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Mathematical Literacy Profile of Vocational High School Pharmacy Students in Solving Drug Dosage Calculation Problems

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ABSTRACT

The purpose of this study is to portray the mathematical literacy profile of pharmacy students in vocational high schools based on the solving of drug dosage calculation problem according to the PISA 2022 perspective. The research design used in this study was qualitative case study in which there were two eleventh-grade female students in SMK Kesehatan Mulia Husada with high and equivalent mathematical ability proven by their scores in the Mathematical Ability Test. The data were gathered through a Mathematical Ability Test, Mathematical Literacy Tasks, the work of the students, and clinical interviews through the think-aloud technique. The analysis was conducted based on the three mathematical literacy processes described in the PISA 2022 framework including formulating, employing, and interpreting and evaluating. The results showed that both students have good mathematical literacy competence in drug dosage calculation. First, in the formulating process, both students could find out the relevant clinical information, choose appropriate mathematical models, and explain the usage of Clark's formula and Body Surface Area. Second, in the employing process, both students could apply proportionally reasoning, do formula substitution, conversion units of measurement, and calculate dosages-volumes as well as self-correct themselves in case of mistakes. Third, in the interpreting and evaluating process, both students explained the interpretation of the numerical answers in terms of dosages' safety and reasoned the choice of rounding up/rounding down by taking into consideration the percentage deviation and the feasibility of measuring devices. Based on the result, it can be seen that the students with high mathematical ability are able to link mathematical procedures with the context of vocational pharmacy problem. Therefore, the learning of mathematics for pharmacy-oriented vocational program must incorporate dosage calculation problem.

Keywords: *mathematical literacy, PISA 2022, mathematical reasoning, drug dosage calculation, vocational education*.

Literasi Matematis Siswa Smk Farmasi Dalam Menyelesaikan Masalah Dosis Obat

ABSTRAK

Penelitian ini bertujuan untuk mendeskripsikan profil literasi matematika siswa SMA kejuruan jurusan farmasi dalam menyelesaikan masalah perhitungan dosis obat berdasarkan kerangka PISA 2022. Desain studi kasus kualitatif digunakan dengan melibatkan dua siswi kelas sebelas dari SMK Kesehatan Mulia Husada yang memiliki kemampuan matematika tinggi dan setara, sebagaimana ditunjukkan oleh skor Tes Kemampuan Matematika mereka. Data dikumpulkan melalui Tes Kemampuan Matematika, Tugas Literasi Matematika, karya tulis siswa, dan wawancara klinis berbasis tugas menggunakan teknik berpikir keras (think-aloud). Data dianalisis berdasarkan tiga proses literasi matematika dalam PISA 2022: merumuskan, menerapkan, dan menafsirkan serta mengevaluasi. Hasil penelitian menunjukkan bahwa kedua siswa menunjukkan literasi matematika yang kuat dalam konteks perhitungan dosis obat. Dalam proses perumusan, mereka mampu mengidentifikasi informasi klinis yang relevan, memilih model matematika yang tepat, dan membenarkan penggunaan rumus Clark dan metode Luas Permukaan Tubuh. Dalam proses penerapan, mereka secara akurat menerapkan penalaran proporsional, substitusi rumus, konversi satuan, dan prosedur perhitungan dosis-volume, termasuk koreksi diri ketika terjadi kesalahan. Dalam proses interpretasi dan evaluasi, kedua siswa menginterpretasikan hasil numerik dalam kaitannya dengan keamanan dosis dan membenarkan keputusan pembulatan dengan mempertimbangkan deviasi persentase dan alat ukur praktis. Temuan ini menunjukkan bahwa siswa dengan kemampuan matematika yang kuat dapat menghubungkan prosedur matematika dengan konteks farmasi kejuruan. Oleh karena itu, pembelajaran matematika di sekolah kejuruan farmasi harus mengintegrasikan masalah perhitungan dosis otentik untuk memperkuat penalaran matematika, akurasi, dan evaluasi kontekstual siswa.

Kata Kunci**:** *literasi matematis, PISA 2022, penalaran matematis, kalkulasi dosis obat, pendidikan vokasi*.

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1. Introduction

Nowadays, mathematical literacy can no longer be viewed simply as an academic competence (Biehler, 2019; Rizki & Priatna, 2019; Gal et al., 2020; Niss & Jablonka, 2020; Venkat, 2020). It has become a professional foundation of safe and accurate decision-making in the vocational health education sector. With regard to pharmacy courses, students should be able to read prescriptions, find appropriate amounts, use unit conversions, apply proportional reasoning, choose dosage formulas and evaluate numerical results. All of these skills coincide with the PISA 2022 definition of mathematical literacy, where reasoning in mathematics and formulating, using, interpreting, and evaluating mathematics in various practical scenarios are considered as core aspects (OECD, 2023a). The latter is especially relevant for the students of vocational high schools with pharmacy courses, because calculating the dose of drugs is not only about mathematics but rather a contextual task where numbers are directly connected to the health of patients.

This problem is proved by the evidence of medication dosage calculation difficulty at the international level, where researchers point out that dosage calculation is a problem for the education of health professionals. The studies of nursing and health students show that the major causes of dosage calculation errors include poor knowledge of basic math skills, inability to solve proportion problems, converting units, choosing formulas, and interpreting clinical information (Wennberg-Capellades et al., 2022; Hijji, 2025; Stake-Nilsson et al., 2022). An analysis of written dosage calculation of nursing students showed that finding sources of errors was crucial to create effective learning opportunities, as students made miscalculations not only because of their arithmetic skills but also due to poor understanding of the problem situation and choice of methods (Wennberg-Capellades et al., 2022). According to another recent research, digital technologies cannot solve the problem of students' medications calculation difficulties (Stake-Nilsson et al., 2022). Consequently, these findings prove that calculating the dose is not only a procedural task but an aspect of mathematical literacy.

This problem acquires more importance in the light of the Indonesian setting. According to the results of PISA 2022, Indonesian pupils still perform worse in mathematics than the average OECD countries' pupils, and the percentage of those who fall behind the threshold of proficiency has risen compared to other cycles (OECD, 2023a). Furthermore, it has been shown by the OECD that even taking the socio-economic level into account, the differences between pupils of general, pre-vocational, and vocational schools in Indonesia are small, thus demonstrating that poor performance in mathematics is a systemic issue and not the problem of a specific educational pathway (OECD, 2024b). Such a situation raises serious concerns with regards to the vocational education system, since mathematics is expected to help develop vocational skills there. Namely, for students studying pharmacy in SMK, poor mathematical skills can be an obstacle to translating the information about medicines into dosage calculation and assessing its plausibility.

Prior studies in relation to mathematical literacy have mainly focused on the problem-solving skill of the learners on PISA-type questions on the school mathematics curriculum which include topics like numbers patterns, geometry and contextualized problems. It has been found that the higher the mathematical abilities of the learners, the better they will be able to construct, apply and interpret mathematical situations while the lower mathematical abilities of the learners hinder their development of skills to go beyond standard procedures (Andari & Setianingsih, 2021; Husni & Herman, 2024). However, the research trend has failed to sufficiently focus on the vocational specific mathematical literacy of pharmacy, especially in the case of mathematical literacy incorporated in authentic dosage calculation.

The above gap is important since the process of dosage calculation involves more than just arriving at the final number. Students need to identify and state the important pieces of information such as age, body weight, adult dose, drug concentration, and body surface area before solving the problem. Next, they have to use mathematics through the use of concepts and procedures like ratio, proportion, unit conversion, formula substitution, and volume calculation. Finally, they have to evaluate the answer based on its reasonableness, rounding deviation, and the available instrument for measurement. Therefore, dosage calculation offers an excellent context in which the entire process of mathematical literacy described by PISA 2022 can be studied. In addition, this research will enable researchers to find out if mathematical procedures used by students are related to contextual understanding of the situation or if they are done independently from context.

In this respect, the research problem for this study is to describe the mathematical literacy of vocational high school pharmacy students who have high mathematical ability in solving dosage calculation problem according to the PISA 2022 framework. This research will analyze the process of formulation, mathematical concept and procedure application, and interpreting

and evaluating the answer related to dosage safety and measurements. By studying the two students with equal high mathematical ability, this research will give an explanation of how mathematical competence works when facing dosage calculation in pharmacy practice. The expected outcome of this research will contribute to mathematics education in vocational schools.

2. Research Method

In conducting this research, a qualitative method was used under the descriptive case study approach. The chosen design was aimed at conducting a detailed analysis of students' mathematics literacy process rather than statistical analysis of their achievements in learning. The focus was made on the ways students developed pharmaceutical dosage problems, used mathematical skills and techniques, as well as analyzed and assessed the results according to the PISA 2022 mathematical literacy framework. The use of such design allowed to observe reasoning patterns, problem-solving, self-assessment and context awareness of students in solving practical problems.

2.1 Research Participants

Selection of participants in this study was made through purposive sampling among 25 Grade 11 pharmacy students enrolled in SMK Kesehatan Mulia Husada having studied the basic subject of pharmaceutical calculation. Selection of the participants was based on the result of Mathematical Ability Test (TKM) that classified the students into three categories according to their level of mathematical abilities: high, medium, and low. Two girls labeled as APFN and SDW became the participants of the study because both got the same high TKM score (94), had the same mathematical ability, and were of the same gender and showed good ability to articulate the process of their thinking aloud. Thus, this sampling method helped to focus more on the process of mathematical literacy of the students rather than their mathematical ability or gender characteristics. That is why the results of the research represent the mathematical literacy of high-ability vocational pharmacy students while solving problems of drug dosages calculations.

2.2 Data Collection

Data collection involved three major methods, namely, document analysis, written mathematics test, and task-based interview. First, academic documents and Mathematical Ability Test were used to assess the initial mathematical skills of the selected students and qualify them for participation in the study. Secondly, the chosen participants solved the Mathematical Literacy Tasks containing real-world drug dosage calculation problems that required using three PISA 2022 processes of formulating, employing, and interpreting and evaluating. Thirdly, after solving the mathematical tasks, each student was interviewed on an individual basis regarding the performed tasks through a task-based interview conducted using think-aloud protocol. In such a way, the task-based interview helped to understand the students' solutions, discover the reasoning they used but did not show in their written tasks, and analyze the reasons for selecting particular formulas, calculating methods, dosages, and contextual interpretation.

2.3. Research Instruments

This study involved the use of three different instruments namely, the Mathematical Ability Test (TKM), Mathematical Literacy Tasks (TLM), and task-based clinical interview guide. The first instrument categorized students' existing mathematical ability into high, medium, and low groups, while the latter was used as the main instrument for measuring students' mathematical literacy in dealing with authentic problems related to drug dosages. TLM test had been developed according to the PISA 2022 Framework which comprised three mathematical literacy processes namely, formulating, using, and interpreting and evaluating. This interview guide is intended to elaborate the students' written responses by think-aloud technique and probing questions regarding formula selection, calculation process, self-correction, dose calculation, and contextual evaluation. The validation of the instruments included the judgment of the two lecturers in mathematics education and one teacher of vocational pharmacy. The experts examined the instruments concerning its relevance to the content, congruence to the PISA 2022 framework, appropriateness for context of pharmacy dosage calculations, and language. From the results of validation, the instruments were considered valid to be used after modification.

2.4. Data Analysis Techniques

The data was analyzed using the Creswell qualitative data analysis method, which includes sorting the data, multiple readings of students' writings and transcripts, coding the data, recognizing patterns, and interpretation of the data. The coding of the data was guided by the PISA 2022 mathematical literacy conceptual framework, where emphasis was laid on three key processes: formulation, utilization, and interpretation and evaluation. First, the writings of the students were examined to determine how the students chose the relevant data, created mathematical models, used formulas, calculated the result, and came up with the solution. Secondly, the transcript was analyzed to determine how the students used their reasoning, corrected themselves, justified the usage of the formulas, and evaluated the dosage accuracy. Comparisons were made between data obtained from the written tasks and interviews to ensure the consistency between the students' writings and explanations.

3. Results and Discussion

3.1 Results

The results of the study are presented based on the three main processes of PISA 2022, which were analyzed for the two subjects (APFN and SDW).

3.1.1 Formulating Process

The process of formulating the solution was analyzed based on how the participants found important information, selected the correct mathematical model, and converted the dosage problem into mathematical representation. In two Mathematical Literacy Tasks, APFN and SDW showed high competency in converting a real-world situation into mathematical representation. From their written answers and interviews, it could be observed that the process of formulating involved more than just finding the numbers. The important part of the process included selecting clinically significant variables, differentiating between important and

supporting information, and selecting the method for calculating the dose, depending on the structure of each task.

In Task 1 (TLM 1), both participants managed to find the relevant information for calculating the dose of the paracetamol syrup, such as age, weight of the child, adult dose, and the concentration of the drug. APFN listed these variables in her writing before she used Clark's formula as a mathematical model for the dosage problem. As seen in Figure 1, APFN was able to extract all the clinical information necessary for solving the problem, which includes age, weight, adult dose, and drug concentration. Thus, it is possible to conclude that the process of formulating included not only copying the data from the problem but also choosing the mathematically and contextually important variables.

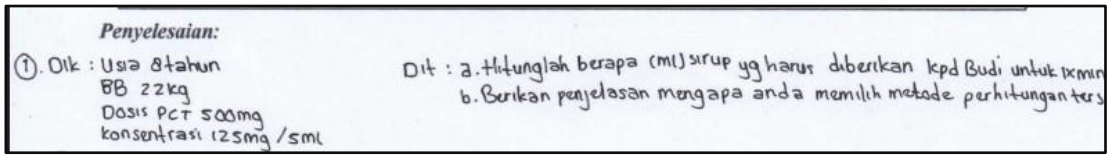


Figure 1. Identification of clinical variables by APFN on TLM 1

In TLM 2, related to the chemotherapy dose situation, both subjects were able to demonstrate their strong skills in formulating solutions of a much more complex and non-routine nature. Both subjects were able to determine which are the important variables – age, height, body weight, concentration of the drug, and chemotherapy scenario. Both subjects chose the Body Surface Area (BSA) formula based on the Mosteller formula due to the need to make a more accurate calculation considering height and weight. APFN knew that the context of the chemotherapy scenario demanded a higher level of accuracy and, therefore, required a formula of increased sensitivity to the patient features. SDW realized that BSA is a more adequate approach as it allows one to estimate the dose based on physical parameters and not on the age or body weight. The results of the thesis show that both participants used the Mosteller formula to calculate BSA and reformulate the chemotherapy scenario into a mathematical model.

The comparison between APFN and SDW (Table 1) shows the tendency toward a similar approach in the formulation stage. Both participants determined clinical data, selected adequate mathematical models and justified the use of this approach considering the context of the problem. The formulation of APFN showed more systematic written formulation, while the formulation of SDW had better verbal justification and awareness of the importance of accuracy in the context. Such distinctions do not show different levels of the participants' achievement but their different styles of presenting mathematical knowledge. In general, both participants showed high-level formulating skills connecting the pharmaceutical context with the mathematical structures before the calculations.

Table 1. Comparison of Formulating Process for TLM 1 and TLM 2

Formulating Indicator	APFN	SDW
TLM 1 information identified	Age, body weight, adult dose, drug concentration	Age, body weight, adult dose, drug concentration
TLM 1 model selected	Clark's formula using 68 kg	Clark's formula using 68 kg
TLM 1 justification	Body weight is more appropriate than age	Body weight is more precise than age

Formulating Indicator	APFN	SDW
TLM 2 information identified	Age, height, body weight, drug concentration, chemotherapy context	Age, height, body weight, drug concentration, chemotherapy context
TLM 2 model selected	BSA using the Mosteller formula	BSA using the Mosteller formula
TLM 2 justification	BSA accounts for height and weight in dosage estimation	BSA reflects patient-specific physical characteristics
Overall pattern	Systematic formulation	Contextually justified formulation

3.1.2 Employing Process

The employing process was investigated via the analysis of how the two participants used mathematical concepts, procedures, and knowledge after the selection of the adequate formula for dosages calculation. This stage was devoted to the application of formulas, their value substitution, proportional reasoning, calculations, units transformation, and procedure corrections. The findings show that both APFN and SDW exhibited high proficiency in the use of the selected formulas to calculate the drug dosages and to convert the dose to the required volume.

In TLM 1, both participants used Clark's formula to calculate the paracetamol dose of a child who weighs 22 kg, while the adult dose is 500 mg. APFN used the formula (22/68) × 500 mg and received 161.76 mg. Then she converted the dose to the syrup volume taking into account the concentration of 125 mg/5 ml and got 6.47 ml. The record of the participant is presented by a fully completed calculation from the dose to volume. As it can be seen from Figure 4, APFN used the Clark's formula to continue the calculation to receive the required syrup volume. This fact reflects the consistency of her procedures, proportional reasoning, and unit conversion.
SDW used the same calculation technique but made a mistake and recorded 16.17 mg instead of 161.76 mg because of tenfold mistake. Then she identified this error, canceled the mistake, re-calculated the dose and received 161.76 mg. After that, SDW converted the dose to 6.47 ml. This mistake and its further correction are shown in Figure 2. In this way, the results show that the participant's employing process included not only procedural activity but also checking the reasonableness of the numeric results during the process. This ability is vital for the calculation of dosages since each calculation should be accurate.

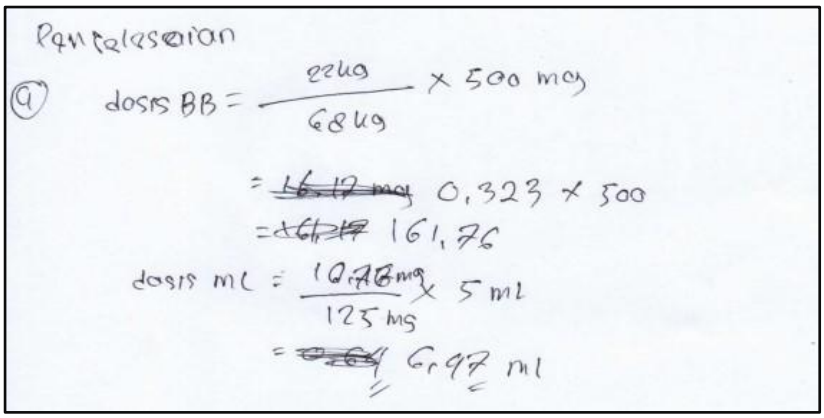


Figure 2. Self-correction process by SDW on TLM 1

In TLM 2, both students utilized the BSA method with the use of the Mosteller formula. In APFN's case, the BSA of the patient was calculated using the Mosteller formula by inputting the values of height and weight, giving an approximate result of 1.04 m². From there, the BSA was used to compute for the chemotherapy dose which was then converted to drug volume. Despite the procedural mistake made by APFN in which she did not correctly complete the square root part of the equation, she was able to correct her mistake and do the computation accurately. As shown in Figure 3, APFN was able to fix her BSA computation and continue using the BSA for the chemotherapy dose calculation.

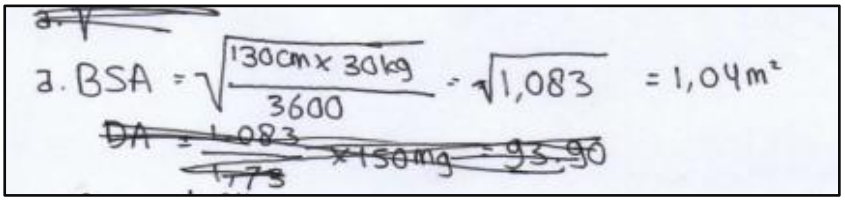


Figure 3. BSA calculation using Mosteller formula by APFN on TLM

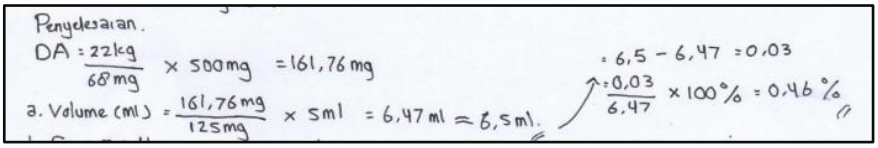


Figure 4. Dosage calculation using Clark's formula by APFN on TLM 1

The SDW used the Mosteller formula and calculated the same body surface area (BSA) of around 1.04 m². She then calculated the dose by using the proportion of her BSA to the standard adult BSA of 1.73 m² and calculated a total of 90.17 mg. She then changed this into 9.017 mL according to the concentration of the drug. Since the results from the calculations done by both APFN and SDW are similar, it can be concluded that both performed the multi-step dose calculation process effectively.

Table 2. Comparison of Employing Process for TLM 1 and TLM 2

Employing Indicator	APFN (TLM 1)	SDW (TLM 1)
TLM 1: Formula application	Applied Clark's formula correctly using body weight and adult dose.	Applied Clark's formula correctly using body weight and adult dose.
TLM 1: Dose calculation	(22/68 \times 500 = 161.76) mg.	Initially wrote 16.17 mg, then corrected it to 161.76 mg.
TLM 1: Volume conversion	Converted 161.76 mg using 125 mg/5 ml and obtained 6.47 ml.	Converted 161.76 mg using 125 mg/5 ml and obtained 6.47 ml.
TLM 1: Procedural control	Calculation was consistent from dose to volume conversion.	Detected and corrected a ten-fold calculation error.
TLM 2: Formula application	Applied the Mosteller formula to calculate BSA.	Applied the Mosteller formula to calculate BSA.
TLM 2: BSA calculation	Obtained approximately 1.04 m² after correcting the square-root step.	Obtained approximately 1.04 m² accurately.

Employing Indicator	APFN (TLM 1)	SDW (TLM 1)
TLM 2: Dose calculation	Calculated (1.04/1.73 \times 150 = 90.17) mg.	Calculated (1.04/1.73 \times 150 = 90.17) mg.
TLM 2: Volume conversion	Converted 90.17 mg using 100 mg/10 ml and obtained 9.017 ml.	Converted 90.17 mg using 100 mg/10 ml and obtained 9.017 ml.
Overall pattern	Strong procedural fluency with immediate correction of a procedural slip.	Strong procedural fluency with effective self-correction of numerical error.

3.1.3 Interpreting and Evaluating Process

As to interpretation and evaluation of the numerical results in the context of pharmaceutical tasks, the way the participants analyzed the reasonability of the results and justified their final dosage decisions was considered. During the interpretive and evaluative stage, neither APFN nor SDW did limit themselves by the mathematical results, rather they re-contextualized the obtained results in relation to dosages' safety, administration convenience and measurement instrument availability. Thus, it can be concluded that besides numerical reasoning skills the participants had an ability to appraise whether the obtained result is reasonable and applicable in the dosage administration situation.

In the first task, both participants interpreted the result – syrup volume of 6.47 ml – and evaluated the need in rounding. APFN rounded 6.47 ml to 6.5 ml on the grounds of the result deviation calculation. As the result, the deviation of 0.46% was lower than 5% of tolerance level for the problem situation. SDW also came up to a similar conclusion, rounding the result to 6.5 ml. The rounded volume was regarded as appropriate since the deviation was small and the result was better to administer due to the measuring devices available. Thus, it can be seen that both participants made a connection between the number precision and the applicability of the result in the dosage administration situation.

In the second task, the interpretation and evaluation was done more deeply owing to the use of BSA method in the chemotherapy dosage calculation. After obtaining the result of approximately 9.02 ml, APFN estimated two options – 9.2 ml and 9.5 ml – calculating the percentage deviation of each option. 9.2 ml showed the deviation of approximately 2.00%, while 9.5 ml – the deviation of 5.32%. As can be seen in Figure 5, APFN explicitly estimated the deviations related to the rounded numbers and discarded the second option as it exceeded 5% tolerance threshold. Thus, it can be concluded that APFN based her evaluation on the quantitative analysis rather than estimations.

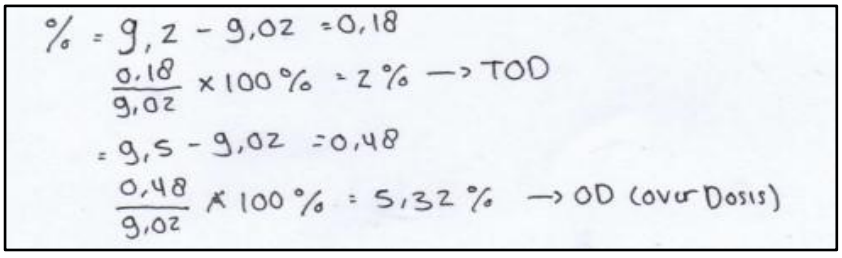


Figure 5. Dosage rounding deviation testing by APFN on TLM 2

The APFN also provided an explanation of the context in which the use of BSA method could be used when dealing with a patient taking chemotherapy treatment. The explanation

indicates that there was need for more accuracy in chemotherapy doses because an incorrect dose may increase risks. The illustration of the explanation is given in Figure 6. In conclusion, this explains how APFN understood the mathematical equation not only as a mere formula, but as a way of doing something related to dosage accuracy.

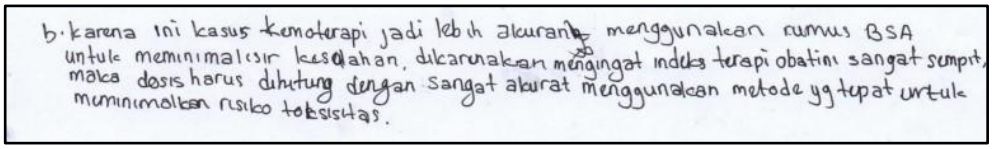


Figure 6. Justification of BSA method selection by APFN on TLM 2

SDW demonstrated a similar evaluation process but ended up opting for a different rounded dose. After establishing the calculated dose at 90.17mg, SDW considered the rounding up of 95 mg and 90 mg. From the calculations, it was clear that 95 mg had a difference of roughly 5.35% and 90 mg had a difference of roughly 0.18%. As seen in Figure 7, SDW opted not to round up to the higher dose since it was above the acceptable margin of error and settled for 90 mg because it had the lower difference.

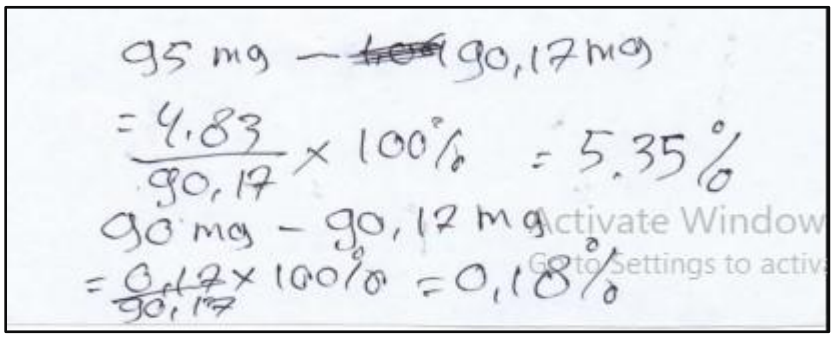


Figure 7. Dosage rounding deviation testing by SDW on TLM 2

APFN vs. SDW Comparison reveals that both participants had strong interpretive and evaluative skills; however, their final conclusions were different in TLM 2. The participant APFN decided upon 9.2 ml since this number falls into acceptable deviation range and is considered to be pragmatic to measure, while SDW chose 9.0 ml or 90 mg based on getting the smallest deviation possible. It proves that interpretive and evaluative skills related to mathematical literacy do not always provide one unique conclusion. Instead, the process consists of making the right decision supported by calculations and practical considerations. Overall, the combination of both participants' approaches shows the ability to evaluate the calculations and choose the dosing value based on deviation and pragmatism.

Table 3. Comparison of Interpreting & Evaluating Process for TLM 1 and TLM 2

Interpreting and Evaluating Indicator	**APFN (TLM 1)**	**SDW (TLM 1)**
TLM 1: Exact result interpreted	Interpreted 6.47 ml as the required syrup volume.	Interpreted 6.47 ml as the required syrup volume.
TLM 1: Rounding decision	Rounded 6.47 ml to 6.5 ml.	Rounded 6.47 ml to 6.5 ml.

Interpreting and Evaluating Indicator	APFN (TLM 1)	SDW (TLM 1)
TLM 1: Deviation evaluation	Calculated the deviation as 0.46%, below the 5% tolerance threshold.	Interpreted the deviation as acceptable because it remained below the tolerance threshold.
TLM 1: Contextual justification	Considered 6.5 ml safe and practical for measurement.	Considered 6.5 ml practical for available measuring tools.
TLM 2: Exact result interpreted	Interpreted approximately 9.02 ml as the calculated chemotherapy drug volume.	Interpreted 90.17 mg or approximately 9.02 ml as the calculated dosage result.
TLM 2: Alternative values evaluated	Compared 9.2 ml and 9.5 ml.	Compared 90 mg and 95 mg, equivalent to approximately 9.0 ml and 9.5 ml.
TLM 2: Deviation evaluation	9.2 ml = 2.00%; 9.5 ml = 5.32%.	90 mg = 0.18%; 95 mg = 5.35%.
TLM 2: Final decision	Selected 9.2 ml because it remained below the 5% tolerance threshold and was practical.	Selected 90 mg/9.0 ml because it had the smallest deviation.
Overall pattern	Strong evaluative reasoning based on tolerance and practicality.	Strong evaluative reasoning based on minimal deviation and dosage accuracy.

3.2 Discussion

From the obtained results, one can see that the two high-ability students demonstrated high-level mathematical literacy in resolving dosing problems of drugs. Not only they were able to produce the right numerical answer but were able to identify the necessary contextual information, select an adequate mathematical model, conduct a multi-step procedure, and assess the reasonableness of the dosages. All this corresponds to the definition of mathematical literacy provided by the PISA 2022 framework. According to it, mathematical literacy is defined by one's capacity to reason mathematically and to formulate, use, interpret and evaluate mathematics in real-life situations (OECD, 2023). Thus, the ability of students to connect age, body weight, adult dose, drug concentration, height, and body surface area with adequate dosing models once again shows that mathematical literacy depends upon the ability of learners to see mathematical structures in contextual problems (Kolar & Hodnik, 2021; Bolstad, 2023; Kappassova et al., 2025). Hence, the current study proves that mathematical literacy in vocational settings becomes robust only when students go beyond procedural computation and apply mathematics to make informed decisions based on context.

Formulation became a key strength for both participants. They chose Clark's formula while solving the case with paracetamol because of the need to adjust the pediatric dosage considering the patient's body weight. At the same time, they used the Body Surface Area (BSA) method while solving the case involving chemotherapy. Therefore, students had the skills to discriminate between available information and relevant one, which is a critical precondition for the solution of contextual mathematical problems. It was shown by previous studies on

mathematical literacy that most students face troubles not while solving a problem but while formulating it (Bolstad, 2023; Kolar & Hodnik, 2021; Kappassova et al., 2025). The current findings contribute to this discussion by showing that in vocational pharmacy education, the formulation of problems is also based on both mathematical and contextual knowledge.

The employment process additionally shows that procedural fluency and metacognitive control play critical roles in the process. Both the participants correctly showed their knowledge of proportional reasoning, formula substitutions, dose calculations, and unit conversions. The most crucial part of this calculation process was the ability of participants to monitor and fix the mistakes in their calculation process before they could come up with the final answer. Fixation of the ten-fold mistake by SDW and the square root step for BSA by APFN shows that correct dosage calculation involves constant monitoring, checking, and estimation of numbers instead of pure arithmetic actions. This finding is consistent with research in health profession education where medication dosage calculation mistakes happen due to low mathematics skills, conceptual knowledge, proportional reasoning and procedural control (Wennberg-Capellades et al., 2022; Dutra et al., 2022; Hijji, 2025; Stake-Nilsson et al., 2022). It further supports the position that drug calculation learning needs to include training on estimation of plausibility of the intermediate and final results since the calculation accuracy in health professions is directly related to medication safety (Wennberg-Capellades et al., 2022; Stake-Nilsson et al., 2022).

Finally, the interpreting and evaluating process provides the best evidence that reflective reasoning was included in mathematical literacy of the participants. Neither of them accepted the calculated number of milliliters without further analysis; both of them estimated the need to round the calculated value based on the percent deviation of the result and the existing measuring devices. In Task LM 1, both decided to round 6.47 ml to 6.5 ml as the percent deviation was small. In TLM 2, APFN chose 9.2 ml as it did not exceed the tolerance and was easier to measure while SDW chose 9.0 ml as it had the smallest percent deviation. Different results show that high level of mathematical literacy does not always lead to the same choices of final decisions but gives mathematically correct and contextually reasonable justification. This finding corresponds to the research in medication calculation teaching that requires from the students not only the ability to calculate doses but also to interpret the results to estimate its safety, accuracy, and applicability (Dutra et al., 2022; Stake-Nilsson et al., 2022; Hijji, 2025). Thus, the skill to interpret and evaluate the results should be recognized as an integral part of mathematics teaching in pharmacy vocations, not the optional addition after calculation.

This study adds to the existing body of knowledge by presenting evidence that the theoretical framework of PISA 2022 is applicable to the analysis of mathematical literacy in such a narrowly defined vocational setting. Unlike previous studies on mathematical literacy, which mainly concentrate on general school environments or PISA-like problems, the current study shows that drug dose calculations serve as a strong context for investigating the whole process of mathematical literacy, including problem identification, use of mathematical procedures, and evaluation/interpretation of results. This result correlates well with other findings showing that mathematical literacy is enhanced through the engagement with meaningful problems and instructional links between mathematics and reality (Bolstad, 2023; Kappasova et al., 2025; Wang et al., 2023). The conclusion is obvious: the educational program in mathematics for vocational schools focused on training pharmacists should include not only learning formulas and performing routine tasks but also meaningful clinical-pharmaceutical situations, explaining the choice of the model, identifying and correcting mistakes in calculations, and evaluating doses.

4. Conclusion

The current study reveals the high mathematical literacy skills of students in terms of drug dosage calculation problems among high-ability vocational pharmacy students, as reflected in their performance on the three major processes included in the PISA 2022 framework. In the formulate process, both the students could recognize relevant clinical information, differentiate important data from additional information, and choose an appropriate model for solution of drug dosage calculation problems, namely, Clark's Formula to calculate the pediatric dosage and Body Surface Area to calculate chemotherapy dosage. In the employ process, the students performed correctly proportional reasoning, formula substitutions, unit conversions, and dosage and volume calculations. They also demonstrated procedural control by correcting themselves in case of error. In the interpret and evaluate process, both the students could connect mathematical results to real life and explain the choices of rounding methods by calculating the percentage deviation from the actual result. It can be concluded that mathematical literacy in vocational pharmacy education goes beyond the procedural calculation and includes integrated modeling, computing, verifying, and evaluating of the mathematical problem-solving process. This study only considers the performance of two female students with high mathematical abilities from a vocational pharmacy school. Thus, the results cannot be generalized to students of vocational settings with medium and low mathematical abilities. The next study should consider a large number of different students with various abilities, genders, and educational institutions. The teachers of mathematics should integrate drug dosage calculation activities into their instruction.

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