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Supporting students to justify choices: A problem-solving mathematics lesson study

Erika Cassar, Jeffrey Borg, Melania Camilleri, Andrea Cassar, Roger Seychell, Karen Galea & Analisa Magro
St Clare College, Madonna tal-Mensija Primary School, San Gwann
***Email:** erika.emily.cassar@ilearn.edu.mt

Abstract: This report presents a lesson study conducted with Year 4 primary students to strengthen their mathematical reasoning and justification skills within a budgeting context. The lesson centred on a realistic scenario in which Mrs. Green aims to create a healthy breakfast hamper with a €25 budget. Students worked in groups, each adopting a character from a concept cartoon – Sally, Maze, Tina, or Finn – who presented different suggestions or challenges related to the hamper's contents. Using a justification fan and a familiar problem-solving mat, students critically evaluated and justified their assigned character's choices, with one group tasked to independently design a suitable hamper. The activity was carefully structured to engage students at varying levels of mathematical ability and encourage the use of precise mathematical language. Observations and group presentations revealed how the structure of the task supported deeper reasoning and reflection. The lesson was purposefully selected due to previously identified students' difficulties in articulating mathematical justifications. This report outlines the lesson study process and discusses how the approach helped foster critical thinking, collaborative learning, and clearer mathematical communication.

Keywords: Budget; justification; lesson study; problem-solving mat; real-life

Introduction

Over the past decade, the Ministry for Education, Sport, Youth, Research and Innovation in Malta has undertaken a concerted effort to address critical challenges within the national education system. This commitment to reform is reflected in the publication of several strategic documents, including the *National Curriculum Framework* (MEDE, 2012),

the Learning Outcomes Framework (MEDE, 2015), the Framework for the Education Strategy for Malta 2014–2024 (MEDE, 2014), and the National Education Strategy 2024–2030 (MEYR, 2024).

Despite differences in emphasis, these policy frameworks share a unified vision for high-quality education that is student-centred and competence-based, with a particular emphasis on preparing students for life beyond schooling. Central to this vision is the promotion of equity and inclusive practices, including targeted measures to reduce early school leaving. Crucially, the successful implementation of these reforms is contingent upon the continuous professional development and collaboration of educators. As noted in the National Curriculum Framework (MEDE, 2012), collaboration among educators is a key factor in achieving improved educational outcomes, a sentiment echoed in the Learning Outcomes Framework (MEDE, 2015), which underscores the need for teachers to work collaboratively and to engage in professional development as part of a culture of lifelong learning

Notably, the more recent strategic document places significant emphasis on the empowerment of educators, acknowledging the multifaceted challenges they encounter, including increasingly diverse classroom populations and the transformative effects of digitalisation. In response to these challenges, the strategy advocates for professional growth and the promotion of collaborative practices among educators, intended to ensure that teachers are continuously equipped to navigate and respond effectively to evolving educational demands.

Lesson study and the Maltese context

The importance given to ongoing professional development and collaborative practices among teachers highlights a critical need in the field that goes beyond episodic workshops. This need can be effectively addressed through the implementation of lesson study (LS). Known to foster continuous growth and collective inquiry within teaching communities, lesson study originated in Japan in the early 1900s (Xu & Pedder, 2014). Serving as a practical mechanism for translating abstract curriculum goals into concrete classroom practices, a lesson study ''involves groups of teachers collaboratively planning, teaching, observing and analyzing learning and teaching in research lessons'', with the possibility of ''innovat[ing] or refin[ing] a pedagogical approach that will improve pupil's learning'' (Dudley, 2014, p.1).

The process, as concisely explained by Rock and Wilson (2005), comprises of eight main stages: (1) defining and researching a problem, (2) planning the lesson, (3) teaching and observing the lesson, (4) evaluating the lesson and reflecting on its effect, (5) revising the lesson, (6) teaching and observing the revised lesson, (7) evaluating and reflecting a second time, and (8) sharing the results.

Throughout the process, educators are required to exchange views, insights, and reflections about the lesson being delivered. Despite the length of the process and the time it requires for it to be exercised, lesson study fosters a strong culture of reflection amongst those involved (Rock & Wilson, 2005). This allows for further research, thoughts and adjustments to the lesson being studied, so that lessons can be honed and modified to better reach children (Lewis, 2002).

Different to other professional development workshops or training, lesson study provides educators with the opportunity to deepen their understanding of how students learn by closely observing their actions, reactions and behaviour (Cheung & Wong, 2014). Since the teachers' professional growth occurs within their own classrooms, as they teach their own students the lessons they are meant to be taught at present, teachers feel they are allowed to "take risks with their practice and feel safe to share their reciprocal, professional vulnerabilities" … providing them with the opportunity to "see, share, tap into and learn from usually invisible stores of tacit professional knowledge that are normally inaccessible as a learning resource" (Dudley, 2015, p. 4).

While the concept of LS in Malta was only introduced in 2017 (Calleja & Formosa, 2020), its integration into the professional learning culture of Maltese primary schools represents a promising step towards more responsive, collaborative, and evidence-informed teaching practices. Its successful implementation, however, will require institutional support, time allocation, and a shift in mindset towards collaborative professionalism.

These are the criteria we considered crucial when implementing a lesson study on problem solving in Mathematics across the Year 4 cohort in a Maltese primary state school, incorporating two cycles of the lesson delivery process. The following section describes the school context, the process followed, and instructional decisions taken throughout the journey.

The lesson study context

The school

At San Gwann Primary, educators endeavour to create a happy, safe environment so that students acquire a positive attitude towards learning. In an environment that is inclusive and conducive to learning, educators aim to develop morally, socially and academically enriched minds, so that students will be able to become lifelong learners and overcome any challenges in an ever-changing world.

The students

Two Year 4 classes were involved in these two cycles of this lesson study having a class in each cycle. The first chosen class was made up of 18 students with a varied level of ability when it comes to Maths. The overall attitude towards the mathematics lessons was a positive one and students showed interest in the subject. Whilst some students were able to answer most of the questions asked and enjoyed being challenged, others struggled to identify the correct method to be used and to reason out what was being asked from them. Students in this class faced challenges when it comes to answering mental questions, remembering the times-tables and remembering the correct method of how to add, subtract and multiply. Moreover, the majority still struggled to identify the keywords needed to identify the operations which need to be used. When solving problems, they found it very challenging to use the correct mathematical words to give a reason for their answer. They also needed additional practice and techniques on providing a mathematical justification during the process of identifying the correct method and whilst answering the given question through understanding, reasoning and expression.

The second class was made up of 16 children. Many of them had a low level of ability for their age group. Most of them struggled to understand the basic mathematical concepts. Accordingly, the lesson needed to be adapted according to their abilities. Whilst some of them liked to be challenged, the others struggled with identifying the solutions to solve mathematical problems. These students also struggled with low attention span which made it more challenging for them to focus during the lessons. Accordingly, they needed more use of tangibles. The topic that was tackled in this cycle of the lesson study was fractions. Many of them struggled to understand the basic concepts of numerators and denominators.

The team members

Name	Role at school	Role in lesson study
Analisa Magro	Head of Department (Maths)	Facilitator
Karen Galea	Maths Support Teacher	Facilitator
Melania Camilleri	Teacher	Team member + taught the 1st lesson trial
Andrea Cassar	Teacher	Team member
Erika Cassar	Teacher	Team member
Roger Seychell	Teacher	Team member + taught the 2nd lesson trial
Jeffrey Borg	Deputy head of school	Team member
Jane Grima	EO Curriculum	Knowledgeable other

The lesson study process

The lesson study involving mathematical problem-solving was carried out with the Year 4 educators, two of whom were already experienced, while the other two members were new to the process.

Due to experience, team members knew upfront that time constraints were going to be an issue, so four meeting dates, together with the date for the lesson delivery and the post-lesson discussion. Following this, a common focus was chosen. This proved to be somewhat a challenge at the start, since the four teachers identified possible foci, yet most of them were not common amongst the four of them. Finally, it was decided that the focus of our problem-solving lesson will be providing a sound mathematical justification for answers, decisions and choices. A shared 'One Drive' folder was created, to ensure that all updated documentation was available to all members of the team at any time. Given that the LS required certain work to be carried out after school hours, all members were flexible to access the updated documentation at any time.

The next phase consisted of planning the lesson. A scenario was created, wherein students needed to choose the best option, given a set of criteria, and justifying their decision. In the beginning of the planning stages, the team conducted research to evaluate different scenarios with such

student responses, in annual examination papers. This allowed us to gain first-hand evidence into the students' needs in this area. With this information in hand, the lesson was created with more focus and a resource, to help the students meet the criteria of a well-explained mathematical justification was created. A lesson plan was drafted together, partly during the in-person meetings and partly through the shared document which all participants could edit at any point. Additional resources were also created digitally.

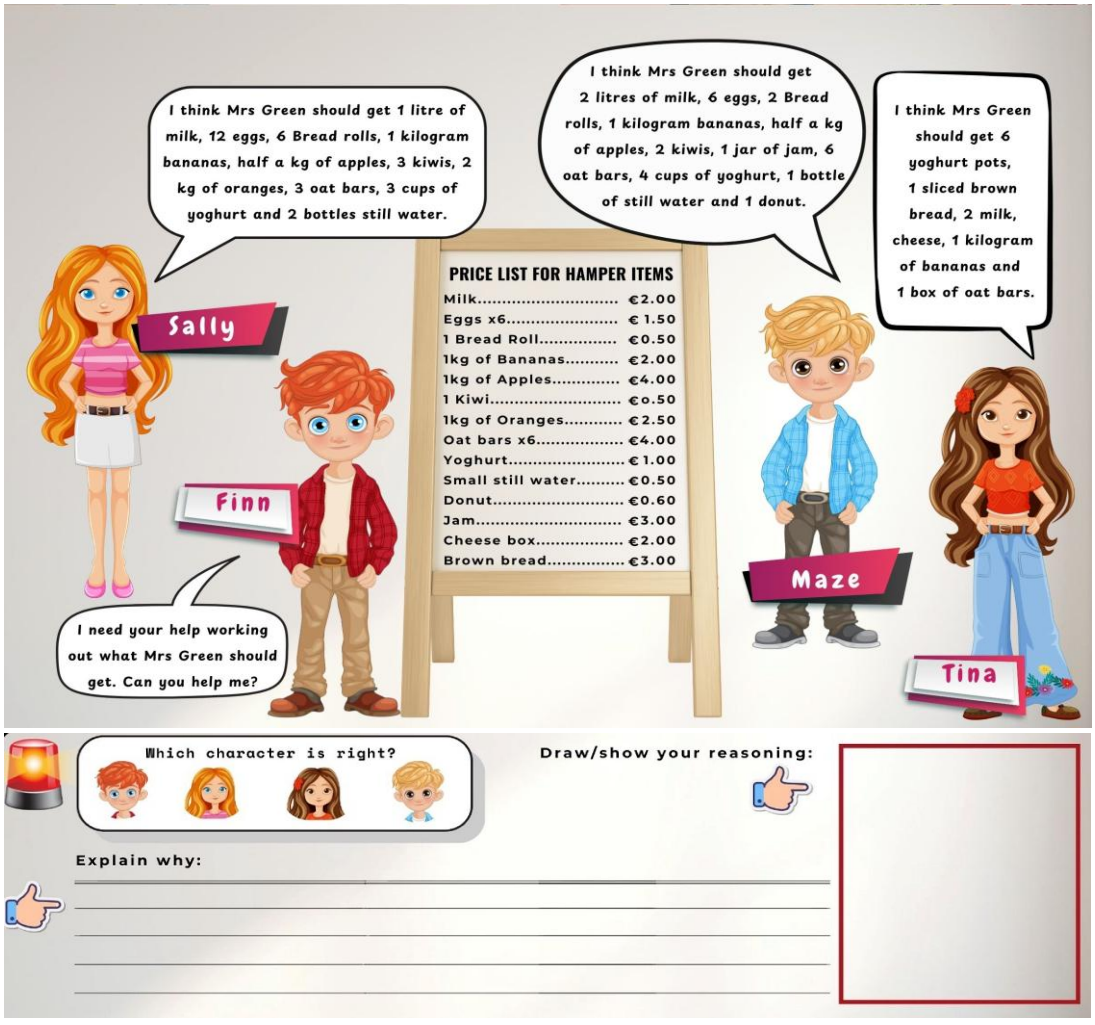
The lesson was delivered by a member of the team in her classroom, a class considered to be mostly made up of students of average ability. The rest of the observers were given a printed copy of the lesson plan, as well as an observation sheet to note down observations of two assigned students. Following the lessons delivery, all the team met up for a post-lesson discussion, where the outcome of the lesson was discussed. The team members reflected on both the successful aspects of the lesson, as well as those aspects which would benefit from improvement. It was agreed that a second cycle of the lesson study will be carried out, to address these areas which needed improvement. This process was carried out later in the year, during the third term of the scholastic year.

The meetings

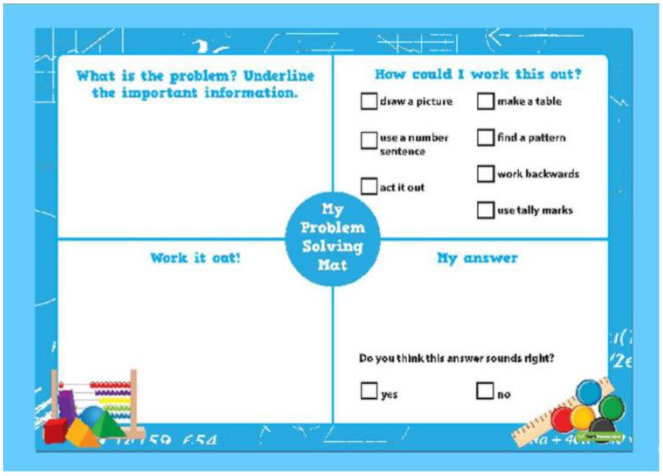
Date	Points discussed
18/11/2024	• Introduce lesson study • Discuss the roles and timeline • Explore what teaching through problem solving means • Discuss the research focus related to problem-solving
28/11/2024	• Set a date for the lesson to be taught • Set goals and start drafting the lesson plan
03/12/2024	• Continue with the lesson plan • Draw up list of resources to be used • Make a first draft of the main task of the lesson
15/01/2025	• Draft resources – justification fan, concept cartoon and mat • Finalise main task (Mrs. Green dilemma) • Setting a supermarket scene in class
22/01/2025	• Review the lesson • Filming of lesson and assign roles • Observation questionnaire

The problem-solving task and resources

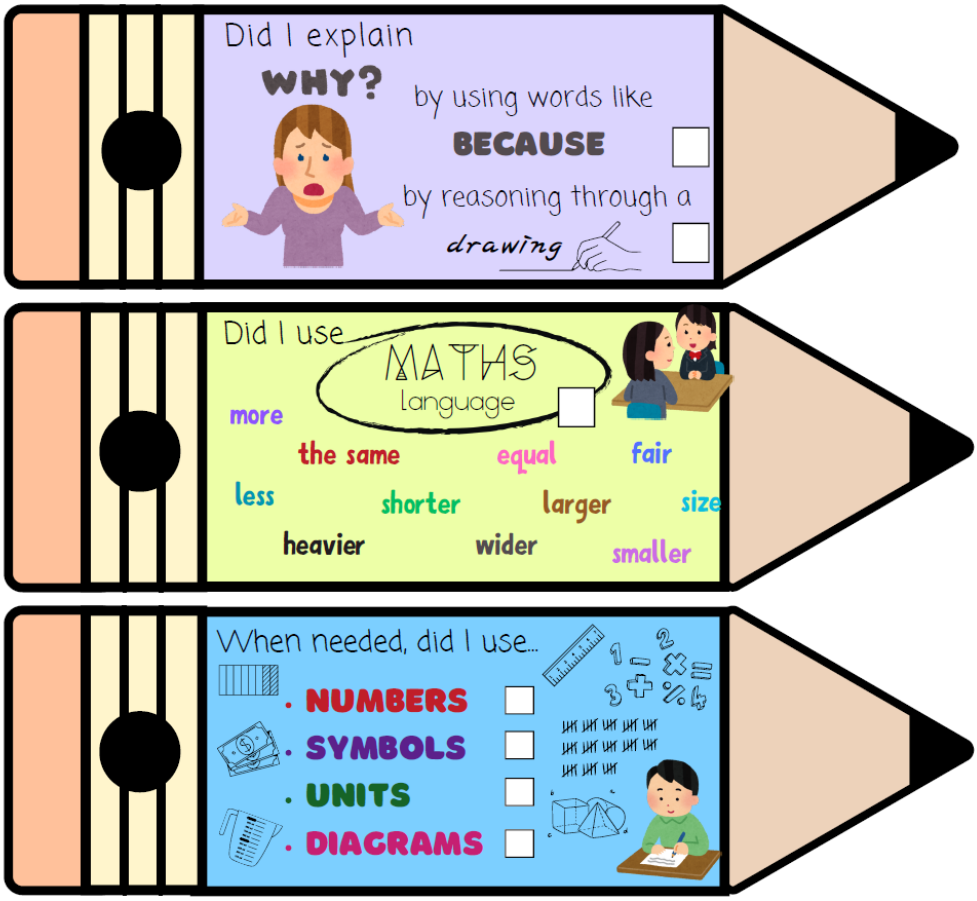
The concept cartoon group worksheet



The problem-solving mat



The problem-solving justification fan



The lesson plan

Phase 1: Introduction	
How will the lesson be introduced? What will you say and/or do to get them interested?	The supermarket situation will be introduced through a supermarket stall with four different hampers. Students are told that we need to gift a healthy breakfast hamper to a friend, within a **€25** budget. If students do not know what a budget is, they may watch the video in the link on the right.
What difficulties might students encounter?	1. What is a budget? 2. Determine what is considered healthy or unhealthy.
How do you intend to address these difficulties?	Define budget and show a video for further understanding. https://www.youtube.com/watch?v=WRcgRimBac8 Refer to previous material referred to during science lessons.
Phase 2: Students' work	
How will students work? Will they be involved in individual work? Or will they be asked to work in pairs or within a small group of 3 or 4 students? Explain how this will be done.	A concept cartoon, presenting four possible scenarios, is presented to the students. Students will be divided into groups, and each group is assigned a scenario (character) according to their ability. The four different characters are introduced, and each one is assigned to one of the four groups of students, the students will be asked to analyse the hamper that their character has put together and to check whether the hamper fits the given criteria: healthy and with a budget of €25. Each group must decide whether the character they are representing is a plausible option. They will work in groups on their working using the problem-solving mat that they are already exposed to. Each student will be given an individual worksheet to record their workings until they reach their final total. Students will be introduced to the justification fan tool to help them explain, through either using words like 'because' or drawing, reminding them to use the correct mathematics language and finally using numbers, symbols, units and/diagram in their justification. Justifications will be written on an A3 worksheet as a group.
What difficulties might students	Some students may come up with the dilemma of deciding whether it is good to have a healthy option;

encounter with the set task/s as they start working on it?	regardless the budget or staying in budget at all costs even if the option is not healthy. Students may think that since this is a mathematics lesson, they must provide a mathematical answer by strictly sticking to cost limits rather than associating the reasoning with the numbers (costs). Besides that, students may encounter Mathematical difficulties when calculating the total amount.
How do you intend to address these difficulties? What kind of help do you intend to provide?	These challenges can be aided by facilitating students with questions that will help them consider if it is possible to have a healthy option and still stay within the budget given. Scaffolded questions should be presented according to each group's need. Moreover, a justification fan will be given to each group to check if the different criteria were met.
Phase 3: Summary and closure	
How do you intend to bring the lesson to a closure?	All groups come together as a class to present their findings and take a unanimous decision about which hamper is the best one.
What difficulties might students face during this phase of the lesson?	Students may feel lost on where to start and how to explain what they found. There may be also instances where not all members of the group express their knowledge and experiences.
How will you try to address these difficulties?	First, students will be aided by the teacher as the moderator of thoughts during the discussion. The teacher can provoke harder or facilitate by using easier and more scaffolded questions according to the circumstances and level of discussion.

The two lesson study cycles

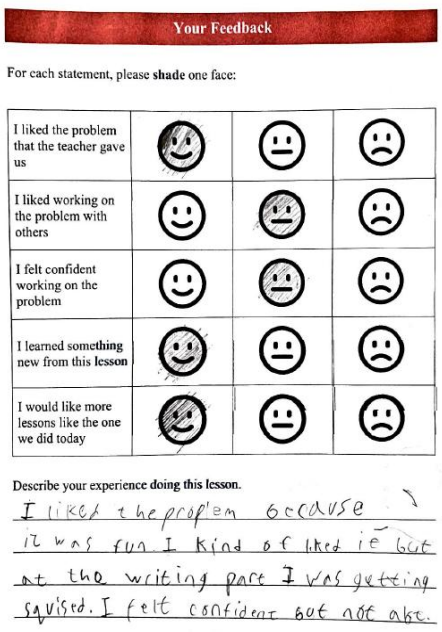
Cycle 1

Students were presented with four different hampers. The students were told that we needed to gift someone a healthy breakfast hamper within a €25 budget. The teacher made use of a concept cartoon where she presented four scenarios to the students. Each cartoon character represented a possible scenario. Students were divided into 4 groups, and each group was assigned a character according to their ability. Students were asked to analyse the hamper that their character had put together. Then, they had to determine whether the hamper was healthy

and within the given budget. The four different characters were introduced, and each one was assigned to one of the four groups of students, the students were asked to analyse the hamper that their character had put together and to check whether the hamper fit the given criteria: healthy and with a budget of €25. They worked in groups and used the problem-solving mat. Students were given a worksheet where


they had to write their workings. Students were also introduced to a justification fan to aid them to explain their findings. Justifications were done on a concept cartoon worksheet.

During the activities the class teacher and the other educators aided those students who struggled by asking scaffolded questions and helping them in the thinking processes. Afterwards, all groups came together to present their findings in front of the whole class. The students needed to pinpoint which hamper was the best one and they also had to explain their choice. At the end, the children filled in the exit



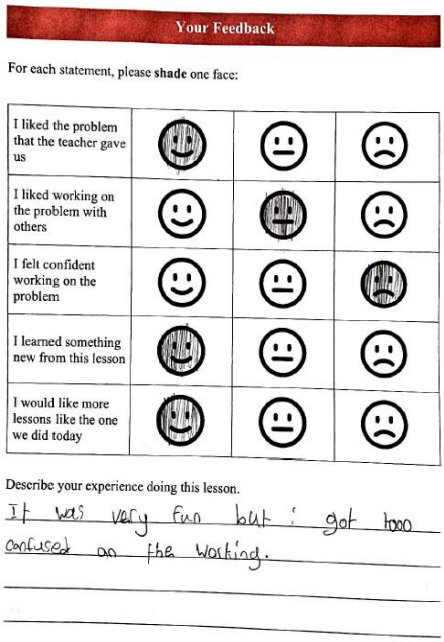
Your Feedback

For each statement, please **shade** one face:

I liked the problem that the teacher gave us	☺	😐	☹
I liked working on the problem with others	☺	😐	☹
I felt confident working on the problem	☺	😐	☹
I learned something new from this lesson	☺	😐	☹
I would like more lessons like the one we did today	☺	😐	☹

Describe your experience doing this lesson.

I liked the problem because it was fun I kind of liked it but at the writing part I was getting confused. I felt confident but not abt.



Your Feedback

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I liked working on the problem with others	☺	😐	☹
I felt confident working on the problem	☺	😐	☹
I learned something new from this lesson	☺	😐	☹
I would like more lessons like the one we did today	☺	😐	☹

Describe your experience doing this lesson.

It was very fun but I got too confused on the working.

ticket to indicate their level of understanding, their overall perspective of the lesson and any feedback they chose to share (see example below).

Cycle 2

In this lesson, we wanted our students to be able to analyse the different scenarios and decide on the best possible choice, followed by a justification for their choice. The aim of this lesson was to help our students grasp the concept of equivalent fractions, compare the various given options and agree/disagree with different statements whilst justifying their reasoning. In the introduction to the lesson, the students were presented with a cartoon of a situation of two children sharing a sandwich. Both children had the same amount of bread, but each bread was cut up in different shapes. Therefore, the children were expected to notice that each character had the same share of bread. Some of them noticed that these two characters had the same while others didn't notice it.

As a class they were encouraged to discuss this scenario and justify themselves. The justification fan was shown to them to help them justify their answers. Like the other class, these students were divided into four groups and were presented with another situation of a sandwich which was cut up into further parts. The children were shown four cartoon characters. These characters gave their views about the situations. The students were challenged to discuss each statement. Each character compared the sizes of the different split parts of the sandwich. The students needed to point out whether their character's thinking was correct. They were also provided some manipulatives for a more concrete experience since they were low achievers. The manipulative consisted in square cardboards cut into pieces. This represented the sandwich. They were also given other square cardboards where they could place the split pieces on it so that they would merge them together so that they would be able to compare the sizes of the pieces with each other. Each group was also given an A3 sheet of the four characters having their thoughts, another A3 sheet to write and justify their answers and a justification fan. The justification fan had words like 'because' or drawing, reminding them to use the correct mathematical terms.


Afterwards, each group presented their answers and reasoning to the whole class. Then, the teacher wanted to assess their understanding and gave them a worksheet. Overall, they showed a good understanding of the main concepts. Finally, they were given an exit ticket where the students assessed their level of understanding.

Post-lesson reflections

Teaching is always about decisions, deciding what fits best for each student. When designing the study-unit, the topic of money was chosen so students could learn to justify something they will use in real-life situations. This was more than just doing an addition or subtraction of totals but to decide for themselves by comparing, prioritising and choosing.


It wasn't just about reaching an answer – it was about understanding their thinking. Why did they choose those items? What made one hamper better than another? Were they focusing on cost, health, variety, or something else? To gain these insights, educators attentively observed student learning.

Initially, the plan was also to explore sustainability as part of the task – looking at food miles, packaging waste, and delivery emissions. The idea of connecting mathematics with real-world environmental issues was exciting, but once we started planning in more detail, we realised we were at risk of the lesson being too broad. The core learning—using money and making healthy choices – was already demanding enough. As Van de Walle, Karp, and Bay-Williams (2019) point out, younger students benefit more from deep, focused exploration than from surface-level coverage of too many ideas. Hence, things were kept simpler and more focused. We let go of the sustainability element and focused on two priorities: which is the most worthed and which one was the healthiest option. And it paid off. The engagement was very evident and most of the children were engaged in conversations. One group debated whether buying an amount of a product over another whilst some opposed the idea. These weren't simple calculations, they were reasoning tasks. And best of all, the students used our resources to explain their thinking. We heard phrases like "I know that this costs more, but it has more servings" and "I picked this one because it's lower in sugar, so it's better for you even though it's more expensive."

To help students focus more on how to justify, it was decided to use two key tools to support this: the justification fan and the mat. The fan helped students to express themselves by starting sentences by "I chose this because…", "This is better since…", and "I think this option works best because…". Besides, the chosen mat (which was used in previous lessons) was a visual prompt placed at each table that really helped some students in their decisions. Truly, these tools gave students structure and helped them build confidence in expressing their ideas, especially for those still developing their verbal reasoning skills. The tools became more than scaffolds; they became part of the thinking process. As Booker, Bond, and Sparrow (2019) suggest, rich mathematical tasks should encourage discussion, reflection, and real-world connections. That's exactly what was seen happening.

Another crucial decision taken, was to group the students by ability, so that different students were either supported or stretched as needed. The different hampers were prepared in such a way that the calculations needed to work out their total price were graded. Furthermore, one group of high achievers, was not presented with a hamper but was rather asked to design a hamper themselves, hence giving them the opportunity to be creative and extend themselves.

Of course, there were lessons learnt. For instance, some students focused only on price, forgetting to think about health. Others tried to stretch the budget by inventing discounts. But those moments led to some of the most valuable reflections. One stopped and discussed there and then with the students: Is cheaper always better? What does "best" mean when you're balancing cost and nutrition? Such decisions and principles were used in the second study lesson; this time about fractions. Although, the topic was changed, the principles of justification and tools were used.

In the end, the decision was to focus on student thinking. The lesson revolved around reasoning, not just results and answers. Giving students the tools to justify, explain, and reflect, they were observed stepping up and being active participants in their learning in a way that felt they were creators rather than only receivers.

Main takeaways

All team members involved in this lesson study reflected on how fruitful this journey was to their professional growth. During the initial stages of the planning, the main aim was to come up with a resource which would in return help the students come up with suitable justifications for their given answers. During both the first and second cycles of the lesson study, the resource which was created; the justification fan, proved to be successful in reaching the aim of both lessons. It was also highly satisfactory seeing the students also making use of the problem-solving mat which was created during last year's lesson study process. This shows that through the lesson study process not only are teachers given the opportunity to analyse and reflect upon the planned lessons but also collaborate to create new resources to help guide the students through specific problems that they might encounter. Through the lesson study, the students now have an additional tool which can be used cross-curricular.

The team members involved have highly appreciated the opportunity that they had when it came to observing the students and having the opportunity to reflect and observe how the lessons which they had planned turned out. During the first cycle of the lesson study, a lot of effort was put into creating elaborate resources. Upon reflection, the team members realised that whilst the lesson was highly engaging to the students, in reality there was no need to include so many resources and it's more beneficial to put the focus on the students' thinking skills as it

was concluded that it would have been more effective to dedicate time to enhancing their thinking skills rather than presenting them with resources which in day to day life in the classroom, the resources will prove to be too expensive and too time consuming to prepare and present on frequent occasions. In addition, in the post lesson discussion, it was discussed that in this lesson's case, the hamper shouldn't have been the focus of the lesson as it ended up taking way too much time from the lesson when the student had to calculate the total amount of the items that the hamper had. It was concluded that in this case, less is more and to not go too over the time limit as it happened it this case, more focus should have been on teaching the justification. In fact, during the second cycle of the lesson study, the planned resources where much simpler and this proved to be effective as the students were still engaged and were able to keep more to the set time for the lesson.

The lesson study proved to be a wonderful opportunity where the team collaborated wonderfully with each other. It was an opportunity to make use of everyone's background, knowledge and past experiences to prepare as best as the team could. It was a rare opportunity where the educators could shift their attention to a small number of students, observing their needs and which aspects of the lesson proved to be successful and/or needed amendments.

Through this lesson study, students had the opportunity to challenge themselves through scaffolded activities whilst remaining highly focused throughout. Another rewarding instance of this lesson study, for both cycles was how great it was to see students collaborating with

each other. During the first cycle of the lesson, the observers were all so pleased to see shy and students coming out of their shell and through using a new tool they managed to come up with detailed explanations for their reasoning. It was however also noted that some children were having difficulties working within a group setting and did better when working in pairs. The team concluded that it would be beneficial to include pair work rather than just group and individual work as it was also noted that some students had difficulties related to language barriers and so pair work could help ease this problem.

Lastly, another aim of the team was to, during the first cycle, to expose students to real life scenarios as it has become evident that they do not have enough real-life experiences going to the supermarket. It was concluded that the activity proved to be a good exposure to students who do not have the opportunity to visit the supermarket. However, it was also noted that given the fact that the main aim was for them to learn the justification fan, exposure to the supermarket scenario should be introduced in another lesson so that they will have more time and the teacher would be able to keep to the time limit of the lesson. Therefore, during the second cycle of the lesson, the students were also introduced to a real-life scenario, but they did not have any additional activities to do related to the scenario, and they mainly focused on how to use the justification fan.

Concluding remarks

Given the fact that for some of the LS team, this was their first experience, it must be noted that at the end everyone agreed that LS works because it improves the quality of teachers' professional learning processes (Vermunt et al., 2019). It has been a great experience for the first time members going through this process during the first and second cycle as well as for the other members who have presented this lesson study process to others and to continue building on last year's work.

It has been such a rewarding process. Despite at times seeming too hectic for the whole team to meet up, through understanding each other and working simultaneously for it to be a success, everyone agreed that this process has been crucial to the individuals' professional development as everyone had hands one experience. It has been a wonderful opportunity to observe colleagues and learn from their different learning styles. This process has provided the students with the

opportunity to be observed up close, and the observers had an opportunity to give in depth feedback of what aspects of the planning, worked and/or needed improvement. It was a one-off opportunity to observe in depth the different ways in which students understood the concept being taught and to then have the time to reflect upon the lesson taught.

This lesson study process provided the team with the opportunity to continue sharing these good practices, when presenting the first cycle of the lesson study at the end-of-project conference as well as later passing on the knowledge at the Council of Head for the school's college in hope that other year groups and schools will start implementing the lesson study project.

The team now only hopes that it continues to inspire other educators so that this lesson study process can form part of other teachers' professional development as well as it continues to offer students with the opportunity to continue enhancing their knowledge through different activities and resources presented.

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