# Mathematical Problem-Solving Achievement in Food Calorie Value Calculation among Home Economics Students

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## ABSTRACT

This study examined the relationship between the level of mathematical problem solving in food calorie value calculation and students' achievement in the same task among Home Economics students at the upper secondary level. Adopting a quantitative correlational design, the study involved 170 Form Five students who were offered Home Economics as an academic elective across three districts of Melaka, Malaysia. The achievement data were obtained from the food calorie value calculation test item of Paper Two (Section B) of the Malaysia Certificate of Education (SPM) exam, and problem solving was measured using the rubric from Polya's four-stage problem -solving model. Data collected were analyzed descriptively and inferentially in SPSS. Summative, performance was weak, with an overall achievement mean of 5.81 (SD = 5.64) of a possible 16, with 111 pupils (65.3%) achieving a score of 5 or less (at or below half of the maximum score). Pearson correlation analysis showed a significant positive correlation between all four parts of problem solving and achievement, namely problem identification ($r = 0.249$ and $p < 0.01$), planning a strategy ($r = 0.285$ and $p < 0.01$), carrying out the solution ($r = 0.701$ and $p < 0.01$), and checking and reporting the answer ($r = 0.903$ and $p < 0.01$). The students demonstrated higher competence in the earlier phases of problem identification and planning, but were markedly weaker in executing the solution and verifying the answer. The results indicate that the teaching and learning of Home Economics should place greater emphasis on the higher-order phases of mathematical problem solving.

**Keywords:** Mathematical problem solving; Polya model; food calorie value calculation; Home Economics; vocational numeracy; academic achievement

## INTRODUCTION

Mathematical problem solving has a well-established place in the modern curriculum, but it is also one of the most robust and difficult skills to learn. The ability to draw on prior knowledge, skills, and understanding to make sense of a situation, determine a course of action, and develop a well-justified solution is essential (Krulik & Rudnick, 1984). Problem solving is not just a mechanical process; it requires learners to make conceptual connections and think reflectively to justify the reasonableness of their solutions. Moreover, the ability to reason quantitatively is not just limited to the mathematics classroom. Competent functioning in the technical and vocational settings is often characterized by the capacity to estimate, measure, cost, and calculate in real-life work contexts (Kar Teck et al., 2023).

This issue is particularly relevant in the Malaysian context given the recent international benchmarking. According to the Trends in International Mathematics and Science Study (TIMSS) 2023, the average mathematics performance of Malaysian Form 2 students decreased compared to the previous cycle. Additionally, a substantial number of these students did not meet the low international benchmark (von Davier et al., 2024). These results underscore persistent learning gaps in both conceptual understanding and problem-solving skills, which are essential for mathematical problem solving. They also emphasize the need to refocus classroom research on mathematical investigations and their applications.

Home Economics is an elective subject for upper secondary students in Malaysian daily schools. It serves as an extension of the primary and lower secondary subject known as Living Skills (Ministry of Education Malaysia, 2015). The subject comprises three main components: Food and Nutrition, Clothing, and Home and Family. It is supported by seven objectives, one of which—objective 5—focuses on applying mathematical skills for measuring, calculating and estimating (Ministry of Education Malaysia, 2003). This objective situates Home Economics squarely within the family of applied, vocationally oriented subjects, where numeracy is not just an abstract exercise but an embedded practical competency.

The utilization of this numeracy is apparent in the structure of the SPM Home Economics examination. Paper One comprises 40 multiple-choice questions, and Paper Two is divided into three sections: Section A has two analytical questions; Section B has two quantitative questions; and Section C has two process-based questions. All Home Economics candidates need to have a good sense of problem solving to arrive at the correct answer in Section B and have some general sense of problem solving in their everyday lives. Examples of learning outcomes related to mathematical problem solving are: calculating the calorie value of food, the cost of a meal, the selling price of a meal, the body mass index and the clothing cost. Notably, food calorie value calculation has always been a central curricular topic in the SPM Home Economics exam for a period of seventeen years (between 2001 and 2017) (Malaysia Examination Board, 2001–2017).

In view of this, the present study aimed to determine whether there is a correlation between the level of achievement in the calculation of food calorie value and the level of problem solving in these students in Home Economics. Defining the most important phases of the problem-solving process that strongly influence achievement provides a diagnostic basis for directed pedagogical intervention.

## LITERATURE REVIEW

Problem solving is considered the most cognitively complex of the mathematics learning skills, as it involves the coordination of number facts, arithmetic operations, information processing, language comprehension and visual-spatial reasoning all at the same time (Tambychik & Meerah, 2010; Tambychik et al., 2010). A deficiency in any of these sub-skills may lead to problems in solving a problem as a whole, and in the Malaysian context, students have been reported to have problems recalling concepts and formulae, converting problems into mathematical sentences and performing procedures correctly (Tambychik & Meerah, 2010). The learner is expected to integrate knowledge, skills, and values to propose solutions to problems and present mathematical ideas effectively, whether as statements, stories, or extended responses (Noraini, 2005).

One of the most prominent models for conceptualizing problem solving is Polya's four-step model: understanding the problem, making a plan, executing the plan, and reflecting on the outcome to check. The model is still used in modern research and instructional design in various educational systems, as evidenced by various studies (Chacón-Castro et al., 2023; Kar Teck et al., 2023). One of the common points that have been observed in recent studies is that the user seems to be successful at the beginning of the learning process, when grasping the meaning and planning, but struggle towards the end when it comes to executing and verifying their solutions. This stage requires computational accuracy and metacognitive self-checking (Chacón-Castro et al., 2023). This asymmetry being able to formulate a solution but failing to complete and evaluate it provides a valuable perspective for current research.

In addition to the Polya model, the problem-solving literature points to a set of problem-solving heuristic strategies: trial and error, drawing diagrams, making tables, experimenting, doing simulations, identifying patterns, solving a simpler analogous problem, and working backwards (Polya, 1957). Complementary schemes focus, for example, on: identifying patterns, working backwards, guessing and testing, reducing and extending a problem, listing and ordering, logical deduction, and writing an equation (Krulik & Rudnick, 1996). In the context of Home Economics, two task strategies are important: first, the table drawing strategy that simplifies and organises information into a single table (Polya, 1957); second, the arrangement-list strategy that arranges information in a list in the order that will be relevant for the task (Noraini, 2005). Both strategies are illustrated in the Home Economics textbook and are directly related to Section B questions in the SPM examination (2001-2017) (Malaysia Examination Board, 2001-2017).

The present study modified Polya's model to characterize the level of problem solving in food calorie value calculation, and the assessment of the level of problem solving is based on the problem-solving rubric of Szetela and Nicol (1992), the problem-solving flow chart of Krulik and Rudnick (1984), and the analytical scale of Charles, Lester & O'Daffer (1987). The contextualization of the study in Home Economics is important because it is one of the applied, vocationally oriented strands of the curriculum in which quantitative reasoning skills with genuine and realistic data are relevant to occupational competence (Kar Teck, et al., 2023; Ting, et al., 2023). It is, therefore, important to analyse problem solving in this context not only for mathematics education but also for the general discourse on numeracy in the context of technical and vocational education and training.

## METHODOLOGY

This study employed a quantitative, correlational research design. The sample comprised 170 Form Five students who were offered Home Economics as an academic elective and were drawn from three districts in Melaka — Melaka Tengah, Jasin, and Alor Gajah. The sample size was determined in accordance with the guidelines of Krejcie and Morgan (1970).

Three instruments were used. The first was the Section B item on food calorie value calculation from Paper Two of the 2005 SPM Home Economics examination, which required students to calculate the total food calorie value for carbohydrate, protein and fat, expressed in kilojoules, for a lunch set menu of chicken rice, orange juice and papaya, based on the percentage of the edible portion given in grams. The second was a scoring rubric for the food calorie value calculation task. The third was a rubric for measuring the level of problem solving, reconstructed to align with the food calorie value calculation task. This latter rubric adapted problem-solving elements from four sources: the problem-solving rubric of Szetela and Nicol (1992); the problem-solving flow chart of Krulik and Rudnick (1984); the problem-solving analytical scale of Charles, Lester and O'Daffer (1987); and the quantitative skill requirements for food calorie value calculation specified in the Home Economics coursework assessment manual of the Malaysia Examination Board (2009). The rubric for the level of problem solving was itself derived from the food calorie value calculation problem-solving rubric developed by Ja'afar (2013).

Data were analysed using the Statistical Package for the Social Sciences (SPSS) through descriptive and inferential procedures. Descriptive statistics summarised the distribution of achievement and problem-solving scores, while Pearson product-moment correlation was used to examine the relationship between the level of problem solving and achievement. The strength of the correlations was interpreted using the conventions of Cohen (1988).

## RESULTS AND ANALYSIS

### Level of Problem Solving in Food Calorie Value Calculation

The level of problem solving in food calorie value calculation was assessed across four phases (P), each scored from 0 to 4 on the basis of the food calorie value calculation problem-solving rubric (Rosini et al., 2012): problem identification (P1), planning a strategy (P2), carrying out the solution (P3), and checking and reporting the answer (P4).

In the case of P1, 46 respondents (27.1%) obtained a score of 1, corresponding to a mean problem-solving level of 1.4. This indicates that the majority of respondents misinterpreted the information provided, correctly identifying only one of the four required elements of the calculation. For P2, 54 respondents (31.8%) obtained a score of 1, corresponding to a mean level of 2.4. This again reflects that only one of the four elements was

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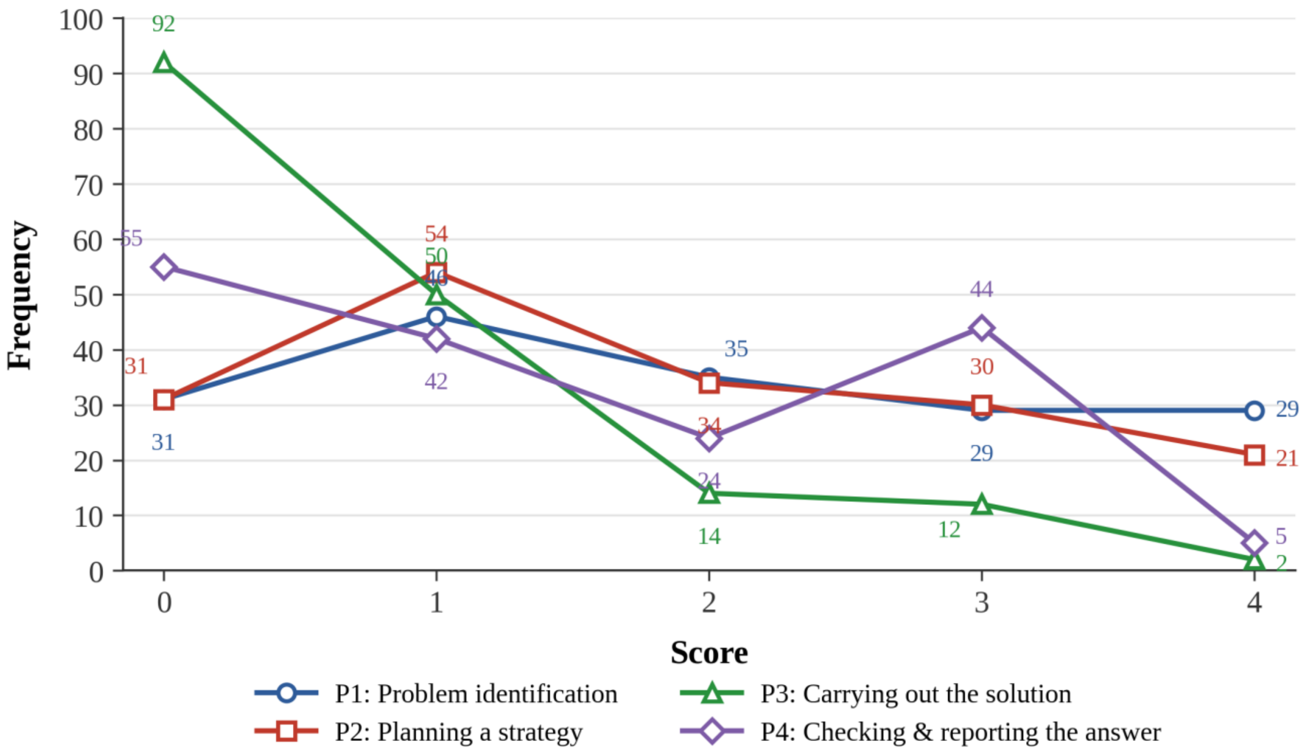
arranged correctly. Performance deteriorated sharply in the later phases. In P3, 92 respondents (54.1%) obtained a score of 0, indicating that they were unable to carry out the solution. In P4, 55 respondents (32.4%) obtained a score of 0, having either calculated the food calorie value entirely incorrectly or provided no answer at all. Figure 1 presents the level of problem solving by procedure, frequency, and score.

**Figure 1 Level of problem solving in food calorie value calculation by procedure, frequency and score**




Note. P1 = problem identification; P2 = planning a strategy; P3 = carrying out the solution; P4 = checking and reporting the answer.

In summary, the majority of respondents obtained a score of 1 for P1 and P2 but a score of 0 for P3 and P4. This pattern indicates that most students are able to identify the problem and plan a strategy, yet they failed to execute the solution and check and report the answer, i.e., they were competent in the lower-order phases but weak in the higher-order phases of the problem-solving process.

**Achievement in Food Calorie Value Calculation**

Achievement in food calorie value calculation was expressed as a score from 0 to 16. A score of 0 indicates that a respondent attempted the question but obtained no marks, or did not answer at all, whereas a score of 16 indicates a fully correct response. The mean achievement score was 5.81 (SD = 5.64). A total of 55 respondents (32.4%) failed to obtain any marks, 21 (12.4%) obtained a score of 4, and only 5 (2.9%) achieved the full score of 16; the frequencies for all remaining scores were below 10%. As 111 respondents (65.3%) scored 8 or below — that is, at or below half of the maximum mark — the findings indicate that the majority of Home Economics students are weak in the mathematics of food calorie value calculation. The full distribution of achievement scores is presented in Table 1.

Table 1 Distribution of respondents' achievement scores in food calorie value calculation

| Score | Frequency | Percentage (%) |
|---|---|---|
| 0 | 55 | 32.4 |
| 1 | 9 | 5.3 |
| 2 | 5 | 2.9 |

| | | |
|---|---|---|
| 3 | 2 | 1.2 |
| 4 | 21 | 12.4 |
| 5 | 5 | 2.9 |
| 6 | 2 | 1.2 |
| 7 | 6 | 3.5 |
| 8 | 6 | 3.5 |
| 9 | 5 | 2.9 |
| 10 | 5 | 2.9 |
| 11 | 9 | 5.3 |
| 12 | 10 | 5.9 |
| 13 | 2 | 1.2 |
| 14 | 13 | 7.6 |
| 15 | 10 | 5.9 |
| 16 | 5 | 2.9 |
| **Total** | **170** | **100** |

Note. N = 170; mean score = 5.81; standard deviation = 5.64.

**Correlation between Level of Problem Solving and Achievement**

The relationship between the level of problem solving and achievement in food calorie value calculation was examined using Pearson product-moment correlation, with the strength of the correlation interpreted following Cohen (1988). As shown in Table 2, all four problem-solving phases were significantly and positively correlated with achievement. The strongest association was observed for checking and reporting the answer (P4), which was strongly correlated with achievement ($r = 0.903$, $p < 0.01$), followed by carrying out the solution (P3) ($r = 0.701$, $p < 0.01$). Problem identification (P1) and planning a strategy (P2) showed weak, though still significant, correlations ($r = 0.249$ and $r = 0.285$, respectively, both $p < 0.01$).

The coefficients of determination reinforce this pattern. Checking and reporting the answer accounted for 81.5% of the variance in achievement, indicating that this phase exerts the strongest influence on students' performance in food calorie value calculation, while carrying out the solution accounted for a further 49.1% of the variance.

Table 2 Correlation between the level of problem solving and achievement in food calorie value calculation

| Problem-solving phase | Pearson r | $r^2$ | % | p | Strength |
|---|---|---|---|---|---|
| Problem identification (P1) | 0.249** | 0.062 | 6.2 | 0.001 | Weak |
| Planning a strategy (P2) | 0.285** | 0.081 | 8.1 | 0 | Weak |
| Carrying out the solution (P3) | 0.701** | 0.491 | 49.1 | 0 | Strong |
| Checking & reporting the answer (P4) | 0.903** | 0.815 | 81.5 | 0 | Strong |

Note. N = 170. $r^2$ = coefficient of determination. ** Correlation is significant at the 0.01 level (2-tailed).

## DISCUSSION

The results reveal an instructive dissociation between the phases of problem solving and their contribution to achievement. Students who scored highly on food calorie value calculation were generally those who succeeded in the higher-order phases, whereas competence confined to the lower-order phases of identifying and planning did not translate into achievement. This is consistent with the long-standing observation that mathematical problem solving is the most difficult of the mathematics learning skills (Tambychik & Meerah, 2010), and with subsequent evidence that difficulty is concentrated not in framing a problem but in executing and verifying its solution.

All four phases correlated significantly with achievement, with the strongest associations found for carrying out the solution and, above all, for checking and reporting the answer. This finding aligns with contemporary research grounded in Polya's model. Studies have repeatedly shown that learners perform adequately when they understand and plan a problem. However, they encounter their greatest difficulties when carrying out the plan and looking back to verify the result (Chacón-Castro et al., 2023). The final, reflective phase of the model — too often neglected in classroom practice — emerges here as the single most powerful correlate of achievement, a result that carries clear pedagogical implications.

The observed profile — relative strength in understanding the problem alongside weakness in planning, execution and verification — is also congruent with earlier Malaysian findings that students possess a high level of skill in comprehending problems but have lower levels of skill in strategy planning and in checking and reporting answers, with execution occupying an intermediate position. Moreover, because Home Economics is classified within the applied, arts-oriented stream of the curriculum, the generally moderate-to-weak performance recorded here is consistent with comparative evidence that students in such streams tend to attain lower problem-solving levels than their peers in the pure science stream. The broader decline in Malaysian students' mathematics achievement documented in TIMSS 2023 (von Davier et al., 2024) situates these subject-specific difficulties within a wider national concern regarding quantitative reasoning.

Taken together, these findings suggest that the weakness lies less in students' initial engagement with a problem than in their capacity to complete and validate a multi-step quantitative procedure. This has direct relevance for the numeracy embedded in technical and vocational subjects, where the value of a calculation depends entirely on its accurate execution and verification in authentic contexts (Kar Teck et al., 2023; Ting et al., 2023).

## CONCLUSION

This study found that the majority of Home Economics students were competent in the lower-order phases of mathematical problem solving related to calculating food calorie values, specifically in identifying the problem and planning a strategy. However, they struggled with the higher-order phases, which involve executing the solution and checking and reporting the answer. The level of problem-solving ability was significantly correlated with academic achievement, with the strongest associations observed during the checking-and-reporting phase, followed by the execution phase. Therefore, to achieve high success in calculating food calorie values, students must master all phases of the problem-solving process, not just the initial phases.

Therefore, particular emphasis should be placed on the factors that influence achievement in the higher-order phases of the process, most notably the teaching strategies employed by Home Economics teachers. Strengthening instruction in the execution and verification of multi-step calculations would not only help students answer the Section B questions of Paper Two in the SPM examination correctly, but also enable them to apply mathematical problem-solving skills in everyday (life / situations) and future careers. Such an emphasis holds clear promise for raising student achievement in the subject. Future research could extend these findings through experimental interventions targeting the execution and verification phases, and through qualitative inquiry into the cognitive and metacognitive processes underlying students' difficulties.

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