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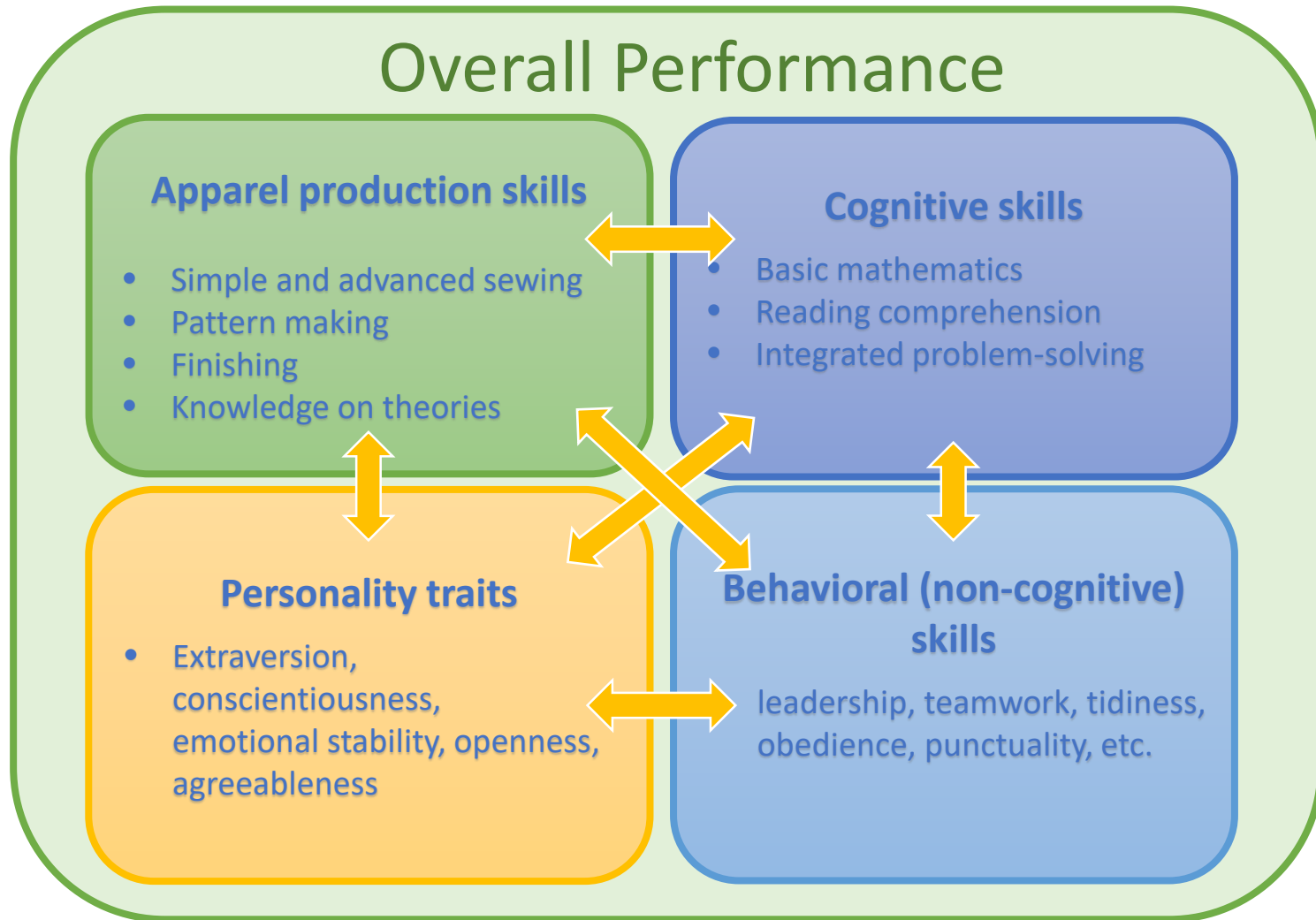
Mathematics achievement and textbook contents: Evidence from Ethiopia

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Skills assessment: A framework



Let's do some maths!

- $46 + 32 =$

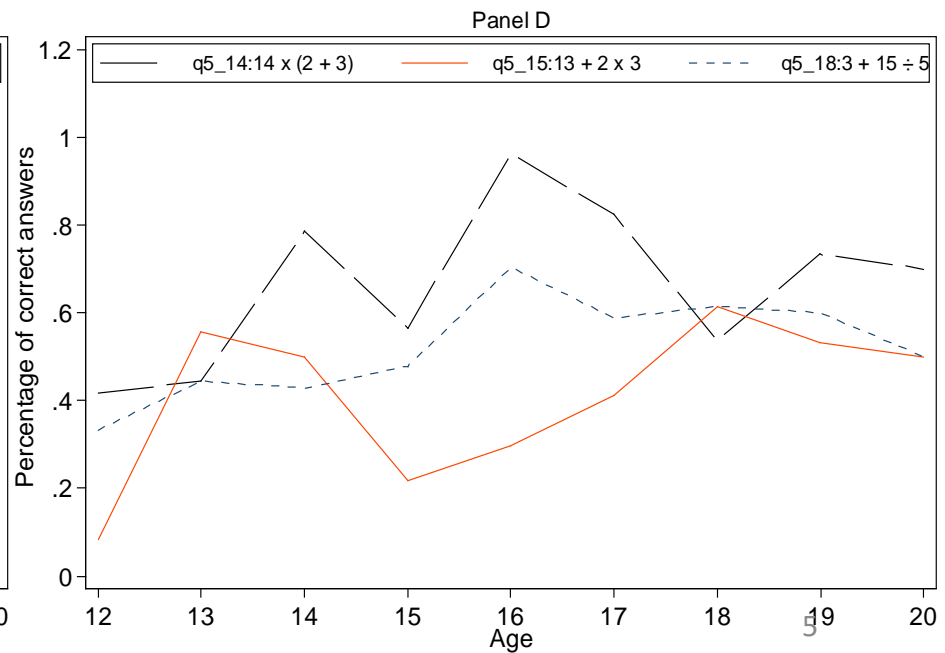
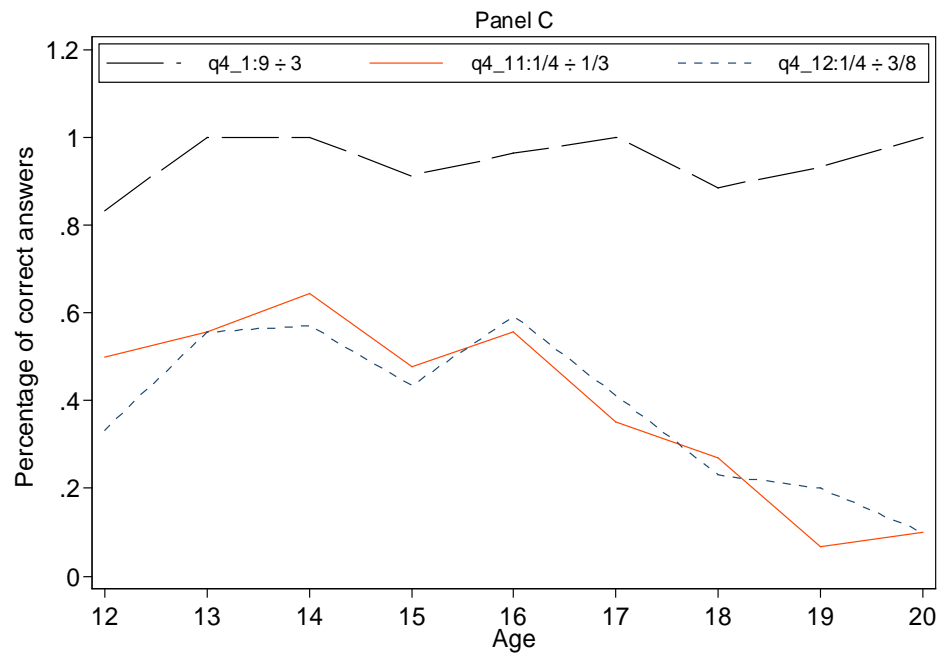
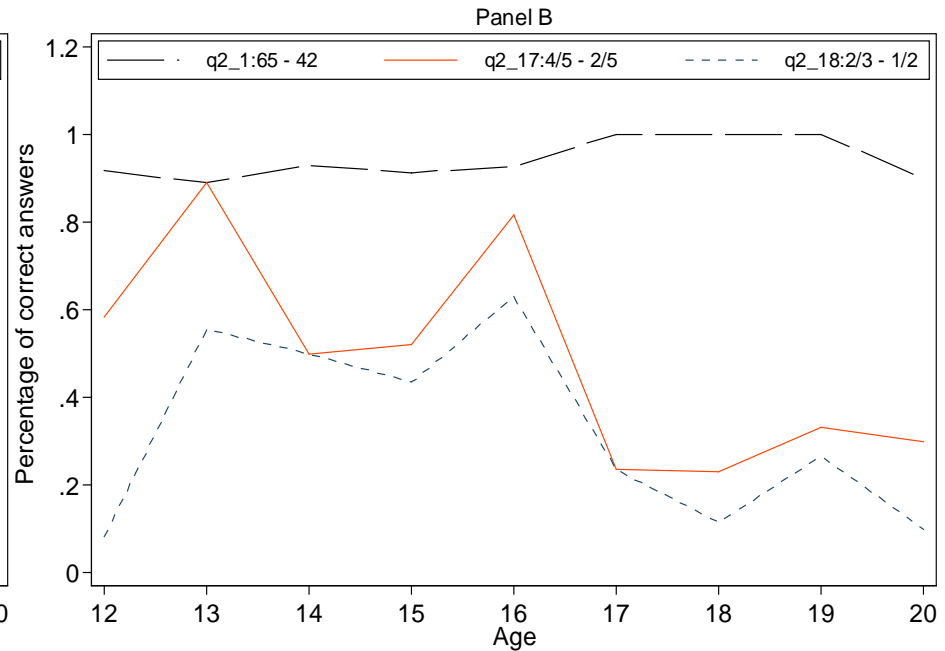
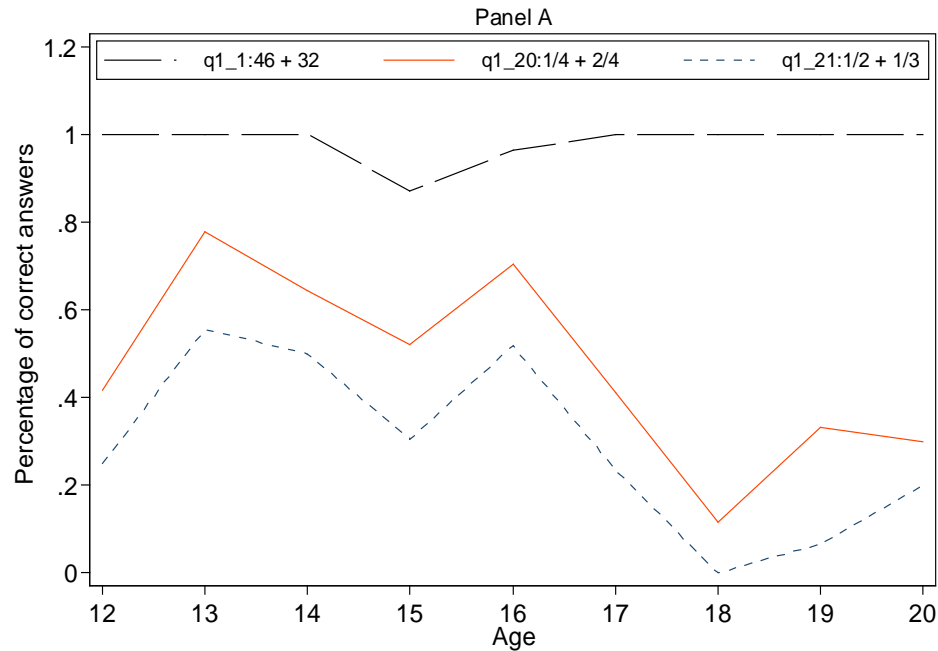
- $1/4 + 2/4 =$

- $1/2 + 1/3 =$

Data

- We randomly selected 153 students in Addis Ababa, Ethiopia in March 2018
- Of our sample, 33% are from Jerusalem Primary School, 32% from Dej Belay Zeleke No.1 Secondary School, and 35% from Misrak Polytechnic College.
- We measured the capacity to perform mathematical tasks at the level of primary school curriculum
- We focused on domains such as addition, subtraction, multiplication, division, combination, reading clock, unit conversion, area calculation, cubage calculation, and reading tables, graphs, and charts.

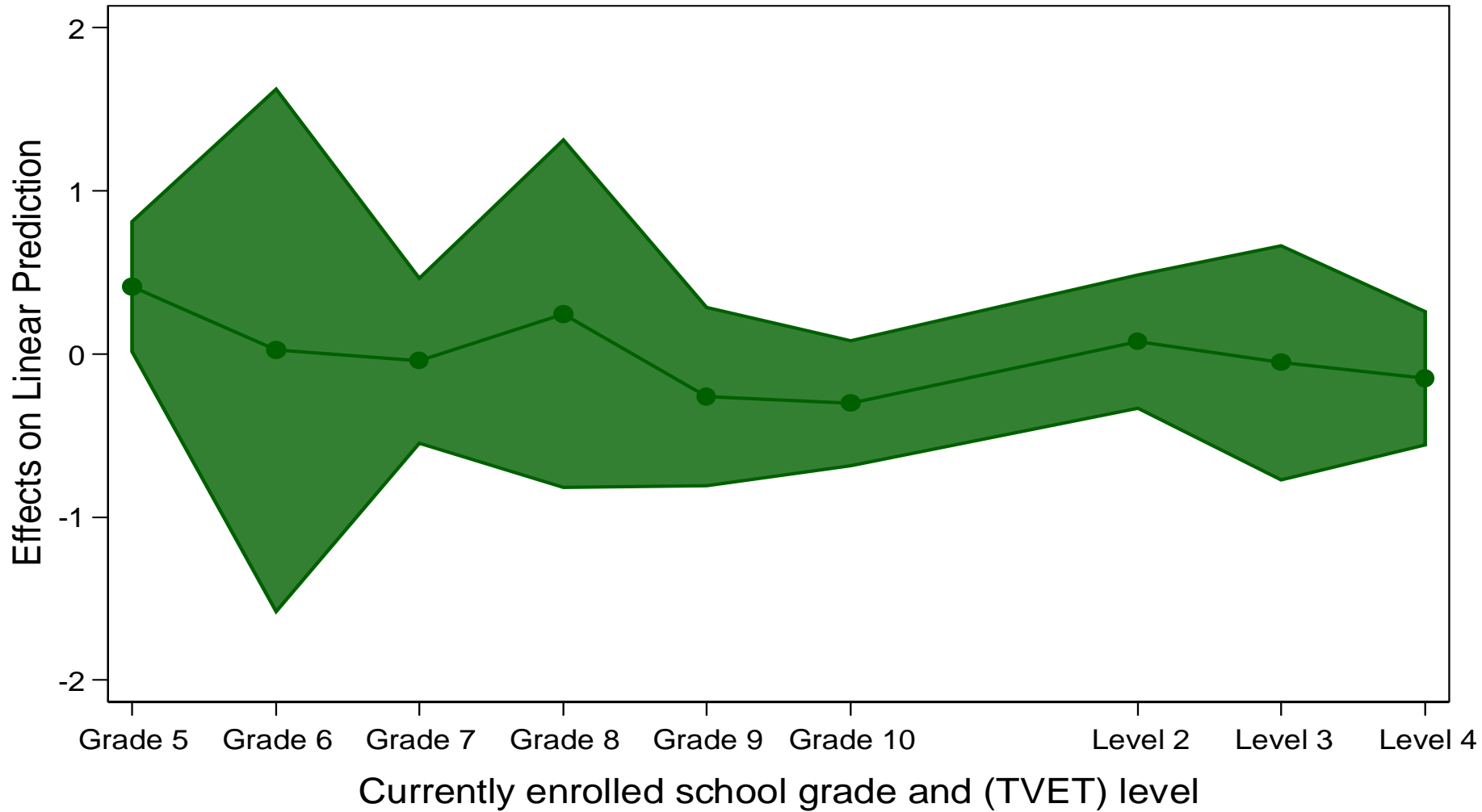
Mathematics achievement



Predicting numeracy score

- Item Response Theory to generate a numeracy score
- Takes into account difficulty levels and discrimination power
- Correct for guessing Interpretation: Mean probability of knowing the answer to any of the items
- Predict probability of correct answer for each item

(Flat) learning profiles

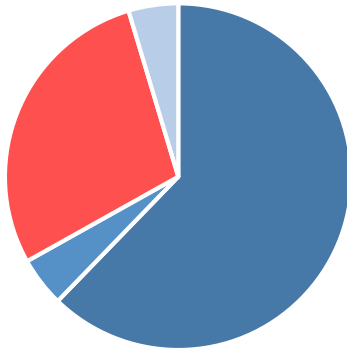


Note: The line represents the average marginal effects of age with 95% confidential interval obtained from regressing Ability on the interaction of Age x Grade. Ability is estimated from an IRT corrected for guessing. We control for peer effect and robust standard errors are estimated at student level.

The Common Mistakes and Textbook Contents

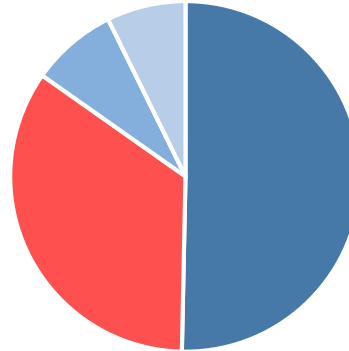
1. Fractions

$$\frac{1}{2} + \frac{1}{3}$$



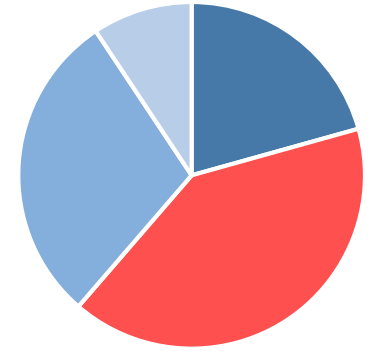
■ 2/5 ■ 1/6 ■ 5/6 ■ 1/5

$$\frac{2}{3} - \frac{1}{2}$$



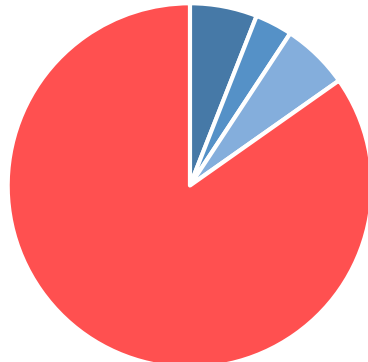
■ 1/1 ■ 1/6 ■ 3/5 ■ 1/5

$$\frac{1}{4} \div \frac{1}{3}$$



■ 1/12 ■ 3/4 ■ 1/1 ■ 0/7

$$\frac{5}{6} \times \frac{3}{4}$$



■ 8/10 ■ 1/3 ■ 19/12 ■ 15/24

- Students do not understand “denominator.”

→ Simply calculate the two numbers on the top and the bottom.

$$\frac{1 \frac{2}{3}}{4 - 3} \quad 1.333$$

→ Could solve multiplication.

The Common Mistakes and Textbook Contents

1. Fractions

- The students have learned about fraction since Grade 2.
- Syllabus allocates certain period of time to learn how to calculate fractions.

Grade	Unit title	Period
G4	Addition and subtraction of fractions with the same denominator	3
G5	Addition and subtraction of fractions with different denominator	13
	Multiplication and division of fraction	
G6	Further on addition and subtraction of fractions and decimals	11
	Further on multiplication and division of fractions and decimals	10

- However, textbooks do not have enough practice questions, since they use many pages for explanation.
- After the fraction unit, there is no brush up questions to recall how to calculate fractions.

The Common Mistakes and Textbook Contents

2. Combined operation

Student A

14. $14 \times (2+3) =$ $\frac{14}{5} 2$
 u. 23
 l. 19
 h. 31
 (sw.) 70

15. $13 + 2 \times 3 =$ $\frac{13}{2}$
 u. 18
 l. 29
 h. 19
 (sw.) 78
 (w) 45

$\frac{15}{3} 1$
 45

Student B

14. $14 \times (2+3) =$ $\frac{14}{5} 2$
 u. 23
 l. 19
 h. 31
 (sw.) 70

15. $13 + 2 \times 3 =$ ✓ $\frac{13}{2}$
 (u.) 18
 l. 29
 h. 19
 (sw.) 78

$\frac{15}{3} 1$ $\frac{15}{3}$
 45 45

Student C

23. $(36 - 24) \div 3 =$
 u. 28
 (l.) 4
 h. 3
 (sw.) 25

24. $15 - 36 \div 6 =$ -3.5
 u. 15
 l. 6
 h. 27
 (sw.) 9

- Could solve questions with bracket, but without ones.
 → Some students even added their own answers.

The Common Mistakes and Textbook Contents

2. Combined operation

Grade 5 textbook explains about the order.

1.2.4 የተለያዩ ስሌቶችን የያዙ ፕሮብሌሞች

ከአንድ በላይ ስሌቶችን የያዙ ፕሮብሌሞችን ለማስላት የስሌቶች ቅደም ተከተል መጠበቅ ያስፈልጋል። የስሌቶችን ቅደም ተከተል ካልጠበቅን ስህተት ሊያጋጥመን ይችላል። ለምሳሌ "8+3×4"ን ብንመለከት መደመርን አስቀድመን ማጠቃለያን ብናስከትል 11×4 ወይም 44 እናገኛለን። ማጠቃለያን አስቀድመን መደመርን ብናስከትል ደግሞ 8+12 ወይም 20 እናገኛለን። ስለዚህ ትክክለኛና አንድ ዓይነት የስሌት ውጤት ለማግኘት የስሌቶች ቅደም ተከተል መመሪያን መከተል አስፈላጊ እንደሆነ እንገነዘባለን።

የስሌቶች ቅደም ተከተል

1ኛ) ቅንፍ ውስጥ ያለ ስሌት ቅድሚያ ይሰጠዋል።

2ኛ) አራቱ መሠረታዊ ስሌቶች በሚከተለው ቅደም ተከተል ይሰላሉ። ማካፈል፣ ማጠቃለያ፣ መደመር፣ መቀነስ።

When you calculate problems containing several operations, you need to know there is a certain order. If you do not follow the order, you will get the wrong answer. For example, let's think about 8+3×4. If you do addition first, you will do 11×4 and get 44 as an answer, On the other hand, if you do multiplication first, you will do 8+12 and get 20 as an answer, Therefore, to achieve only one correct answer, you must learn the right order for the calculation.

The order for problems containing several operations

1st) Calculate inside of the brackets

2nd) Calculate in the following order: Division, Multiplication, Addition, and Subtraction

The Common Mistakes and Textbook Contents

2. Combined operation

Practice questions for combined operation on the textbook

$$m) 2 \times 9 \div 3 - 1$$

$$n) (52 + 3) \div 7$$

$$o) (20 + 30) \div 5 \times 2 + (24 - 1)$$

$$p) 4,257 + (6,028 - 5,993) \div 5$$

$$q) 250 \times (300 \div 6) + 150$$

$$r) (420 \times 6 + 4) \div (16 \times 2 - 28)$$

$$u) 324 + (512 - 473) \div 3$$

$$v) 285 + (483 - 387) \div 4$$

$$w) (5000 - 800) \div 70 + 23$$

$$x) 16 \times (24 \div 4) + 10$$

$$y) (5 \times 4 + 4) \div (4 \times 4 - 8)$$

$$z) (15 \times 2) \div (14 + 1)$$

$$aa) 100 - (12 \div 4 + 2)$$

- Most of the practice questions focuses on teaching students how to solve questions with brackets.
- Except the questions in the red boxes, students can simply calculate from left to right if they know “calculate inside of brackets first” rule.

Possible extensions

- Inter-relations between skills (see our framework for skills assessment)
- Classroom observations
- School factors and family background
- Is TVET different? A closer look