

NOTE FOR PARENTS

Children observe the pattern and induce that the value of the number doesn't change when zero is added to it.

LET'S DO IT



2 + 1 = 3

This is same as

See the domino above. Does the answer change when we turn the domino?

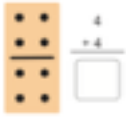
2 + 1 is same as 2
+ 1

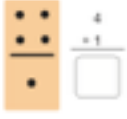
Now solve the following questions.

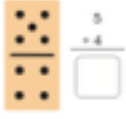
1. 

2. 

3. 

4. 

5. 

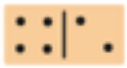
6. 

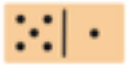
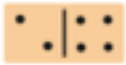
LET'S TALK

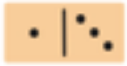
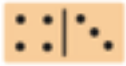
See this card. It is 2 + 3 . What do we get when we add these numbers? If we rotate the card, what do we see? It is 3 + 2 . What do we get when we add these numbers? Why does this happen? Is this true for other numbers as well? Let us check. Take any two cards and add the numbers written on them. Now change their order and check whether you get the same answer or not. Ask your friends to repeat this activity and check if their answers also match after changing the order of numbers.

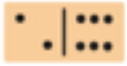
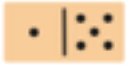
FUN AT HOME

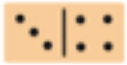
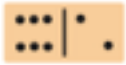
Match the cards with same number of dots.

1. 


2. 


3. 


4. 


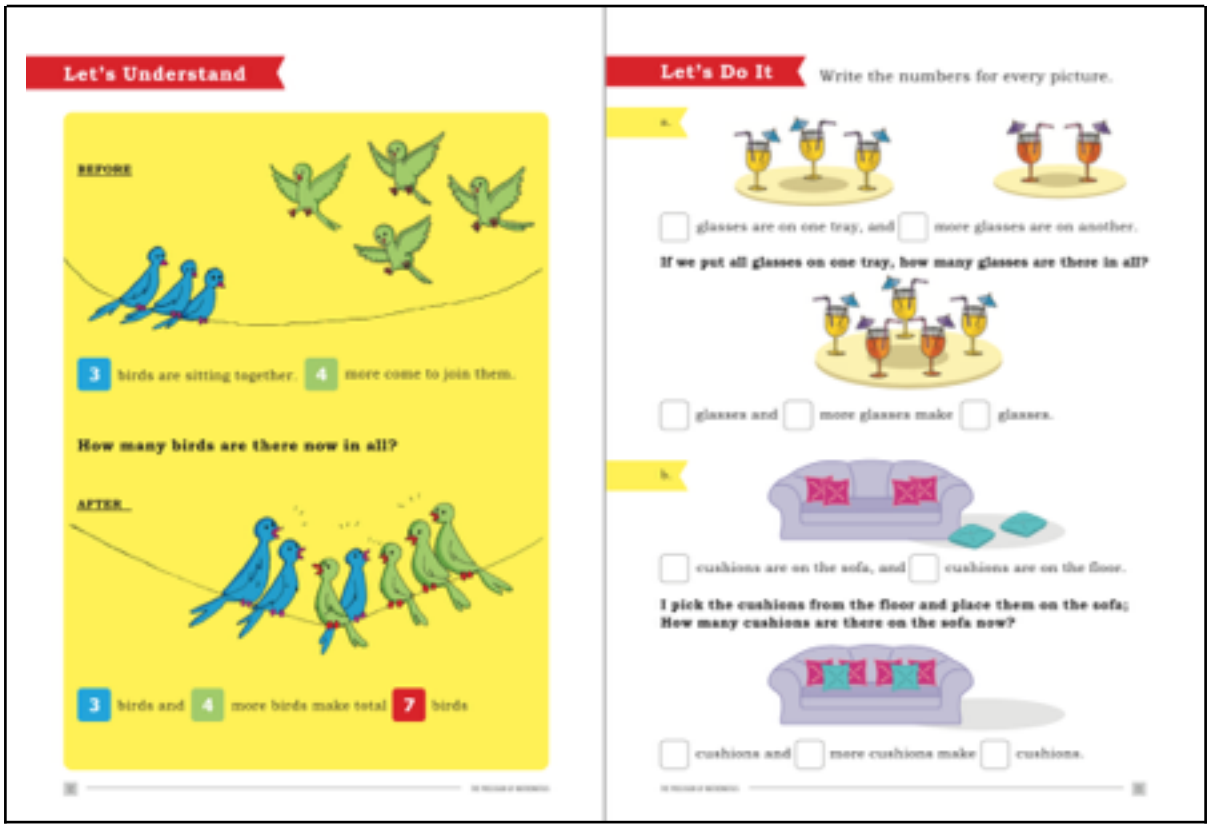
5. 


NOTE FOR PARENTS

At this stage, children only explore the commutative property of addition using dominoes in the classroom. They revisit and use it later in higher grades.

Annexe 2 : NEW DESIGN of Unit on Addition in Math Book for Grade 1

(Re-designed with design application of Gestalt's Laws)



c.

☐ candies are on a plate, I get ☐ more candies to put on it.

How many candies are there in all now?

☐ candies and ☐ more candies make ☐ candies.

d.

☐ balls are lying on a mat ☐ more balls come rolling.

Now, how many balls are there on the mat?

☐ balls and ☐ more balls make ☐ balls.

c.

☐ books are stacked in a pile, and ☐ more are in another pile.

If we stack all books together, how many books are there in all?

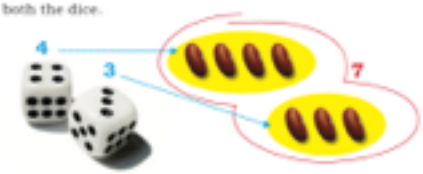
☐ books and ☐ more books make ☐ books.

Fun at Home — Play time!

Play this game with your parents.

Take two dice  and 50 kidney beans in a bowl.

Roll both the dice and take out the number of kidney beans shown on both the dice.



Count and tell the total number of kidney beans taken out.

Take turns with your parents to do the same. Every correct answer fetches you 1 point. The one who gets 10 points first, wins the game!

Let's Understand — Mathemat

2 green plugs, and
2 purple plugs make-
4 plugs

Let's Do It

Colour the plugs in Mathemats as per the question, then count the total number of plugs and write the answer in ☐.

a.

2 blue plugs, and
2 red plugs make-
☐ plugs

b.

3 blue plugs, and
4 red plugs make-
☐ plugs

c.

4 blue plugs, and
2 red plugs make-
☐ plugs

d.

3 blue plugs, and
4 red plugs make-
☐ plugs

e.

6 blue plugs, and
3 red plugs make-
☐ plugs

f.

4 blue plugs, and
4 red plugs make-
☐ plugs

Let's Understand Dominoes

6

4 and 2 make 6

These are addends. This is the sum.

Now we know that when we put things together, we add them.

Let's Do It

Match the dominoes cards on left with the correct sum

7

9

6

7

10

Fun at Home Estimate and Check

Estimate and write the answer in the given circle.

Then add and fill the boxes with numbers.

See how close your estimation was.

Estimated / Checked

a.

☐ oranges + ☐ oranges = ◯ / ☐ oranges

b.

☐ apples + ☐ apples = ◯ / ☐ apples

c.

☐ bananas + ☐ bananas = ◯ / ☐ bananas

Note for Parents

Help the child to estimate the answer by just looking at the pictures for a moment. Let them check their answers by counting later.

Let's Understand Number Line

We use our fingers or objects for addition.
Let us now use number line to add.

To add **4** and **2**, first point your finger to 4 and then move it 2 steps forward. You will reach 6. That is the answer.

Fun at Home

Draw and show how you will use the number line to add the following. Write the answer in the box.

a. 5 + 1 = ☐

b. 3 + 2 = ☐

c. 1 + 5 = ☐

d. 5 + 5 = ☐

e. 8 + 2 = ☐

f. 6 + 3 = ☐

g. 3 + 5 = ☐

Let's Talk — Adding Zero

Once there lived a man called **Zero**. He loved gifting zeroes to everybody. He would swing his fist in the air with thumbs up and say, 'Hey, I have a surprise for you', and then give "zero" to them.

Once he met Anu and said, 'Hi, you have 2 chocolates. Let me give you some more.'
Then he opened his fist and there was **nothing!**
Zero laughed aloud.

Did **Zero** give any chocolates to Anu? **Yes / No**

Let us see how we can write this as a number.

2 + 0 = 2

Let's Do It

Let us see what happens when we add **0** to a number

a. 2 + 0 = ☐
b. 6 + 0 = ☐
c. 8 + 0 = ☐
d. 3 + 0 = ☐
e. 5 + 0 = ☐
f. 9 + 0 = ☐
g. 1 + 0 = ☐
h. 4 + 0 = ☐

Fun at Home

Recite the story of **Zero** at home to your parents.
Tell them what happens when we add **0** to any number

Note for Parents
Children observe the pattern and induce that the value of the number does not change when **zero** is added to it.

Let's Understand — Vertical Addition

Does the answer change when we turn the domino?

4 + 2 is the same as 4 + 2

Lets's Do It — Now solve the following

a.  6 + 1 = ☐
b.  4 + 3 = ☐
c.  5 + 4 = ☐
d.  5 + 3 = ☐
e.  3 + 6 = ☐
f.  5 + 5 = ☐

Let's Talk

See this card.

It is **4 + 3**
What do we get when we add these numbers?

4 + 3 = 7

If we rotate the card, what do we see?

It is now **3 + 4**
What do we get when we add these numbers?

3 + 4 = 7

The SUM in both the cases is same!

Why does this happen? Is this true for other numbers as well?
Let us check.

Take any two cards and add the numbers written on them.
Now change their order and check whether you get the same answer or not.

Ask your friends to repeat this activity and check.
Do their answers also match after changing the order of numbers.

Fun at Home Match

Match the blue domino card with the green domino card that has the **same SUM**
Dominoes with same sum will have same total number of dots.

Note for Parents
At this stage, children only explore the **commutative property** of addition using dominoes in the classroom. They revisit and use it later in higher grades.

Annexe 3 : QUESTIONNAIRE (For collecting Qualitative Data)

Dear Teacher

We are trying to collect feedback from all of you on some ideas about the presentation of the content material in our books.

For this pilot exercise, one chapter from Grade 1 Math book has been re-designed; This is based on certain established principles of design which was shared with our team of designers during a short design training workshop in the recent past.

We are hoping that your valuable input and feedback will help us improve the presentation of the content in such a way that aids students learning better.

General Instructions:

Your facilitator will share a small kit with you in order to assist us towards this objective. This includes a set of re-designed unit along with the original design (currently in use), a questionnaire to gather your feedback, and sheets of paper to record your answers.

- The Questionnaire requires you to observe and compare the two sets (Existing Design and New Design) for visual presentation and design of the content, in different sections.
- Kindly do not leave any question unaddressed.
- Please use your experience of teaching children of this age and this subject in providing unbiased and honest opinion.

Please note:

- The purpose of this exercise is not to evaluate just the “Aesthetic” (Visual appeal / pleasantness) of the design but to test if the design and presentation of the content can aid students’ learning.
- The purpose of this exercise is also not to evaluate the quality of content. For this reason the content has been kept the same in both the versions of design.
- In some of the tasks the number of problems may have changed (increased or decreased) based on space on page available- This should not be accounted for in your analysis of the impact of the design as it is a change in content and not design.
- As part of this research, we have deliberately kept the style and quality of illustrations the same. Therefore do not give feedback on the style of illustration.

Your participation in this activity is valued and we are grateful to you for sparing some time to complete this study.

Best regards,

Prachi Mittal

Name :

Qualification :

Total Work Experience (as n educationist in primary schools)

Years of working at Presidium :

Branch : ***Current Designation / Role :***

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1. Observe and compare the two sets for the presentation of **"Picture Reading"** task *(task on pg. 49 of Old Design & pg. 11 of New Design)*, specifically from the point of view of placement and distribution of elements as well as colouring.

   Spot and list the changes made in the re-designed set. State your opinion on the effect (positive or negative) these changes will have on children's learning experience.

   Please do not give inputs on "Aesthetics" - what looks better or seems more attractive for the children. Base your response on how this will impact children's understanding of addition.

2. Compare the two sets for the presentation of the **task for Adding two Sub-sets** ("Let's Do It" task on pg. 49 of Old Design & pg. 12-15 of New Design) - con*sider the presentation of the example as well as the task portion where the child has to work/ write*.

   Spot and list the changes made in the re-designed set. State your opinion on the effect (positive or negative) these changes will have on children's learning experience: understanding of both the procedure as well as the concept.

3. In the re-designed set, **examples** have been highlighted strongly; In your opinion what kind of an impact (positive or negative) will this have on the child's learning experience as well as your teaching practice. Give reasons for your response.

4. Compare the two sets for the presentation of the **example for "Vertical Addition"**.

   Spot and list the changes made in the re-designed set. State your opinion on the effect (positive or negative) these changes will have on children's learning.

5. Compare the two sets for the presentation of any one of these 3 tasks - **MatheMat / Number line / Vertical addition** using dominos. *Consider only the task portion, where the child has to work/ write, not the example.*

   Spot and list the changes made in the re-designed set. State your opinion on the effect (positive or negative) these changes will have on how children work on this task. *Specify the task you have observed and are comparing.*

6. Compare the two sets for the presentation of **"Estimate and Check" task** (Fun at Home).

   Spot and list the changes made in the re-designed set. State your opinion on the effect (positive or negative) these changes will have on how children work on this task.