Error Analysis of Pre-Service Mathematics Teachers in Solving Verbal Problems

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Abstract: Mathematics proficiency in the Philippines is a persistent concern, seen by many as a sign of an educational crisis. Teachers are responsible for improving learning outcomes in any discipline, including math. Thus, the study intended to conduct an error analysis of verbal problems among pre-service mathematics teachers. The researcher employed descriptive research and Newman's Error Analysis to suffice the research objectives. The findings revealed low levels of error in reading stage, but moderate levels of error in comprehension, transformation, process skills, and encoding stages. In addition, underlying factors contributing to these errors were incomplete solutions and answers, incorrect or incomplete processes, grammatical errors, conversion errors, and failure to indicate an answer. The researchers concluded that pre-service teachers are proficient in the early stage of problem solving, but challenged in properly constructing equations, the utility of operations, and interpreting their results.

Keywords: newman's error analysis, verbal problems, educators, mathematical operations

INTRODUCTION

Mathematics has been recognized as a discipline paramount to the acquisition of various abilities, such as logical reasoning, critical thinking, and problem-solving. Educators play a pivotal role in shaping students' understanding and appreciation of mathematics. Hence, it is vital to assess and correct the mathematical errors of pre-service mathematics teachers to improve their mathematical ability and to eventually become better educators.

In the Philippines, Filipino students were revealed to have low mathematics proficiency, scoring only 355 points while the average score was 472 points, as per the Program for International Student Assessment (PISA) 2022 International Report (OECD, 2023). Mumu et al. (2021) also revealed that mathematics achievement is adversely affected by growing instructional issues while Panthi et al. (2019) mentioned that theoretical problems in instruction are rampant among developing countries. Similarly, it was reported that the proficiency issue in mathematics was anchored to the lack of understanding the English language – the language used in teaching mathematics in the Philippines (Vera, 2021); thereby resulting to lack of understanding verbal concepts, ideas and principles in mathematics. Therefore, to attain proficiency in mathematics, it is necessary for students to comprehend mathematical language such as symbols (inequalities symbols, summation, integration, and approximation), operators (exponentiation, square root, and factorial), geometric shapes or figures (circle, sphere, and cube), and equations. In line with this, solving verbal problems can be a suitable assessment for understanding mathematical language.

In pursuit of alleviating mathematical proficiency among students, it is crucial that their educators also exhibit mathematics proficiency by mastering the content of the mathematics subjects. Further, University at Buffalo (2023) revealed desirable learning outcomes can be achieved through efficient teaching methods, such as mastery of the content of the course. Also, Gholami (2021) emphasized in their study the impotance of mathematics teachers' proficiency to enhance learning outcomes. Meanwhile, pre-service teachers undeniably have skills and knowledge that are still not at the same level as experienced teachers. Also, it is important that these individuals are determined to be ready in practice considering the dynamic educational approach brought by the pandemic (Nasir et al., 2022). Nevertheless, Ocampo (2021) mentioned that the pedagogical competence of pre-service teachers in the Philippines has increased in the 21st century and the new normal modalities. However, there is still a lack of studies focusing on error analysis among pre-service mathematics teachers regarding their verbal problem-solving skills. Existing studies focus on error analysis of pre-service teachers in their English written texts (Cocjin, 2020), in their mathematical literacy (Khalo et al., 2015), and in estimation problems known as Fermi problem that aim at encouraging students to make educated guesses (Segura & Ferrando, 2021). Thus, there was still a lack of knowledge regarding error analysis among pre-service mathematics teachers regarding solving verbal problems.

This work assesses the content knowledge on verbal problem solving of the graduating pre-service mathematics teachers who experienced asynchronous online learning from 2020 to 2023 due to the COVID-19 pandemic. Asynchronous learning, is a student-centered learning approach where the students are expected to self-study the given modules and reading assignments. This study then sheds light to the errors of pre-service mathematics teachers in solving verbal problems. It utilized the Newman's Error Analysis to identify underlying factors and the level of reading, comprehension, transformation, process skills, and encoding errors of the respondents in solving verbal problems. In line with this, the identification of committed errors among the respondents may give direction to the academe to further enhance tertiary pedagogy and possible academic interventions.

Theoretical Framework

This study employed Newman's Error Analysis by Australian educator Newman (1977) to uncover respondents' mathematical errors and evaluate their attitudes toward mathematics as a course and discipline (Seng, 2020). Additionally, it helps discover students' mathematical knowledge, language gaps, and challenge them when they do not understand the subject. This strategy also helped teachers discover areas of misunderstanding and provided a foundation for thinking about students' arithmetic verbal problem issues (White, 2010). Newman's Error Analysis also suggested ways teachers might use efficient teaching methods to avoid them.

This analysis has five stages: reading, comprehension, transformation, process skill, and encoding (Triliana & Asih, 2019). In the reading stage, students should understand the question and recognize what is being asked. In the comprehension stage, students should be able to understand what is needed to solve the verbal problem. Students should choose the right mathematical operations to solve the problem in the transformation stage. While in the process skill stage, the students should use the mathematical operations with the correct procedure. Finally, the encoding stage involves students writing their final answers based on what is asked in the problem and accurate format, such as proper indication of units.

In pursuit of identifying the best instructional tactics, models, and material to use with students, it is necessary to recognize and analyze the mistakes they make (Ling, 2020). The process of finding and analyzing can be made more focused and organized by employing Newman's error analysis. Thus, educators and academic institutions throughout the globe have been utilizing this method in identifying the type of mistakes of the students.

Mathematics is challenging; thus, students are encouraged to approach problems systematically. Students must be able to recognize and understand problems that are similar to those that have been addressed and adapt problem-solving theory or method to the issue. Mathematics also helps students learn abstract concepts that improve problem-solving skills. Mathematically proficient students have fewer arithmetic problems. Knowledge of the subject helps students avoid many errors. Hence, Saleh et al. (2022) suggested that students must learn ideas and theorems before solving the problems. Meanwhile, Boonen et al. (2016) revealed that researchers and educational professionals have paid close attention to mathematical word problems, which are mathematical exercises that offer pertinent information on a subject as text rather than in the manner of mathematical language. Development of realistic mathematics problems is also being encouraged towards the objective (Agustina et al., 2021). Therefore, it is assumed that student's ability to solve arithmetic word problems successfully depends on both their ability to comprehend the word problem's text accurately and their ability to execute the necessary mathematical operations.

In addition, several studies that utilized Newman's Error Analysis also explore the factors that resulted in the errors in each stage. Patac and Patac (2015) said that errors in the problem-solving process among students are anchored to incorrect procedures, incomplete schema, and failure to show their solutions. Impulsive styles in solving mathematical problems often lead to inaccurate answers (Zamzam & Alfiana, 2017). Thus, this study further explores the factors that cause errors in solving verbal problems of PSMTs. Hence, Newman's Error Analysis was deemed suitable as it explored the errors committed by the PSMTs. Specifically, it served as a foundation as the study adapted the stages encapsulated in the theory, such as reading, comprehension, transformation, process skills, and encoding errors.

Literature Review

The Program for International Student Assessment 2018 results revealed that a mere 53% of learners from various nations involved in their conducted assessment were able to successfully tackle tasks that demanded more than straightforward deduction and the utilization of many sources of information for mathematics problem-solving (Klang et al., 2021). Hence, there can be a need for better strategies, approaches, and tools necessary for instruction. Similarly, Khatimah and Sugiman (2019) discovered that various problem-solving approaches can result in varied abilities for solving mathematical problems. For instance, Setyaningsih et al. (2018) revealed the learners' approach to addressing ratio and proportion issues will vary concerning their strategies.

The increasing importance of introducing and developing problem-solving among students can be observed considering its influence on their thoughts, knowledge, and skills (Sinaga et al., 2023). Students solve problems to learn important mathematical concepts and problem-solving techniques (Albay, 2019). During such activity, students must actively explore and think using mathematical principles, theories, and procedures (Xu & Qi, 2022). However, students can also be susceptible to errors as they conduct problem-solving. Ratnaningsih and Hidayat (2021) revealed in their study that lacking cognitive skills makes it hard for students to understand and use representations, convey logical reasoning, and explain their interpretations. More often than not, students struggle with explaining, arguing, and expressing reasons, which results to hesitancy, imprecision, failure to calculate, lack of problem comprehension, and rapid interpretation without examination that further causes errors.

Students often find solving mathematical word problems challenging due to the numerous mathematical principles involved. Furthermore, the predominant mistake identified in students' responses was their inability to perform calculations accurately (Haryanti et al., 2019). Thus, various studies have examined variables affecting errors during problem-solving. One of these studies was conducted by Abu Bakar et al. (2021), which revealed mathematics self-efficacy does not contribute significantly to mathematical problem-solving performance. Another study focused on language issues, lack of resources, mathematics pedagogical understanding, parent participation, encouragement and assistance, and lack of instruction and seminars contributed to poor problem-solving at the integrated school (Chirimbana et al., 2022). However, the analysis of errors and factors that contribute to inaccuracies in solving mathematical problems is crucial due to their significant impact on performance (Ratnaningsih & Hidayat, 2021). Meanwhile, Rushton (2018) mentioned that the pedagogy of mathematics education has predominantly relied on educators displaying accurately solved example problems as examples for students to emulate when completing their exercises. Thus, by integrating accurately solved exercises with error analysis, one can get enhanced mathematical comprehension.

An error analysis can assist educators in identifying common mistakes made by pupils and offering suitable remedies to address these faults. By identifying and comprehending the errors made by pupils, strategies can be developed to mitigate or rectify these faults effectively (Putri et al., 2023). Furthermore, the usage of Newman's Error Analysis has been practiced, this analysis is a technique used to analyze errors made by students when completing issues in the form of descriptive problems (Zamzam & Patricia, 2018). Specifically, Zulyanty & Mardia (2022) suggested that this method of analysis is typically used for exploring verbal problem-solving.

METHOD

This study utilized a quantitative-descriptive study considering the data that sufficed the research objectives are numerical in nature. Descriptive research refers to a research method that allows the researcher to measure actual behavior, which in this case was the errors in solving verbal mathematics problems. The study was undertaken in Central Luzon State University (CLSU), Philippines where the research respondents are 38 pre-service mathematics teachers who are graduating Filipino students, aged 20 to 23 years old, and have 480 hours of teaching experiences. Among them, 23 (61%) are female and 15 (41%) are male. They are selected considering that the study aimed to determine the performance among the country's future mathematics educators who experienced asynchronous learning. In addition, a purposive sampling technique was utilized for the selection of the respondents. Purposeful or purposive sampling is a sampling technique used for the identification and selection of cases that are data-rich and relevant to the research variables (Palinkas et al., 2015).

Research Instrument

To acquire this data, the researcher formulated a research questionnaire for the assessment of verbal problem solving. The number of items in this instrument consists of five (5) verbal problems that must be solved to determine the errors in answering the verbal problems by the respondents. The verbal problems consisted of digit problem, age problem, work problem, mixture problem, and rate problem. These problems are as follows.

Digit problem. The denominator of a certain fraction is 5 more than twice the numerator. If 8 is added to both terms, the resulting fraction is 3/5. Find the original fraction.

Age problem. The sum of Mary and John's ages is 32. Four years ago, Mary will be twice as old as John. What are their ages now.

Work problem. A farmer can plow the field in 8 ½ days. After working for 4 days, his son joins him and together they plow the field 3 more days. How many days will it require for the son to plow the field alone?

Mixture problem. Twelve liters of 30% salt solution and 15 liters of 35% salt solution are poured into a drum originally containing 36 liters of 16% salt solution. What is the percent concentration of salt in the mixture?

Rate problem. A jogger starts a course at a steady rate of 10kph. Eight minutes later, a second jogger starts to run the same course at 12kph. How long will it take the second jogger to catch the first?

Table 1 shows the five (5) indicators based on the error categories defined by Newman (1977) were utilized. The descriptions and scoring rubric were adapted from Rohmah and Sutiarso (2017).

It should be noted that the work of Rohmah and Sutiarso (2017) is also based from the Theory of Newman (1977).

No.	Indicators	Descriptions	Score
1.	Reading Errors	Identify the problem completely	2
		Identify the problem incompletely	1
		Didn't answer/ Incorrect answer	0
2.	Comprehension Errors	Write down what is known or given value completely	2
		Write down what is known or given value incompletely	1
		Didn't answer/ Incorrect answer	0
3.	Transformation Errors	Write down the formula or mathematical model correctly	2
		Write down the mathematical model but not complete	1
		Didn't answer/ Incorrect answer	0
4.	Process Skills Errors	Using a particular procedure right and the answer is correct	2
		Using a particular procedure right but the answer is wrong	1
		Didn't answer/ Incorrect answer	0
5.	Encoding Errors	The conclusion is rendered right	2
		The conclusion is given less precise	1
		Didn't answer/ Incorrect answer	0

Table 1: Newman's error analysis indicators and scoring rubric

To ensure the questionnaire's validity, the researcher assessed the suitability of its items for pre-service mathematics teachers. The items underwent a systematic review by mathematics experts, and researchers incorporated feedback and suggestions to make necessary revisions and edits. Following this validation process, the mathematics test was developed and subsequently subjected to a pilot test. Further, the researcher utilized descriptive statistics to determine the level of the committed errors of the respondents using weighted mean and standard deviation. The scores on problem-solving tests using Newman's Error Analysis were also transmuted into the qualitative description to rate the level of problem-solving performance of the respondents by establishing the norm which includes high $(0.00 - 0.67)$, moderate $(0.68 - 1.34)$, and low level $(1.35 - 2.00)$ as shown in Table 2.

Mean Percentage Score	Interpretation
1.35-2.00	Low Level
0.68-1.34	Moderate Level
0.00-0.67	High Level

Table 2: Qualitative description of errors in solving verbal problems

RESULTS

Level of Errors of Pre-Service Mathematics Teachers in Solving Verbal Problems

Reading errors

Table 3 shows the level of reading errors of the pre-service mathematics teachers in the different verbal mathematics problems. Notably, the higher the computed mean, the lower the level of the respondents' errors in solving verbal problems. Analogously, the lower the computed mean, the higher the level of the respondent's errors in problem solving. Based on the findings, the respondents had a low level of reading errors: digit problem solving with mean $(\bar{x})$ =1.95, and standard deviation $(\sigma) = 0.23$, age problem $(\bar{x} = 1.71, \sigma = 0.46)$, work problem $(\bar{x} = 1.89, \sigma = 0.39)$, mixture problem $(\bar{x} = 1.68, \sigma = 0.62)$, and rate problem $(\bar{x} = 1.63, \sigma = 0.77)$. The overall mean of 1.77 and standard deviation of 0.27 implied that they had generally low levels of reading errors in the selected verbal problems. In other words, majority of them were able to completely identify the question being asked. This result agrees with Singh et al. (2010) that students usually commit fewer errors in the reading stage as compared to the preceding stages.

Types of Verbal Problems	Frequency				Mean $(\bar{x})$	Standard Deviation (σ)	Interpretation
	2	1	0	Total			
Digit Problem	36	2	0	38	1.95	0.23	Low Level
Age Problem	27	11	0	38	1.71	0.46	Low Level
Work Problem	35	2	1	38	1.89	0.39	Low Level
Mixture Problem	29	6	3	38	1.68	0.62	Low Level
Rate Problem	31	0	7	38	1.63	0.77	Low Level
Overall					**1.77**	**0.27**	**Low Level**

Legend: High Level (0.00-0.67), Moderate Level (0.68-1.34), Low Level (1.35-2.00)

Table 3: Level of reading errors of pre-service mathematics teachers in solving verbal problems

Comprehension errors

Table 4 presents the level of comprehension errors of the pre-service mathematics teachers in the different verbal problem solving. Based on the findings, the respondents had a low level of error in digit problem ($\bar{x} = 1.39$, $\sigma = 0.82$) while moderate level in the rest of the verbal problems: age problem ($\bar{x} = 1.13, \sigma = 0.78$), work problem ($\bar{x} = 0.71, \sigma = 0.90$), mixture problem ($\bar{x} = 1.08, \sigma = 0.78$), and rate problem ($\bar{x} = 0.76, \sigma = 0.82$). In general, the respondents had moderate levels of comprehension errors in verbal mathematics problems as implied by the overall mean of 1.02 and standard deviation of 0.61. However, the study of Hijada and Dela Cruz (2022) yielded a contradicting result, illustrating that comprehension of students do not predict their performance in solving verbal problems. On the other hand, the findings of Kurshumlia and Vula (2019) were consistent with the results of the current study, which infers that comprehension has a positive influence on the enhancement of verbal mathematics problem-solving skills.

Types of Verbal Problems	**Frequency**				$\bar{x}$	σ	**Interpretation**
	2	**1**	**0**	**Total**			
Digit Problem	23	7	8	38	1.39	0.82	Low Level
Age Problem	14	15	9	38	1.13	0.78	Moderate Level
Work Problem	11	5	22	38	0.71	0.90	Moderate Level
Mixture Problem	13	15	10	38	1.08	0.78	Moderate Level
Rate Problem	9	11	18	38	0.76	0.82	Moderate Level
Overall					**1.02**	**0.61**	**Moderate Level**

Legend: High Level (0.00-0.67), Moderate Level (0.68-1.34), Low Level (1.35-2.00)

Table 4: Level of comprehension errors of pre-service mathematics teachers in solving verbal problems

Transformation errors

Table 5 shows the level of transformation errors committed by pre-service mathematics teachers in the given verbal problems. Results revealed that the respondents had a low level of transformation errors in digit problem ($\bar{x} = 1.71, \sigma = 0.61$), whereas they had a moderate level of comprehension error in age problem ($\bar{x} = 1.03, \sigma = 0.82$), work problem ($\bar{x} = 0.87, \sigma = 0.94$), mixture problem ($\bar{x} = 0.97, \sigma = 0.92$), and rate problem ($\bar{x} = 0.76, \sigma = 0.94$). In general, the respondents had moderate levels of transformation errors in verbal math problems as implied by the overall mean of 1.07 and standard deviation of 0.52. Similar to the findings of Singh et al. (2010), transformation errors among students are also at moderate levels and one of the stages where students are more likely to commit errors.

Types of Verbal Problems	Frequency				$\bar{x}$	σ	Interpretation
	2	1	0	Total			
Digit Problem	30	5	3	38	1.71	0.61	Low Level
Age Problem	13	13	12	38	1.03	0.82	Moderate Level
Work Problem	14	5	19	38	0.87	0.94	Moderate Level
Mixture Problem	15	7	16	38	0.97	0.92	Moderate Level
Rate Problem	13	3	22	38	0.76	0.94	Moderate Level
Overall					**1.07**	**0.53**	**Moderate Level**

Legend: High Level (0.00-0.67), Moderate Level (0.68-1.34), Low Level (1.35-2.00)

Table 5: Level of transformation errors of pre-service mathematics teachers in solving verbal problems

Process skills errors

Table 6 shows the level of process skills errors of pre-service teachers in the different verbal problem solving. The respondents had a low level of process skills errors in digit problem ($\bar{x} = 1.50, \sigma = 0.73$) and age problem ($\bar{x} = 1.39, \sigma = 0.79$). The least of the respondents had a high level of process skills errors in work problem ($\bar{x} = 0.61, \sigma = 0.82$) while several of them had a moderate level of said errors in mixture problem ($\bar{x} = 1.03, \sigma = 0.85$) and rate problem ($\bar{x} = 0.79, \sigma = 0.99$). The overall mean of 1.06 and standard deviation of 0.57 implied that the respondents had a moderate level of process skills errors. This is a consequence of not being able to transform the problem into correct mathematical equation. Zamzam and Alfiana (2017) revealed that students often commit errors in the stage of process skills due to forgetting the next step that they have to undertake, which further results in difficulty in the completion of problem solving.

Types of Verbal Problems	Frequency				$\bar{x}$	σ	Interpretation
	2	1	0	Total			
Digit Problem	24	9	5	38	1.50	0.73	Low Level
Age Problem	22	9	7	38	1.39	0.79	Low Level
Work Problem	8	7	23	38	0.61	0.82	High Level
Mixture Problem	14	11	13	38	1.03	0.85	Moderate Level
Rate Problem	15	0	23	38	0.79	0.99	Moderate Level
Overall					**1.06**	**0.57**	**Moderate Level**

Legend: High Level (0.00-0.67), Moderate Level (0.68-1.34), Low Level (1.35-2.00)

Table 6: Level of process skills errors of pre-service mathematics teachers in solving verbal problems

Encoding errors

Table 7 presented the level of encoding errors of the pre-service mathematics teachers in the different verbal problems provided. Findings showed that the respondents had low levels of encoding errors in digit problem ($\bar{x} = 1.39, \sigma = 0.92$) and age problem ($\bar{x} = 1.63, \sigma = 0.71$). Few of them had a high level of said error in work problem ($\bar{x} = 0.61, \sigma = 0.89$) and rate problem ($\bar{x} = 0.63, \sigma = 0.85$). Some of the respondents had moderate levels of such error in mixture problem ($\bar{x} = 1.03, \sigma = 0.82$). In general, respondents had moderate levels of encoding errors with an overall mean of 1.06 and a standard deviation of 0.54 in the provided verbal math problems. Moreover, Rohmah and Sutiarso (2018) revealed in a similar study that 19.57% of respondents are more likely to commit encoding errors.

Types of Verbal Problems	Frequency				$\bar{x}$	σ	Interpretation
	2	1	0	Total			
Digit Problem	26	1	11	38	1.39	0.92	Low Level
Age Problem	29	4	5	38	1.63	0.71	Low Level
Work Problem	10	3	25	38	0.61	0.89	High Level
Mixture Problem	13	13	12	38	1.03	0.82	Moderate Level
Rate Problem	9	6	23	38	0.63	0.85	High Level
Overall					**1.06**	**0.54**	**Moderate Level**

Legend: High Level (0.00-0.67), Moderate Level (0.68-1.34), Low Level (1.35-2.00)

Table 7: Level of encoding errors of pre-service mathematics teachers in solving verbal problems

Overall errors

Table 8 shows the overall findings, there was a low level of reading errors committed by the pre-service teachers, which infers their ability to accurately read and identify what is being asked in mathematical verbal problems. However, the errors committed in the preceding stages manifested moderate levels. For comprehension errors, a moderate level was revealed but entails the lowest mean. As a result, PSMTs are more likely to struggle with identifying the supplied values in verbal problems, which they can work on further by understanding the problem again. Meanwhile, there was a moderate level of mistake in the transformation stage, indicating that students did not select the correct operation and equation while answering problems. Moving on, there was also a moderate level of process skill errors committed by the respondents, indicating that some students struggled with appropriately employing the specified equations. Lastly, the researcher concluded that there was a moderate level of encoding errors, which infer that even though pre-service teachers were able to complete the process, their interpretation of the result was inaccurate. In general, the pre-service math teachers committed a moderate level of errors implying that they have gaps in their mathematical knowledge or understanding of concepts, and not developed effective problem-solving strategies.

Indicators	$\bar{x}$	σ	Interpretation
Reading Error	1.77	0.27	Low Level
Comprehension Error	1.02	0.61	Moderate Level
Transformation Error	1.07	0.53	Moderate Level
Process Skills Error	1.06	0.57	Moderate Level
Encoding Error	1.06	0.54	Moderate Level
Overall	**1.20**	**0.32**	**Moderate Level**

Legend: High Level (0.00-0.67), Moderate Level (0.68-1.34), Low Level (1.35-2.00)

Table 8: Overall errors of pre-service mathematics teachers in solving verbal problems

DISCUSSION

Reading errors

Common reading errors committed by the respondents were incomplete identification of the problem where the respondents failed to fully grasp or understand the main question or task presented in the reading material. Among the errors are misspelled words, which disrupt the flow of reading and cause confusion, making it harder for respondents to comprehend the content accurately. As a result, their responses or answers to the questions may be incorrect or insufficient.

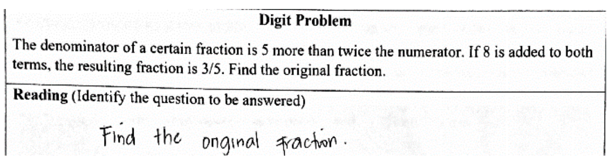
Specifically in the given digit problem, findings revealed that 36 (or 95%) of the pre-service teachers did not commit any reading error and almost were able to identify the question to be answered completely, and two of them (or 5%) only scored 1 which means they were able to identify the question to be answered incompletely. The digit problem states that “The denominator of a certain fraction is 5 more than twice the numerator. If 8 is added to both terms, the resulting fraction is 3/5. Find the original fraction”. As seen in the sample answer in Figure 1.1, Respondent 17 understood that the problem is asking to find the original fraction. Hence, a score of 2 was provided since the respondent was able to identify the question to be answered completely. Meanwhile, Respondent 25 encountered difficulty articulating the question as he/she forgot the crucial term "original." Consequently, he/she only received a score of 1 due to this oversight.

In the given age problem, 27 (or 71%) of them were able to identify the question being asked completely while 11 (or 29%) of them were not. The age problem goes, “The sum of Mary and John’s ages is 32. Four years ago, Mary will be twice as old as John. What are their ages now?”. In the sample answer (Figure 1.2), Respondent 9 was able to completely identify the question being asked, “What are the present ages of Mary and John” which was deemed to be a complete statement of the question being asked since the subjects and the timeline being referred to were specified. Hence, a score of 2 was provided to the respondent. On the other hand, Respondent 34 was not able to completely identify the question to be answered. In the same figure, Respondent 34 repeated exactly what was stated in the problem therefore a score of 1 was given. This is deemed incomplete as the answer did not specify whose ages were being asked unlike the answer provided by Respondent 9.

In the work problem, 35 (or 92%) of the respondents scored 2 or were able to completely identify the question being asked; two of them (or 5%) scored 1 or incompletely identified the question being asked; while one (or 3%) scored 0 or did not answer. Respondent 22 was able to identify entirely the question being asked and hence was provided a score of 2. On the other hand, as seen in Figure 1.3, Respondent 8 failed to clearly indicate that the question pertained specifically to "how many days it will require for the son to plow the field alone," rather than addressing the general timeframe for plowing the field. This lack of precision led to a score of 1 being assigned.

In the mixture problem, 29 (or 76%) of them had completely identified the question being asked; six (or 15%) were not; and three (or 8%) of them did not answer. As seen in the sample in Figure 1.4, Respondent 21 was able to completely identify the question, hence was provided a score of 2 while Respondent 13 had written a wrong word in his answer, writing "present" rather than "percent" which is why the respondent had been provided a score of 1 only. Finally, in a rate problem, findings showed that 31 (or 82%) of the respondents had specified the question completely while seven (or 18%) of them did not answer. As seen in Figure 1.5, Respondent 20 was able to identify the question completely and hence was provided a score of 2.

(1.1) *Digit Problem*



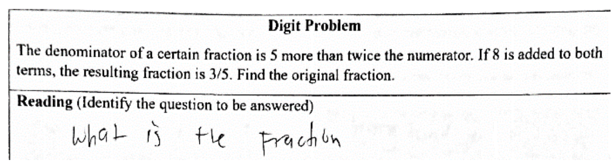
Digit Problem

The denominator of a certain fraction is 5 more than twice the numerator. If 8 is added to both terms, the resulting fraction is 3/5. Find the original fraction.

Reading (Identify the question to be answered)

Find the original fraction.

Respondent 17



Digit Problem

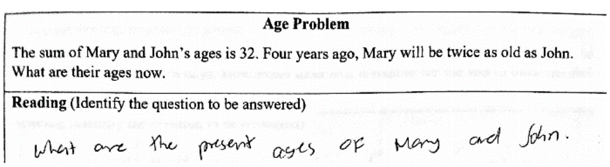
The denominator of a certain fraction is 5 more than twice the numerator. If 8 is added to both terms, the resulting fraction is 3/5. Find the original fraction.

Reading (Identify the question to be answered)

What is the fraction

Respondent 25

(1.2) *Age Problem*



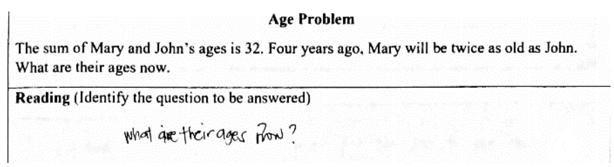
Age Problem

The sum of Mary and John's ages is 32. Four years ago, Mary will be twice as old as John. What are their ages now.

Reading (Identify the question to be answered)

What are the present ages of Mary and John.

Respondent 9



Age Problem

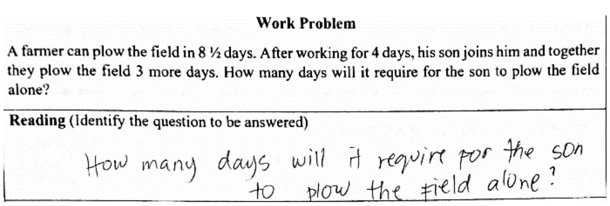
The sum of Mary and John's ages is 32. Four years ago, Mary will be twice as old as John. What are their ages now.

Reading (Identify the question to be answered)

What are their ages now?

Respondent 34

(1.3) *Work Problem*



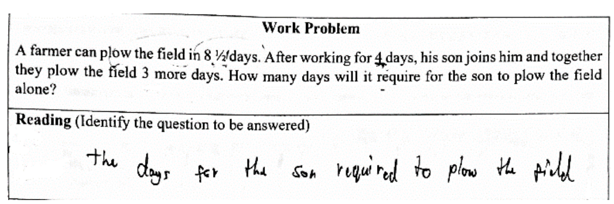
Work Problem

A farmer can plow the field in 8 ½ days. After working for 4 days, his son joins him and together they plow the field 3 more days. How many days will it require for the son to plow the field alone?

Reading (Identify the question to be answered)

How many days will it require for the son to plow the field alone?

Respondent 22



Work Problem

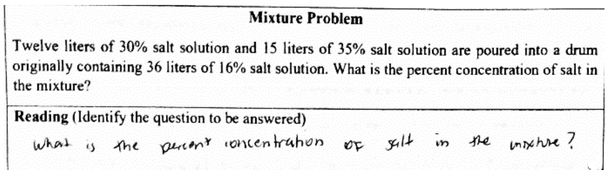
A farmer can plow the field in 8 ½ days. After working for 4 days, his son joins him and together they plow the field 3 more days. How many days will it require for the son to plow the field alone?

Reading (Identify the question to be answered)

the days for the son required to plow the field

Respondent 8

(1.4) *Mixture Problem*



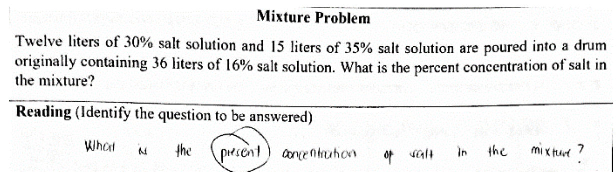
Mixture Problem

Twelve liters of 30% salt solution and 15 liters of 35% salt solution are poured into a drum originally containing 36 liters of 16% salt solution. What is the percent concentration of salt in the mixture?

Reading (Identify the question to be answered)

what is the percent concentration of salt in the mixture?

Respondent 21



Mixture Problem

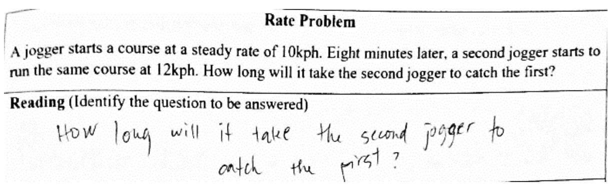
Twelve liters of 30% salt solution and 15 liters of 35% salt solution are poured into a drum originally containing 36 liters of 16% salt solution. What is the percent concentration of salt in the mixture?

Reading (Identify the question to be answered)

What is the percent concentration of salt in the mixture?

Respondent 13

(1.5) *Rate Problem*



Rate Problem

A jogger starts a course at a steady rate of 10kph. Eight minutes later, a second jogger starts to run the same course at 12kph. How long will it take the second jogger to catch the first?

Reading (Identify the question to be answered)

How long will it take the second jogger to catch the first?

Respondent 20

Figure 1: Reading errors in solving verbal problems – sample of correct and incorrect answers

Comprehension errors

The respondents found digit problem easier to comprehend than the rest of the problems. It should be noted that eight (or 21%) did not attempt to answer what the given are in the posted digit problem, and more than half (22 or 58%) did not attempt to determine the given in the posted work problem. A common comprehension error committed by the respondents was incompletely identifying the given values in the problems.

Specifically, 23 (or 61%) of the respondents did not commit any comprehension error in the digit problem while seven (or 18%) of them did, and another eight (or 21%) of them did not answer. Shown in Figure 2.1 is a sample of the answers provided by selected respondents. Respondent 4 was able to write down the given value completely and correctly, while Respondent 2 wrote down the given incompletely. The said respondent only wrote down the denominator and the numerator but failed to include the details about the sum of the provided values. Hence, Respondent 4 scored 2 while Respondent 2 scored 1.

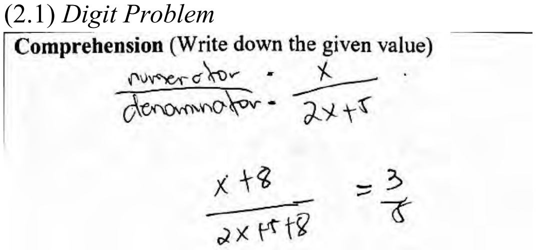
In the given age problem, 14 (or 37%) of the respondents did not commit any comprehension error, 15 (or 39%) of them did not completely write down the given value, while nine (or 24%) of them did not answer. In Figure 2.2, Respondent 10 was able to write down the given value completely and correctly. Individual ages of Mary and John, including both of their ages, were written down. On the other hand, Respondent 19 fell short of identifying the given value resulting an incomplete answer.

In the given work problem, 11 (or 29%) of the respondents had committed no comprehension error, five (or 13%) failed to completely write down the given, whereas 22 (or 58%) did not answer. As shown in Figure 2.3, Respondent 8 completely identified the given values, hence was provided a score of 2 while Respondent 3 failed to do so, hence was provided a score of only 1.

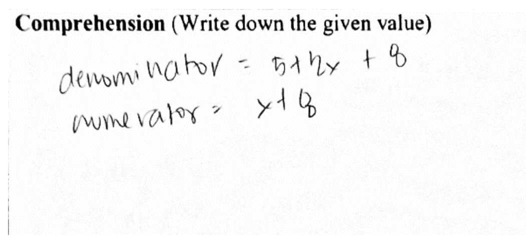
In the given mixture problem, 13 (or 34%) of the respondents were able to completely identify the given values, 15 (or 40%) of them failed to do so, while 10 (or 26%) of them had incorrect answers and did not answer. As presented in Figure 2.4, Respondent 2 completely and correctly identified the given values, while Respondent 11 inaccurately represented the given values, led him/her score marked as 0.

In the given rate problem, nine (or 24%) of the respondents did not commit any comprehension error, 11 (or 29%) of them incompletely identified the given values, while 18 (or 47%) did not answer. As seen in Figure 2.5, Respondent 16 completely and correctly specified the given whereas Respondent 24 failed to specify which jogger covered the indicated distance.

(2.1) *Digit Problem*

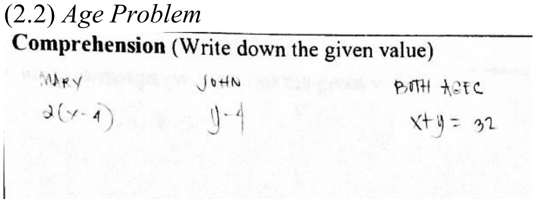


Respondent 4

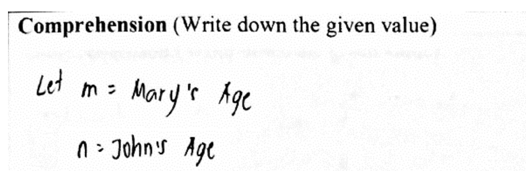


Respondent 2

(2.2) *Age Problem*

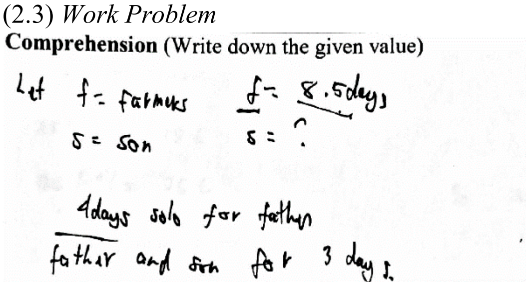


Respondent 10

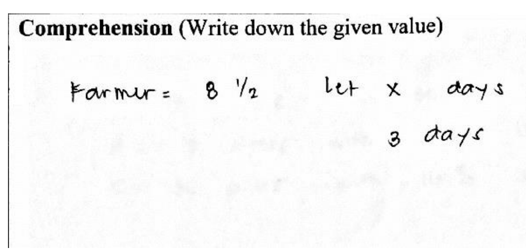


Respondent 19

(2.3) *Work Problem*

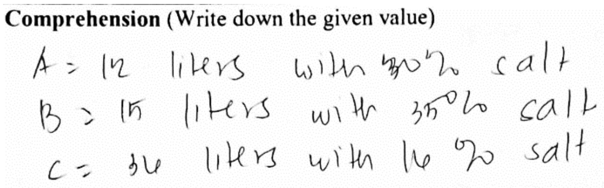


Respondent 8

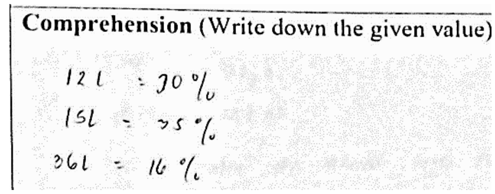


Respondent 3

(2.4) *Mixture Problem*

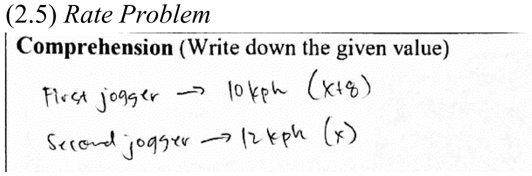


Respondent 2

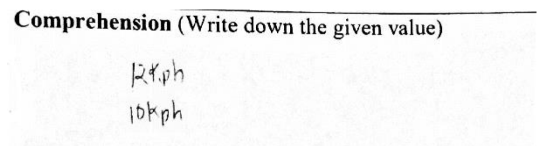


Respondent 11

(2.5) *Rate Problem*



Respondent 16



Respondent 24

Figure 2: Comprehension errors in solving verbal problems – sample of correct and incorrect answers

Transformation errors

The respondents found digit problem easier than the other problems. However, it is concerning that almost half of respondents did not write the mathematical equation properly specifically in rate problem. It should be noted that only three (or 8%) did not attempt to answer what is the corresponding mathematical equation of the digit problem, but in the given rate problem more than half (22 or 58%) did not attempt to determine what is the corresponding mathematical equation. A common transformation error committed by the respondents was incompletely and inaccurate transcription of mathematical equations, a noteworthy challenge in maintaining precision during problem-solving.

Specifically, 30 (or 79%) of the respondents had committed no transformation errors in the digit problem, five (or 13%) of them failed to do so, while three (or 8%) of them did not answer. As shown in Figure 3.1, Respondent 17 demonstrated proficiency by successfully identifying the formula and constructing the model or equation as required. In contrast, Respondent 35 encountered challenges in accurately translating the problem into its corresponding mathematical equation, resulting in an incorrect representation. Hence, receive a score of 0.

In the given age problem, 13 (or 34%) of the respondents did not commit any transformation error, 13 (or 34%) of them were not able to completely identify the formula and equation, while 12 (or 32%) of them did not attempt to answer or had incorrect mathematical equations. As presented in the sample answers in Figure 3.2, Respondent 28 successfully identified and accurately construct a model or equation, along with correctly articulating the relevant formula. Conversely, Respondent 26 faced a limitation as he/she failed to provide the complete formula, resulting in a score of 0.

In the given work problem, 14 (or 37%) had no transformation errors, five (or 13%) had some while 19 (or 50%) of them either did not write an answer (14 of 19) or had incorrect equations. As gleaned in the sample answers in Figure 3.3, Respondent 32 was able to write down the model or equation completely and correctly while Respondent 30 had incorrect construction of the equation.

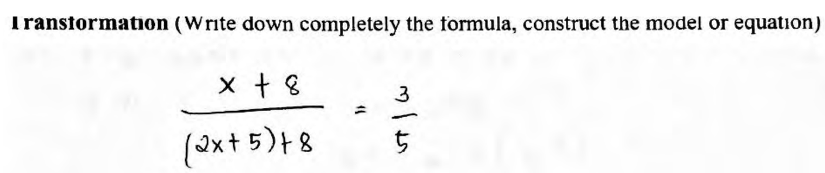
The answer of Respondent 30 suggests that he/she did not understand that the addend "$3\left(\frac{1}{8\ 1/2}\right)$" means that the farmer having the ability to finish one task alone in $8\frac{1}{2}$ days only worked for 3 days alone.

In the given mixture problem, 15 (or 40%) of the respondents did not commit any transformation error; seven (or 18%) had some errors; while 16 (or 42%) of them did not answer or had incorrect answers. Sample answers as shown in Figure 3.4, revealed that Respondent 12 was able to write down the equation and model completely and correctly, whereas Respondent 25 failed to do so. Some respondents similar to Respondent 25's answer did not define what variable x represents. In Respondent 25's answer, the equation "$(12)(30\%) + 15(35)\% + 36(16\%) = x$" suggests that x represents the amount of salt in the mixture. However, what the problem ask is the percent concentration of salt in the mixture. Another notable concern is the use of the symbol $\times$ for multiplication in the answer of Respondent 30. In his/her answer, "$[(.30 \times 12) + (.35 \times 15) + (.16 \times 36)] = x$" the symbol $\times$ may cause vagueness and misunderstanding since the variable x is also used in the equation.

Finally, 13 (or 34%) of the respondents committed no transformation error in the given rate problem, three (or 8%) had committed some, while 22 (or 58%) had incorrect answers or did not write any answer. In the presented sample answers in Figure 3.5, Respondent 13 was able to simply and correctly present the answer whereas Respondent 27 had written incorrect formulas and mathematical equations, hence had been scored 0.

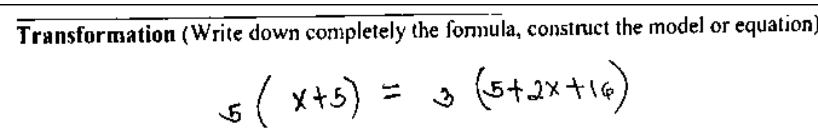
(3.1)

Digit Problem


Transformation (Write down completely the formula, construct the model or equation)

$\frac{x + 8}{(2x+5)+8} = \frac{3}{5}$

Respondent 17

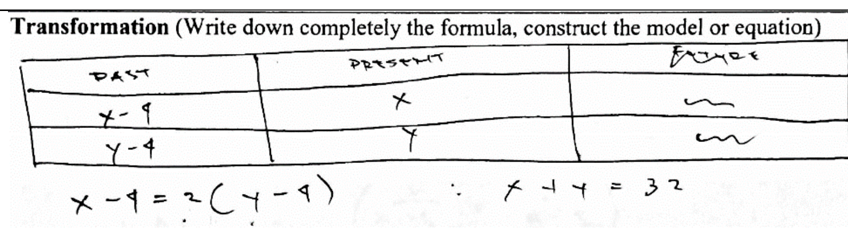

Transformation (Write down completely the formula, construct the model or equation)

$5(x+5) = 3(5+2x+16)$

Respondent 35

(3.2)

Age Problem


Transformation (Write down completely the formula, construct the model or equation)

PAST	PRESENT	FUTURE
x - 4	x	~
y - 4	y	~

$x - 4 = 2(y - 4)$ ∴ $x + y = 32$

Respondent 28

Respondent 26

Transformation (Write down completely the formula, construct the model or equation)

Past	Present	~~Future~~
x-4	x	Mary
y-4	y	John

(3.3)

Work Problem

Respondent 32

Transformation (Write down completely the formula, construct the model or equation)

$$4\left(\frac{1}{8.5}\right)+\left[3\left(\frac{1}{x}\right)+3\left(\frac{1}{8.5}\right)\right]=1$$

Respondent 30

Transformation (Write down completely the formula, construct the model or equation)

$$3\left(\frac{1}{8\frac{1}{2}}\right)+3\left(\frac{1}{x}+\frac{1}{8\frac{1}{2}}\right)=1$$

$$3\left(\frac{1}{17/2}\right)+3\left(\frac{1}{x}+\frac{1}{17/2}\right)=1$$

$$3\left(3/17\right)+3/x+\left(4/17\right)=1$$

(3.4)

Mixture Problem

Respondent 12

Transformation (Write down completely the formula, construct the model or equation)

$$12(0.3)+15(0.35)+36(0.16)=63(x)$$

Respondent 25

Transformation (Write down completely the formula, construct the model or equation)

~~(12+30%+15~~

$$12(30\%)+15(35\%)+36(16\%)=X$$

$$3.6+5.25+5.76=X$$

$$X=14.61$$

Respondent 30

Transformation (Write down completely the formula, construct the model or equation)

$$12+15+36=x$$

$$[(.30\times12)+(.35\times15)+(.16\times36)]=x$$

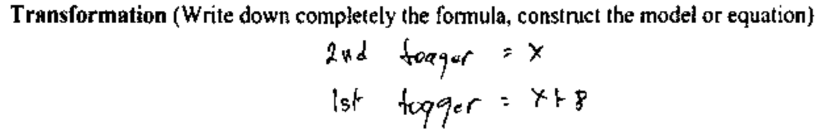
(3.5)

Respondent 13

Transformation (Write down completely the formula, construct the model or equation)

$$(x+8)(10)=(12)(x)$$

Rate Problem



Respondent 27

Figure 3: Transformation errors in solving verbal problems – sample of correct and incorrect answers

Process skills errors

The respondents found digit problem easier to comprehend than the rest of the problems. It should be noted that five (or 13%) did not attempt to answer or had incorrect procedures regarding the given digit problem, and more than half (23 or 61%) did not attempt or have incorrect answers in the posted work and rate problem. A common process skills error committed by the respondents was incorrect process leading to incorrect answers in the given problems.

Specifically, in the given digit problem, 24 (or 63%) had committed no process skills errors; nine (or 24%) had some; while five (or 13%) did not answer or had incorrectly used a procedure. As presented in Figure 4.1, Respondent 12 had correctly evaluated the provided problem, arriving at the correct answer, hence had scored 2 while Respondent 24 used the wrong evaluation process, arriving at incorrect answer, hence had scored 0.

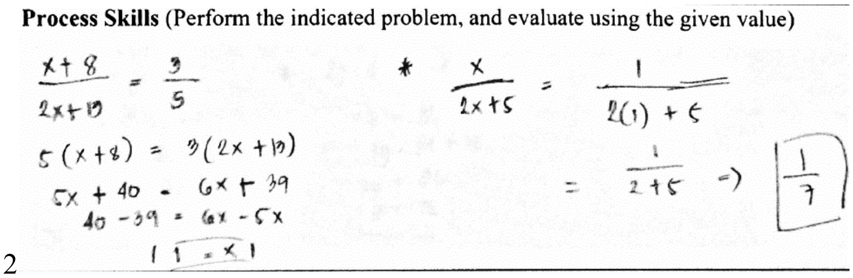
In the given age problem, 22 (or 58%) did not commit any process skills errors; nine (or 24%) had committed some; whereas seven (or 18%) incorrectly used a process or did not answer. As seen in the sample answers in Figure 4.2, Respondent 32 had followed the process leading to correct answer whereas Respondent 5 had an incomplete process but arrived at the same correct answer. As seen in the figure, he/she did not write the proper cancellation of the constant on variable "j" which is dividing both sides by 3 to determine the value of the variable.

In the given work problem, eight (or 21%) scored perfect or had committed no process skills errors; seven (or 18%) only scored 1 while 23 (or 61%) did not answer or had written the wrong answer. As shown in the sample answer in Figure 4.3, Respondent 17 had correctly and completely evaluated the problem, thus scored 2 while Respondent 25 had performed with unfinished solution leading him/her to not determine the value of "x".

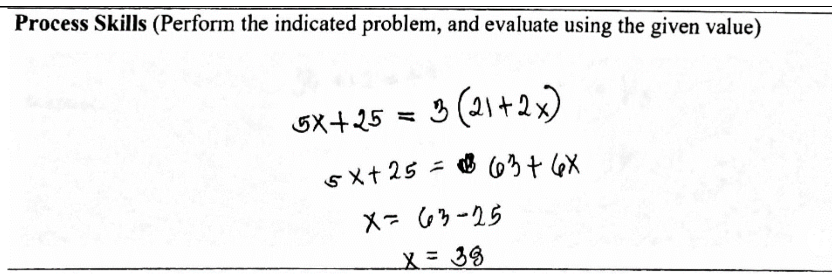
In the given mixture problem, 14 (or 37%) had correctly used a procedure, and thus were scored 2; 11 (or 29%) had incompletely employed a process; whereas another 13 (or 34%) did not answer or had incorrectly used a process. As apparent from the sample answer in Figure 4.4, Respondent 22 had a simple yet complete procedure with a correct answer. Respondent 24 on the other hand, had failed to convert his answer to percentage which was what is asked in the provided problem. Hence, the respondent scored 1 only.

Finally, in the given rate problem, 15 (or 39%) had committed no process skills errors while 23 (or 61%) of them had either answered incorrectly or gave a blank answer. In Figure 4.5, Respondent 5 have correct process and answer. The rest of the respondents did not answer.

(4.1)
Digit Problem

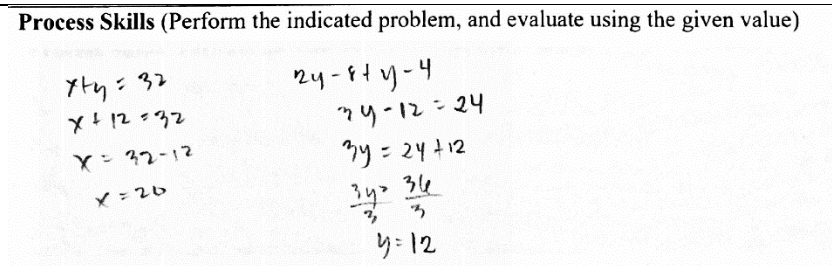


Respondent 12

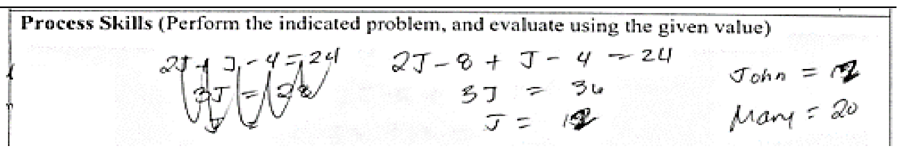


Respondent 24

(4.2)
Age Problem

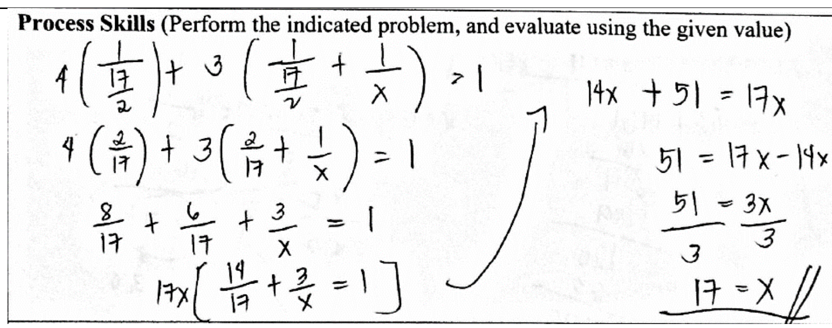


Respondent 32

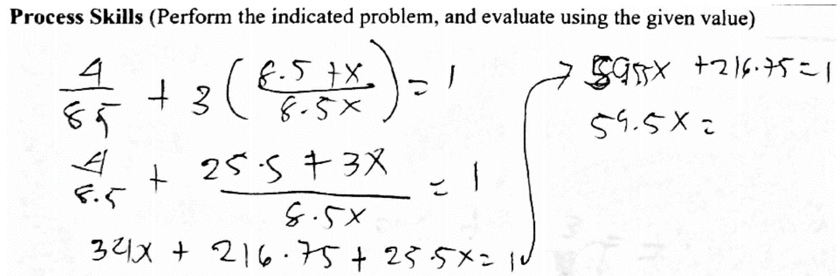


Respondent 5

(4.3)
Work Problem

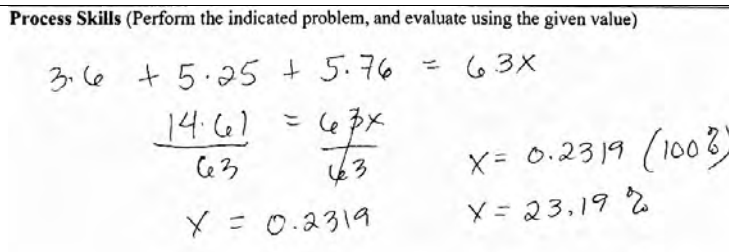


Respondent 17

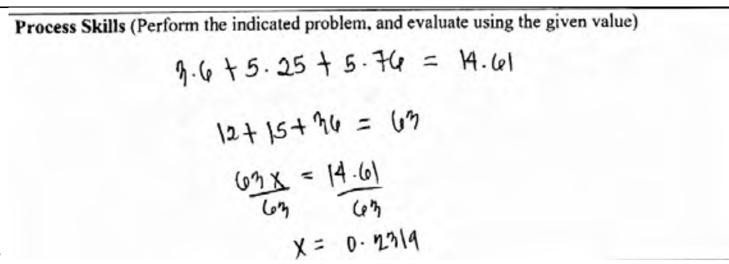


Respondent 25

(4.4)
Mixture Problem

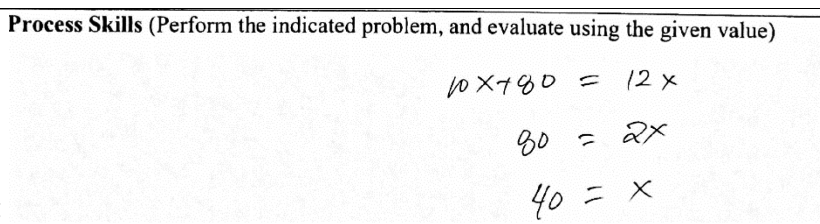


Respondent 22



Respondent 24

(4.5)
Rate Problem



Respondent 5

Figure 4: Process skills errors in solving verbal problems – sample of correct and incorrect answers

Encoding errors

The respondents found age problem easier than the rest of the problems. It should be noted that five (or 13%) had incorrectly provided a conclusion or failed to write any answer, and more than half (25 or 66%) of them had either provided incorrect conclusions or did not answer in the posted work problem. Common encoding errors committed by the respondents were incorrect grammar and failure to convert the answer which lead them to incorrect answers.

To be more specific, 26 (or 68%) of the respondents had committed no encoding errors in digit problem while one (or 3%) of them committed some, and 11 (29%) of them had either incorrectly provided a conclusion or did not answer. As shown in Figure 5.1, Respondent 5 had drawn a precise conclusion. The rest of the respondents did not.

In the given age problem, 29 (or 76%) did not commit any encoding error while four (or 11%) of them had committed some and another five (or 13%) had incorrectly provided a conclusion or failed to write any answer. As presented in Figure 5.2, Respondent 9 had precisely drawn a conclusion, hence was scored 2 whereas Respondent 6 arrived at a wrong answer hence, arrived at a wrong conclusion therefore was scored 0.

In the given work problem, 10 (or 26%) scored perfect or had not committed any encoding error; three (or 8%) committee some; whereas 25 (or 66%) of them had either provided incorrect conclusion or did not answer. As seen in the sample answer in Figure 5.3, Respondent 17 wrote down a precise conclusion while Respondent 35 had a wrong answer which is why the conclusion drawn was also incorrect.

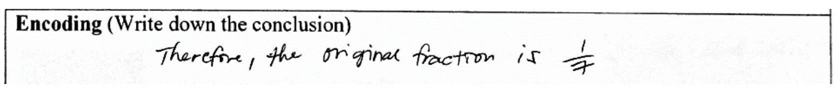
In the given mixture problem, 13 (or 34%) of them committed no encoding errors; 13 (or 34%) failed to do so; while 12 (or 32%) did not answer or had incorrectly written conclusion. As shown in the sample answer in Figure 5.4, Respondent 8 drew a precise conclusion whereas Respondent 14 had drawn otherwise.

Finally, in the given rate problem, nine (or 24%) provided a concise conclusion; six (or 15%) provided a less precise conclusion while 23 (or 61%) failed to provide a conclusion. As presented in Figure 5.5, Respondent 10 had a precise conclusion while Respondent 19 had a less precise conclusion. Said respondent had provided the correct answer but the grammar was slightly incorrect which is why a score of 1 was provided.

(5.1)

Digit Problem

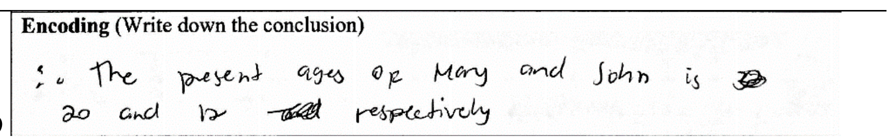
Respondent 5



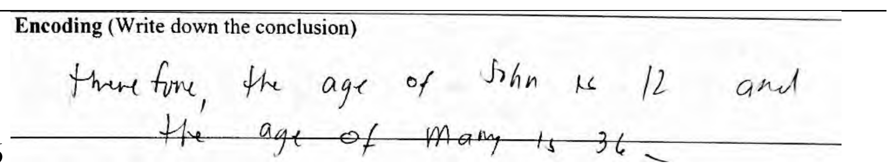
(5.2)

Age Problem

Respondent 9



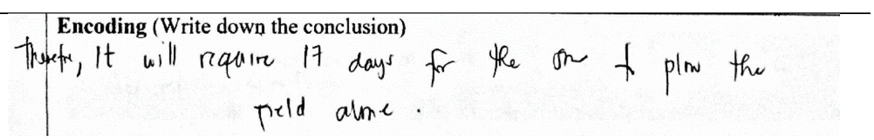
Respondent 6



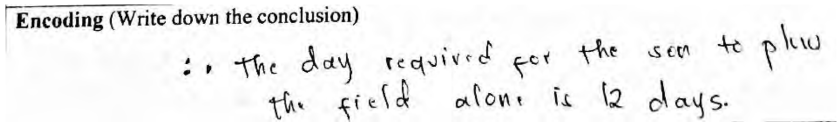
(5.3)

Work Problem

Respondent 17

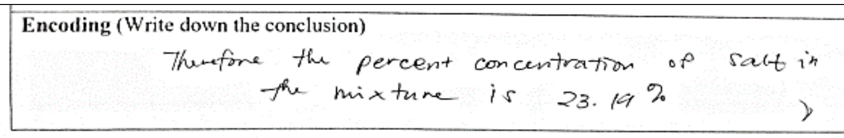


Respondent 35

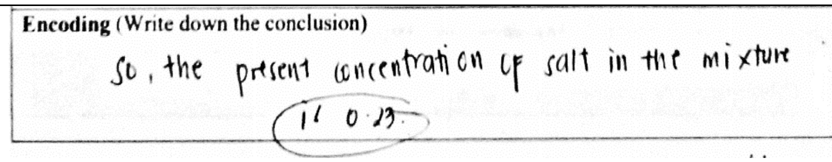

Encoding (Write down the conclusion)
∴ The day required for the son to plow the field alone is 12 days.

(5.4) *Mixture Problem*

Respondent 8

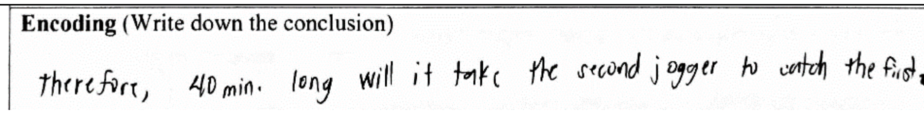

Encoding (Write down the conclusion)
Therefore the percent concentration of salt in the mixture is 23.19%

Respondent 14


Encoding (Write down the conclusion)
So, the present concentration of salt in the mixture is 0.23.

(5.5) *Rate Problem*

Respondent 10


Encoding (Write down the conclusion)
therefore, 40 min. long will it take the second jogger to catch the first.

Respondent 19

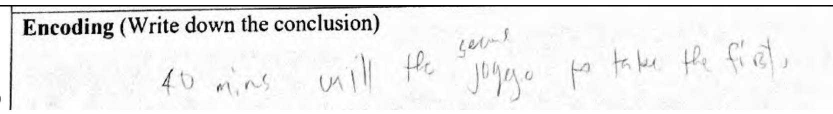

Encoding (Write down the conclusion)
40 mins will the second joggo to take the first,

Figure 5: Encoding errors in solving verbal problems – sample of correct and incorrect answers

Factors of error in solving verbal problems

Through the analysis of the answer sheet of the respondents, factors that resulted in the committed errors in solving verbal problems were revealed. First, incomplete answers and solutions were present in all stages, implying that it is a prominent factor that causes errors in verbal problem solving. According to Dofková and Surá (2021), complete and accurate solutions increase the likelihood of getting the right answers, but students are more likely to doubt their solutions and delete or struggle to finish. Thus, students' cognitive processes made them skeptical, which prevented them from addressing the problem.

Misspelling was a prominent error in the reading stage. Capone et al. (2021) found that several respondents miswrote and misspelled words and figures, causing errors in subsequent stages. Lopez (2004) found that students' mathematical problem-solving thoughts can alter their spelling. Due to erroneous values and words in the first stage, the remaining procedures will be inaccurate, independent of tool use.

Another cause of errors was poor grammar, especially while encoding. Considering that the given problems were in English language, the respondents can be deemed susceptible to error considering that the Philippines is slipping in its rank in terms of English proficiency, indicating a declining performance (Suelto, 2012). However, the education system in the country is implementing mother tongue-based multilingual education, especially in early education, because it is proven that a good mother tongue foundation can result to strong literacy abilities (Bernardo et al., 2012). Thus, the pursuit of enhancing literacy abilities among Filipino students have been implemented. In line with the findings, Guce (2017) found that while formulas and equations are crucial to mathematical work, ordinary grammatical norms also apply. Along with subject-verb agreement, mistaking a phrase for a sentence is a common grammar error. An inaccuracy in grammar might change meaning, causing errors.

In the transformation stage, incorrect construction of formulas or equations was most evident. Winarso and Toheri (2021) found that students can misidentify the right theorem or tool and be inconsistent with their equation. Thus, this evidence suggests that pre-service teachers build formulas or equations incorrectly, which causes errors, especially during the transformation stage, when these formulas are critical to solving the problem.

Similarly, there was also a problem with the incorrect process, especially in the process skills stage. According to Gurat (2018), student teachers can also be challenged in undertaking proper procedures for problem solving. Thus, this data may infer that pre-service teachers commit incorrect construction of formula or equation that leads to error, especially in the transformation stage where these formulas are crucial to be used accurately to arrive at the accurate answer.

Additionally, other errors involve the usage of wrong solution, but arriving at the correct answer. Such phenomenon has been explored by Tong and Loc (2017) that the solutions used by students for their chosen operations are incorrect, but they arrive at to correct answer, which they perceived to be more important. This data may infer that students have their own strategy, which focuses on getting the accurate answer rather than undertaking the right process or right solution. However, it can also be inferred that even though the given answers were correct, but the solution was incorrect, it can be suspected that logical thinking and conceptual understanding of students are still in need to be further developed (Kholid et al., 2021).

Meanwhile, process skills and encoding stage entail another prominent factor resulting in error, which was the failure to convert the answer. As cited in the study of Chizeck et al. (2009), students can commit mistakes in failing to convert their answers, especially on the measurement unit of their answers. This data may infer that arriving to the right answer also involves the proper conversion that is suitable to the context of the problem. Essentially, students may utilize the Polya four-step problem-solving process that demands the problem to be thoroughly understood, developing a plan through working with an equation, implementing the plan, and to look back with the problem to validate the answer (Airth & Boddie, 2019).

Finally, failing to answer or not answering was shown in all stages. In the study of Carson (2007), found that students get trapped in problem-solving stages, leading to hopelessness and failure. It also involves gaps between theory and practice, where learning mathematical theories is distinct from using them to solve problems. Since respondents failed to answer or provide a response, this element challenges their knowledge and skills.

CONCLUSIONS

This study focused on the error analysis of pre-service mathematics teachers' verbal problem solving using the Newman's Error Analysis, which included five stages. The data analysis demonstrated that the respondents made few errors during the first stage of problem solving, which was the reading stage. However, moderate level of errors, which were also shown in the latter stages, such as process skills and encoding stages. As a result, it can be concluded that respondents are more likely to make mistakes throughout the process of performing the appropriate operation for the problem and then interpreting the outcome of the computation. In line with this, a deeper understanding of the mathematical concepts and operations is necessary as well as the ability to have a grasp on the context of the problem in pursuit of an accurate interpretation of the result.

As a result, the researcher suggests that academe and instructors in tertiary level further strengthen their focus on lessons on the proper utility of operations, equations, and interpretation of results in solving verbal problems by thoughtful teaching strategies and active learning approaches. Because they are the final steps of the problem-solving process, it is crucial that they lessen errors because previous answer may have been ineffective. Furthermore, educators should encourage critical thinking, encourage active participation in the subject, and provide opportunities for application and practice. Encouraging students to ask questions, seek clarification, and explore topics in-depth can enhance their understanding and fill in the gaps in their knowledge.

Also, educators should develop and implement classroom activities that enable pre-service mathematics teachers to highly understand the construction and usage of the mathematical equations, especially the processes they entail. The use of various and relevant examples to demonstrate the practical applications of the concepts that help them for more complete understanding is also beneficial to the students. Additionally, pre-service teachers may work on their knowledge and skills in terms of mastering the operations, and equations and interpreting the results of the verbal problems they intend to solve.

Lastly, the researcher suggests conducting a refresher program among graduating pre-service mathematics teachers, which can serve as an assessment regarding their knowledge and skills, especially in verbal problem solving, and assistance in preparation for their board exam. This program can focus on pre-service mathematics teachers who took their course during the pandemic considering that there can be lapses in their understanding and lesson retention. These lapses can be caused by the fact that online learning during the pandemic was conducted in their respective houses, which is not a suitable learning environment. The problems and procedures in this study can be adapted for this program.

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