Lesson Details	Lesson Study Group
Name of Lesson: Explain That Formula **Topic:** Surface Area of Cylinder **Year Group:** 5th **Level:** Ordinary	**School Name & Address:** Deele College, Raphoe, Co. Donegal **Associate:** Paddy Flood **Link Advisor:** Enda Donnelly **Teachers:** Shauna Kelly, Stephen Gibson, Katy Herron, Rose Stockdale, Orla McCafferty

Research Theme

At Deele College, we aim to develop students who engage purposefully in meaningful learning activities. We are putting particular emphasis on improving students' level of interest and participation in all curriculum areas, including Maths. Also, we want our teachers to select and use teaching approaches appropriate to relevant learning intentions and students' learning needs.

As a Mathematics Department we will actively support the achievement of these standards in the following ways:

(a) by delivering creative and effective instruction which is directed at encouraging deep student engagement through various methodologies.

(b) by promoting interactions among students and teachers which are respectful and conducive to positive attitudes to Maths.

(c) by encouraging students to contribute their opinions and experiences to class discussions with confidence.

(d) by valuing students asking questions and suggesting possible solutions confidently and safely, and getting them to see all responses, correct or incorrect, as learning opportunities.

(e) by developing in students higher levels of motivation, resulting in them getting enjoyment from engaging and persisting with increasingly challenging work.

(f) by enabling teachers to use a range of questioning techniques effectively for a variety of purposes including stimulating substantial student responses and extending learning beyond the lesson.

(g) by meaningfully differentiating content and activities to challenge all students.

(h) by providing opportunities to teachers to plan collaboratively learning experiences that enable and empower students to see learning as a holistic and lifelong endeavour.

Background & Rationale

School Self Evaluation (SSE) and DEIS in Deele College have specified a number of aims for 2022-2023. In relation to Maths, one aim is to improve student attitudes in Maths, and to develop effective student-centred methodologies to this end. We regularly survey students to gauge attitudes to Maths, with the aim of improving perceptions. We want to develop more positive answers when students rate their opinions on statements such as “I am good at school Maths”; “When I solve problems, I think of different ways to solve them”; “When a solution is reached, I am able to explain clearly to others how I solved the problem”. Our work here will specifically target development of the skills of multiple approaches to problems and clear communication of solutions.

We are looking to develop students’ understanding of student-friendly success criteria and how features of quality in CBAs can inform their work. Improving attitudes and perceptions of ability in Maths is part of the numeracy targets in our overall school DEIS Plan. In this Lesson Study we also plan to work on Digital Literacy skills. We will look to incorporate IT in constructive and purposeful ways.

In common with most schools, and as is clear from SEC examiner reports, teachers in Deele College have identified students regularly having problems with understanding and applying formulae. Ordinary and Foundation Level students have particular difficulties. This sometimes baffles teachers, who think of formula use as straightforward until they encounter reality in the classroom. Our students seem to lack confidence in dealing with basic algebraic techniques. In a survey of students on attitudes to Maths that Forbairt conducted, difficulties with algebra emerged as one of the main negative contributors to a lack of enjoyment of our subject. One aim in this lesson, as part of the overall unit, is to give students time to explore various approaches to developing, understanding and applying formulae. We want students to initially develop a specific formula (the surface area of a cylinder) using nets, scaled diagrams, physical models and possibly other resources such as appropriate IT. Through this development of the formula we anticipate a better understanding of exactly what the formula is, and the significance of dimensions and units. We then hope to facilitate better use of the formula for the surface area of a cylinder. We want students to get a sense of the power and effectiveness of formulae. Use of formulae is a skill which must be developed. This Lesson Study class will be a task of manageable proportions to give teachers and students useful insights.

Students must develop confidence and certainty in basic algebraic methods applied to simple situations. They must learn to apply a variety of approaches and methodologies. Furthermore, students need an understanding of the basis of these procedures, particularly how various elements of all strands connect with each other, as well as links to other areas of learning. If students cannot refer back to these links between elements that may have been introduced to them separately, then they will struggle to get the full benefit of Maths in general. They will also miss an essential purpose of our Maths course which looks for comprehensive understanding. We want pupils not only to carry out these investigations, but to find links with other aspects of the curriculum.

Relationship of the Unit to the Syllabus		
Prior Learning	**Current Learning**	**Future Learning**
U.2 Apply the procedures associated with each strand accurately, effectively, and appropriately **U.4** Represent a mathematical situation in a variety of different ways, including: numerically, algebraically, graphically, physically, in words; and to interpret, analyse, and compare such representations **U.5** Make connections within and between strands **U.6** Make connections between mathematics and the real world **U.7** Make sense of a given problem, and if necessary mathematise a situation **U.8** Apply their knowledge and skills to solve a	**3.4 Length, Area and Volume** 2D shapes and 3D solids, including nets of solids Using nets to analyse figures and to distinguish between surface area and volume Problems involving perimeter, surface area and volume Modelling real-world situations and solving a variety of problems (including multi-step problems) involving surface areas, and volumes of cylinders and rectangular solids Investigate the nets of rectangular solids and cylinders Select and use suitable strategies to find length of the perimeter and the area of the following	**3.3 Arithmetic** Check a result by considering whether it is of the right order of magnitude and by working the problem backwards; round off a result Accumulate error (by addition or subtraction only) Make and justify estimates and approximations of calculations; Calculate percentage error and tolerance **3.4 Length, Area and Volume** Use the trapezoidal rule to approximate area **4.2 Rearrange formulae**

problem, including decomposing it into manageable parts and/or simplifying it using appropriate assumptions **U.9** Interpret their solution to a problem in terms of the original question **U.10** Evaluate different possible solutions to a problem, including evaluating the reasonableness of the solutions, and exploring possible improvements and/or limitations of the solutions (if any) **U.13** Communicate mathematics effectively: justify their reasoning, interpret their results, explain their conclusions, and use the language and notation of mathematics to express mathematical ideas precisely **GT.1** Calculate, interpret, and apply units of measure and time **GT.2** Investigate 2D shapes and 3D solids so that they can: a. draw and interpret scaled diagrams b. draw and interpret nets of rectangular solids, prisms (polygonal bases), cylinders c. find the perimeter and	plane figures: disc, triangle, rectangle, square, and figures made from combinations of these Select and use suitable strategies to estimate the area of a combination of regular and irregular shapes Select and use suitable strategies to find the volume and surface area of rectangular solids, cylinders and spheres Draw and interpret scaled diagrams Investigate the nets of prisms, cylinders and cones Solve problems involving the length of the perimeter and the area of plane figures: disc, triangle, rectangle, square, parallelogram, trapezium, sectors of discs, and figures made from combinations of these Solve problems involving surface area and volume of the following solid figures: rectangular block, cylinder, right cone, triangular-based prism (right angle, isosceles and equilateral), sphere, hemisphere, and solids made from combinations	**5.1 Functions** – recognise that a function assigns a unique output to a given input – form composite functions – graph functions of the form • ax+b where a,b ∈ Q, x ∈ R • find the roots and turning points of functions • graph functions of the form $ax^2 + bx + c$ where a,b,c ∈ Q, x ∈ R **5.2 calculus** – find first and second derivatives of linear, quadratic and cubic functions by rule – associate derivatives with slopes and tangent lines – apply differentiation to • rates of change • maxima and minima • curve sketching

area of plane figures made from combinations of discs, triangles and rectangles, including relevant operations involving π d. find the volume of rectangular solids, cylinders, triangular-based prisms, spheres, and combinations of these, including relevant operations involving π e. find the surface area and curved surface area (as appropriate) of rectangular solids; also at Higher Level the surface area and curved surface area cylinders, triangular-based prisms, spheres, and combinations of these **AF.2** Investigate situations in which letters stand for quantities that are variable so that they can: a. generate and interpret expressions in which letters stand for numbers b. find the value of expressions given the value of the variables	of these	

Goals of the Unit

- Students will derive, understand and use formulae of measure.
- Students will demonstrate clarity on the meaning of and distinctions between length, perimeter, circumference, area, total surface area, curved surface area, nets, volume and capacity.
- Students will apply various approaches, interpret results, explain findings and justify conclusions.
- Students will apply their knowledge and skills to solve problems in familiar and unfamiliar contexts.
- Students will evaluate the appropriateness, benefits and drawbacks of each approach.
- Students will make use of suitable IT where appropriate.
- Students will develop confidence in communicating the ideas underpinning their work verbally and in written form.
- Students will be encouraged to extend these ideas to further scenarios.
- Students will reflect on the outcome of their work, looking at what went well and at what they may wish to improve in the future.

Unit Plan	
Lesson	**Brief overview of lessons in the unit**
1.	Units of Measurement Area and Perimeter of Square, Rectangle
2 & 3	Area and Perimeter of Triangle, Parallelogram, Trapezium
4.	Area and Perimeter of Compound Shapes
5.	Net of a Cube - Surface Area and Volume; Scaled Diagrams
6.	Net of a Cuboid - Surface Area and Volume
7. Research Lesson	**Net of a Cylinder - Surface Area**
8.	Volume of a Cylinder
9.	Sphere and Hemisphere – Surface Area and Volume
10.	Cone – Surface Area and Volume
11.	Trapezoidal Rule

Goals of the Lesson

a) Mathematical Goals

- Students will explore properties of 3-dimensional shapes.
- Students will attempt to generalise propositions, conjectures, outcomes and

results.

- Students will become aware of the possibility of using nets of 3-d figures to develop formulae on area.
- Students will use nets to understand how formulae are derived.
- Students will begin to appreciate the benefits and potential of using formulae.
- Students will learn to use appropriate formulae correctly.
- Students will look to make connections between various approaches.
- Students will communicate their learning effectively.

b) Key Skills and Statements of Learning

This lesson will promote Key Skills in the following ways:

- Being numerate: seeing patterns, trends, relationships and the significance of generalisation; gathering, interpreting and representing data; developing a positive disposition towards investigating, reasoning and problem-solving.
- Being literate: expressing ideas clearly and accurately.
- Managing myself: students will have the opportunity to reflect on their own learning.
- Communicating: students will present, explain, justify and discuss their mathematical thinking on measure.
- Being creative: students will be encouraged to explore options and alternatives and will actively participate in creative learning.
- Working with others: students will cooperate and will learn with and from each other.
- Managing information and thinking: measuring dimensions and applying them to formulae; becoming aware of units of measure; students will be encouraged to be curious, to think creatively and critically, and to reflect on and evaluate their learning.

Flow of the Lesson		
Timing, activities, steps, resources, problems	**Teacher support, activity**	**Assessment, questions, comments, strategies**
Introduction To start proceedings the teacher will introduce any guests and observers and will emphasise to students that class will be conducted as normal. The teacher will briefly explain the role of the	At the start of the class the teacher will divide the class into pairs at tables, ensuring differentiated levels of student abilities within each group. The teacher will discuss	Use nets (plans), exploded views. Provide cylindrical objects such as Pringles boxes, toilet rolls, etc., to enable physical dismantling or

observer (observing work, gathering information, taking photos as a record of work, etc.). The teacher begins by presenting the learning objectives of the lesson: ● Students will explore the area of the surfaces of a cylinder and formulate and apply various approaches. In particular, students will try to develop a general formula for finding the total surface area of a cylinder. Students will then interpret any results, explain findings and justify conclusions. The class has been working in previous classes on finding lengths, areas and volumes of various shapes, either by formulae or modelling. An initial examination of a cylinder was presented as the previous night's homework. This gave the students an opportunity to consider the problem and to start to formulate solutions. It also gives the	homework as a basis for today's work. We want to be certain that students understand basic ideas and terms associated with investigation of measure of 2-d and 3-d shapes. We need to use effective questioning to ascertain students' prior knowledge.	decomposition of a cylinder. Prepare and practice relevant terminology in advance. Differentiation - we hope to get to the point where stronger students can be asked to explain clearly the derivation of formulae. Check diagrams the day before the live class (students often struggle with scaled diagrams, accurate drawings, units of measure, correct use of geometry equipment). Can students express to a reasonable level what they know about the properties of a cylinder? Are students clear on the concept of surface areas of 3-d shapes? Are students clear on the concept of nets of 3-d shapes? Are students clear on the distinction between curved surface area and total surface area, where relevant? Do students understand how to calculate lengths

opportunity at the start of the research lesson for the teacher and students to clarify any uncertainty about what is being asked in the problem. 'Before we start today's lesson, did you notice any interesting facts about the properties of a cylinder?' 'Did you put any thought into how to identify important features associated with the measure of cylinders?' 'What would we like or need to know about the dimensions of a cylinder to be able to draw the net?' 'Have you thought about how we could analyse the surface area of a cylinder?' 'What might help us break down the surfaces of a cylinder to find the overall surface area?'		and areas of surfaces of various sizes? Are students clear on the various possible approaches?
Posing the task Each student in the class will have had a chance to take a preliminary look at a cylinder. Each student will be assigned the same cylinder to work on with dimensions diameter of 5cm and height 6cm. Students will work individually for 10 minutes, then in pairs (or	Teacher ensures clarity for all students on what they are being asked to do.	Ask brief questions to make sure everyone understands the problem to solve and the desirability of different types of approaches.

in groups of 4) for 15 minutes The students' task will be to calculate, organise, and analyse the areas of surfaces of the cylinder. They will also be asked to justify their conclusions. Students will be encouraged to look at the potential benefits of developing an appropriate formula if possible, based on their concrete examination of the problem. **'Now I would like each student to look at one cylinder along the lines of our homework last night. You are asked to find the total surface area of the given cylinder. You will work individually for 10 minutes, then as a pair for a further 15 minutes, on this problem. Calculate areas of surfaces of a cylinder with diameter 5cm and height 6cm as in the diagram on your desk. <u>Whatever way you look at the problem, you are required to draw a net of the cylinder at some stage.</u>** **How could you find the total surface area of any cylinder? i.e. can you develop a formula?**		

When we have looked at the problem, I will ask a number of you to come to the board to outline your answers, explain your ideas and to take some questions from the class.'		
Student Individual Work [10 minutes] and Collaborative Pair Work [15 minutes] *Student Response 1* Draws an inaccurate net (wrong shape). *Student Response 2* Draws net inaccurately by measurement which does not fit. *Student Response 3* Draws accurate net from physical measurement only. *Student Response 4* Draws accurate net connecting the length of the rectangle surface (curved surface of the cylinder) to the circumference of the base circle. *Student Response 5* Constructs accurate net and works out the **curved** surface area using this net.	Use teacher's seating chart (or equivalent on Lesson Note app on iPad) to record the approach used by each student and each pair. Note the order in which you will call a representative from each pair to the board during Ceardaíocht, based on increasing sophistication of each pair's work. The aim will be to have a student or pair come to the board to outline and explain examples of any type of approach to producing a solution. Observers will use the *Observation Template* designed by the group of teachers (see Appendix 1) to gather and record relevant data. Observers must be clear on their tasks (watching progress, listening to conversations,	As teacher walks around classroom, are students able to meaningfully engage with the problem? Can students demonstrate an ability to look at the problem in different ways? Where necessary, encourage physical dismantling of cylinders to explore their dimensions, surfaces and other properties. Where necessary, suggest approaches such as rolling out cylinders, tracing or tracking paper, e.g. label of tin, roll of kitchen paper. Can students develop multiple solutions? Are students identifying key features of organising

Student Response 6 Constructs accurate nets and works out the **total** surface area by adding the areas. *Student Response 7* Constructs accurate net, works out the total surface area and generalises to find the formula for total surface area of a cylinder. Then uses this formula correctly.	recording evidence of progress and points of interest). Observers should be particularly looking to record evidence of moments when key learning occurs. If students are having difficulties, the teacher may guide them by asking appropriate questions. Students or groups may struggle to see different possible approaches. The teacher may gently guide them towards approaches that are not occurring to them after a period of time. We expect that this may occur when breaking down the surfaces. The teacher will look out for this, and may offer some initial help such as indicating how a concrete model may be used. During the "Ceardaíocht" phase discussion, students will be asked to comment, reflect and elaborate on what other students say. The teacher will use this and other strategies to ensure that all students remain engaged. The teacher will look out	strategies for solving the problem? What limitations may apply to different approaches to solving the problem? What strengths and weaknesses does each proposed solution have? Do any approaches have so many advantages that we may wish to focus on them in future? Why are some approaches more useful than others? By identifying key features in each approach, could solutions have wider applications? Can we develop a general solution, such as a formula?

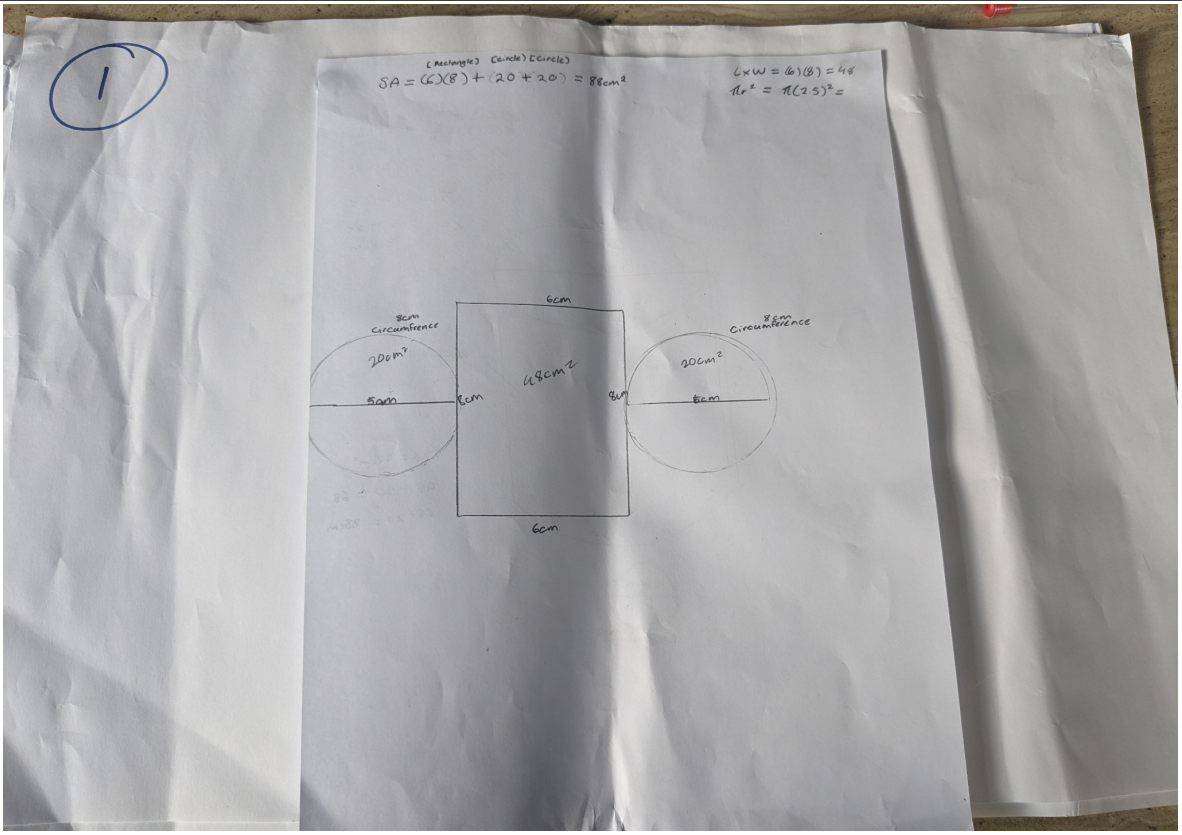
	for opportunities to use student errors or misconceptions to consider and analyse common difficulties among students. After 10 minutes of individual work, the teacher will ask students to work in pairs. The aim of the pair or group work is to debate the various approaches offered and to enable effective communication. This pair work almost serves as a pre-Ceardaíocht.	
Ceardaíocht /Comparing and Discussing [20-25 minutes] As students or groups are developing solutions, if it becomes apparent that some of the above approaches are not emanating from any student or group, the teacher may hint at or give some basic guidance towards considering them. The teacher must ask questions of the presenter and of other students, to try to ascertain levels of understanding of key elements of solutions. It is important that the whole class is engaged	It is a central component of the whole Lesson Study process that, when students are presenting solutions at the board, they must communicate verbally with the teacher and the class. The teacher must ensure this. Appropriate comments or questions may be helpful. Write any student answers and predictions on the board. If there is enough time, the teacher could employ Solid Works or Geogebra to expand on various forms of analysis.	Can each student clearly explain his/her approach to solving the problem when up at the board? Can each student justify elements of his/her solution and communicate this effectively? Can students express an understanding of solutions developed by others? Do students recognise similarities or differences between their own approach and that presented on the board?

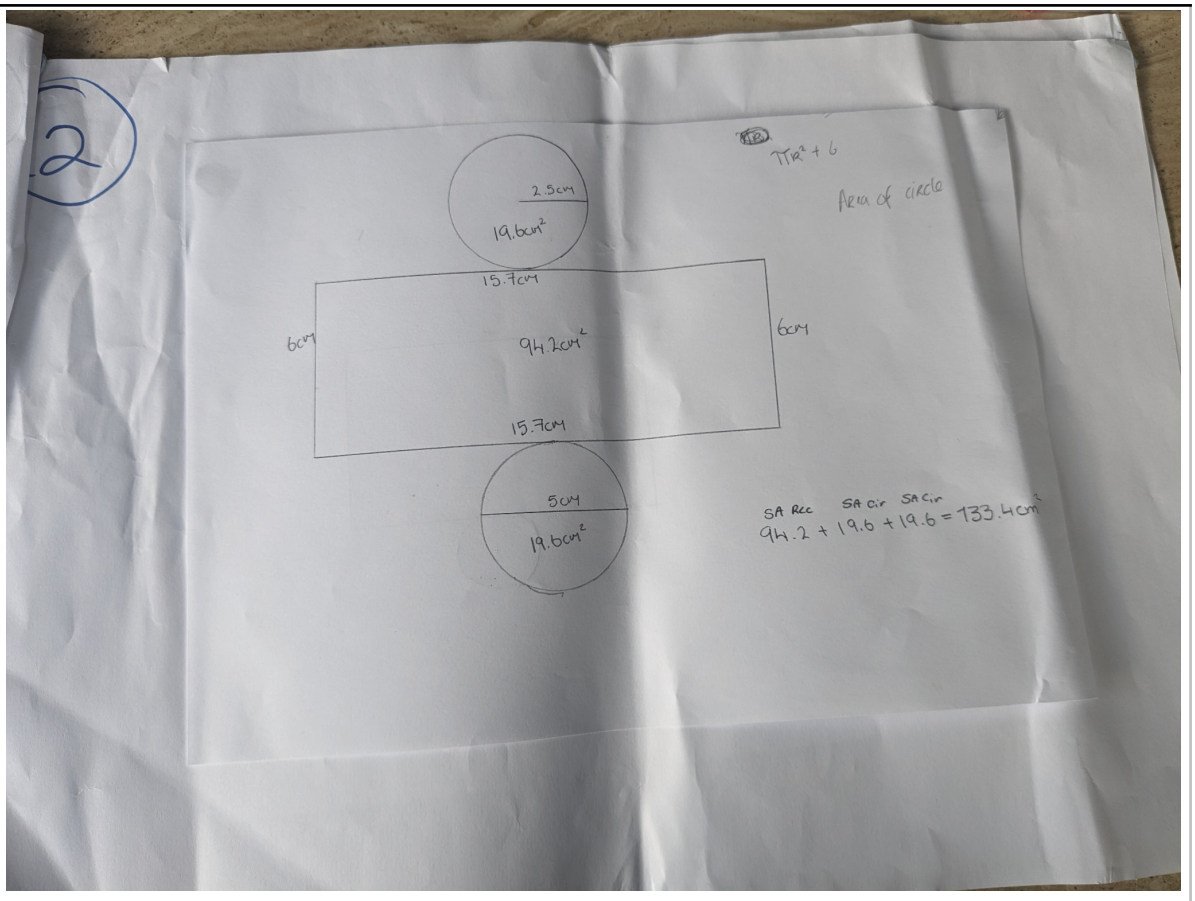
and that students understand they may be called on at any stage to reflect on what another student said. The teacher must keep in mind that clear student communication and understanding are goals of the lesson. In keeping with the goals of the lesson, teacher questioning will focus on the most important elements of proposed solutions, as well as how students worked. For example, “How does the size of the cylinder affect your approach to investigating it?”; “When the curved surface is ‘rolled out’, what shape is it?”; How could you find the circumference of the base circle of the cylinder?”; “It’s an area problem - why are we bothered with the circumference of the base circle?”; “What connection is there between the base circle and the curved surface?”; “How did you find this result?”; “Could anyone suggest another approach in this case?”; “Did anyone else get a similar result?”; “Is this the best strategy?”; “Explain the meaning or	At the Ceardaíocht stage it is important to keep in mind the goals of the lesson. The focus of the teacher’s questioning and direction of the discussion should be guided by these goals. Students may need to be reminded that a major goal of the lesson is to examine the problem in a variety of ways, not just to find a solution. This also allows for differentiated work, allowing stronger students to be challenged while weaker students can maintain confidence in their work. For each anticipated student response the teacher (in conjunction with the full Lesson Study group) will have prepared a basic initial position (typically an appropriate diagram) as a starting point for the student to build on and develop his/her solution on the board. When a student presents work on a board, make sure to attach his/her name (or a group’s name) to it.	Do students offer alternative approaches to solving the problem? What major misconceptions or errors are arising as discussion of solutions is proceeding? If a solution does not work out, can students see exactly where the problem arose?

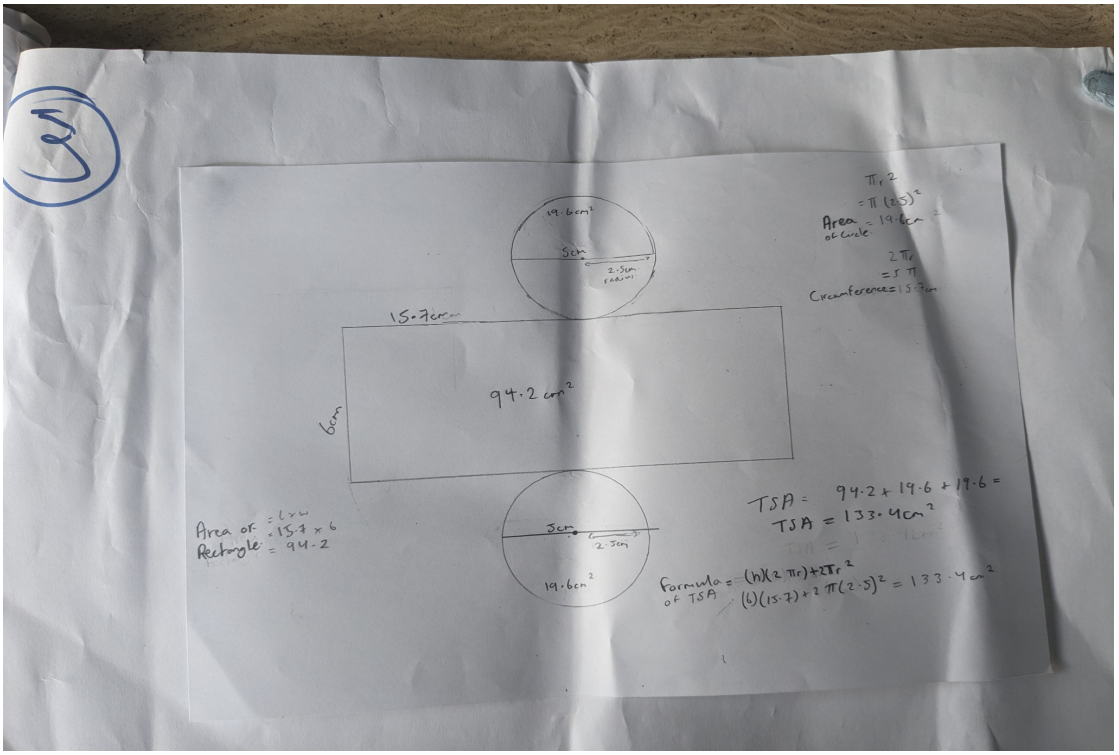
significance of this result.”; “Would you prefer a physical or formulaic approach here?”; “Why?”; “Why are you looking at a lot of examples?”. Teacher will pay attention to the use of π. Are students clear on how to use calculator when dealing with π? What is the advantage of giving answer “in terms of π” or approximating? The teacher should highlight comparable and different features in various solutions. For example, “Can anyone see any similarities or differences between the outcomes for various examples or various cylinder sizes?”; “What does the outcome tell us?”; “Compare and contrast the differences we have found.”; “Were you surprised by any result?”; “Is that a coincidence, or do you feel it happens all the time?”. Teacher questioning should lead debate on interesting features, merits or misconceptions of solutions. When all solutions have	Ask other students to raise their hands if they used the same method. When each anticipated solution has been presented and discussed, ask did anybody use a different approach. The teacher should use any opportunity in the discussion to introduce terminology, e.g. dimensions, length and circumference, circle, disc, surface, edge, prism, surface area, net, curved surface area, volume, capacity, units of measurement, approximation, error and tolerance, etc. From past experience we have found that students have difficulty communicating with the class when they are presenting solutions at the board. They often “talk to the board”, or don’t talk at all. The teacher must ensure that presenters engage clearly with the class.	

been presented, the teacher may pose the question “Was any solution particularly good or interesting or surprising? Why?”. The teacher could also ask students to consider if the comparisons between solutions may apply generally to analysis of the situation. To finish the Ceardaíocht stage, the teacher will ask students to move around classroom on a “one stay rest stray” basis, i.e. one student from each group will remain at his/her table to answer any questions, while the other students move around to look briefly at the work of others.		
Summing up & Reflection Teacher will use Mentimeter to ask students to write down any major thing they learned in class. [Padlet a possibility here too].	Teacher must explicitly ask students to give specific, detailed comments.	Are responses too general, or do they show evidence of progress in the main aims of the lesson?

Board Plan


1
[Rectangle] [Circle] [Circle]
SA = (6)(8) + (20 + 20) = 88cm²
LxW = (6)(8) = 48
πr² = π(2.5)² =
6cm
5cm
circumference
20cm²
48cm²
8cm
circumference
20cm²
5cm
6cm


2
2.5cm
19.6cm²
15.7cm
6cm
94.2cm²
6cm
15.7cm
5cm
19.6cm²
Area of circle
SA Rec SA cir SA cir
94.2 + 19.6 + 19.6 = 133.4cm²


3
19.6cm²
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2.5cm
15.7cm
94.2 cm²
6cm
5cm
2.5cm
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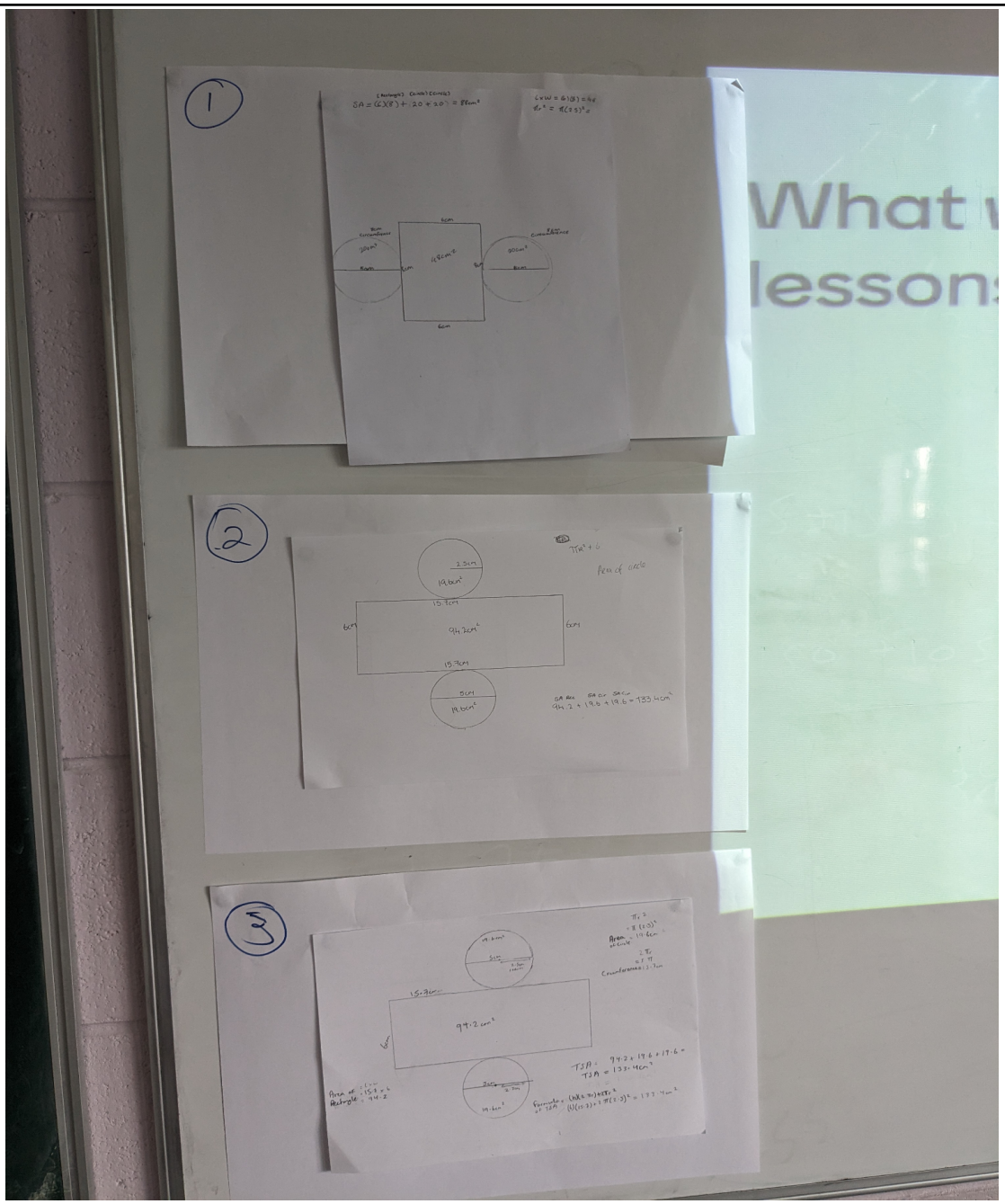
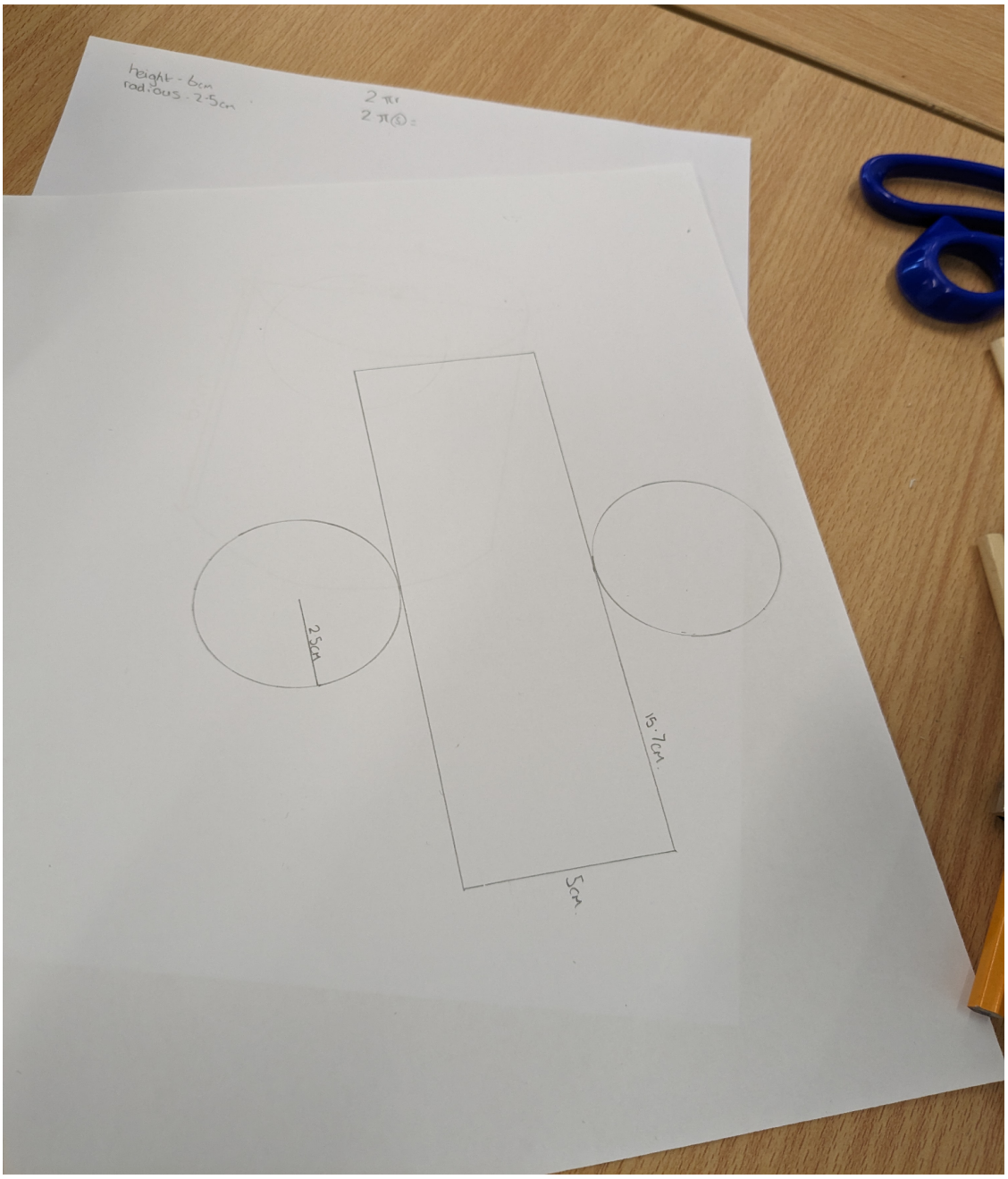
Area of Rectangle = 15.7 x 6 = 94.2
Area of Circle = 19.6cm²
Circumference = 15.7cm
TSA = 94.2 + 19.6 + 19.6 =
TSA = 133.4cm²
Formula of TSA = (6)(15.7) + 2π(2.5)² = 133.4cm²


1
2
3
What
lesson

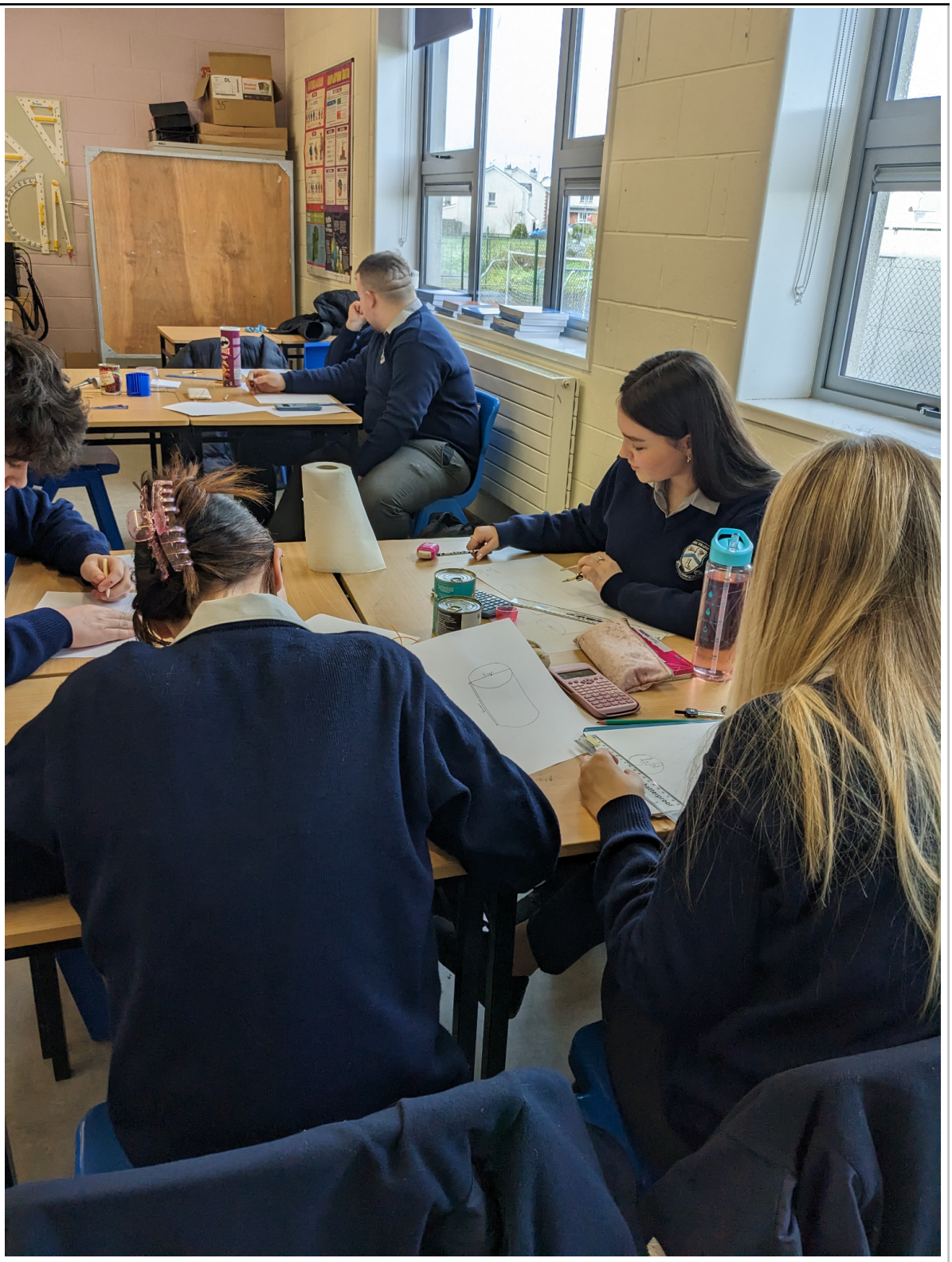
Evaluation of Lesson

In general we were happy that the lesson went well and most of our aims were reasonably well achieved. Our main focus was to look at how students could move from concrete work to creating an appropriate formula. This would help understanding of and correct use of the formulae associated with a cylinder. This has often been surprisingly difficult for students. We wanted to study how they went about measure and where particular difficulties arose.



Preparation in advance helped the lesson to flow well and the activities prepared did enable the students to get to grips with the problem physically, numerically and algebraically. We felt in previous years that we perhaps tried to cover too much in the class and we therefore limited the task. We wanted to keep our central focus. Differentiation of work is something we must consider in Lesson Study and indeed in our work in general. Concrete models and drawing of diagrams helped weaker students to get a foothold in the problem. The use of foldable shapes and items like toilet rolls made deriving relevant formulae, and correct use of these, more likely. Students were able to move from the specific cylinder in this lesson to general formulae. The strongest students sometimes had the work done quickly here and could have spent the time after that on some extension of the problem. This could have involved activities such as dealing with an open cylinder, other shapes or real-life examples. Although it was a priority they think in-depth about the main problem, we could try and plan for some extended activities too. On the opposite side, sometimes weaker students check out of the problem entirely if they feel that they're in trouble and they may lack confidence. Once again, we need to consider carefully how we can address this. Concrete aids helped these students to feel more able to engage. One type of model we didn't emphasise, that may have given another perspective to students, would be to cut out the net and try to make the 3-dimensional shape. The dimensions we chose for our cylinder were to enable the net to fit on an A4 page. We possibly could have considered using a larger net on A3 or A2 paper. This would require larger compasses than the standard maths set model, but may give more clarity.

In previous rounds of Lesson Study we felt that setting up the students to work in pairs was better than working in groups of four. In pairs everybody had to engage, whereas in groups of four weaker or less confident students can sometimes stop working and contribute less. However, this year, pairs of students gravitated to wider discussions around their tables of four, and this was quite productive.



A lesson we learnt previously was that we must take care in selecting pairs or groups rather than allowing the students to select pairs themselves. We made an effort to mix stronger and weaker students. We find that weaker students can learn

from the stronger ones and stronger students themselves can benefit from teaching and therefore really understanding the solutions in depth.

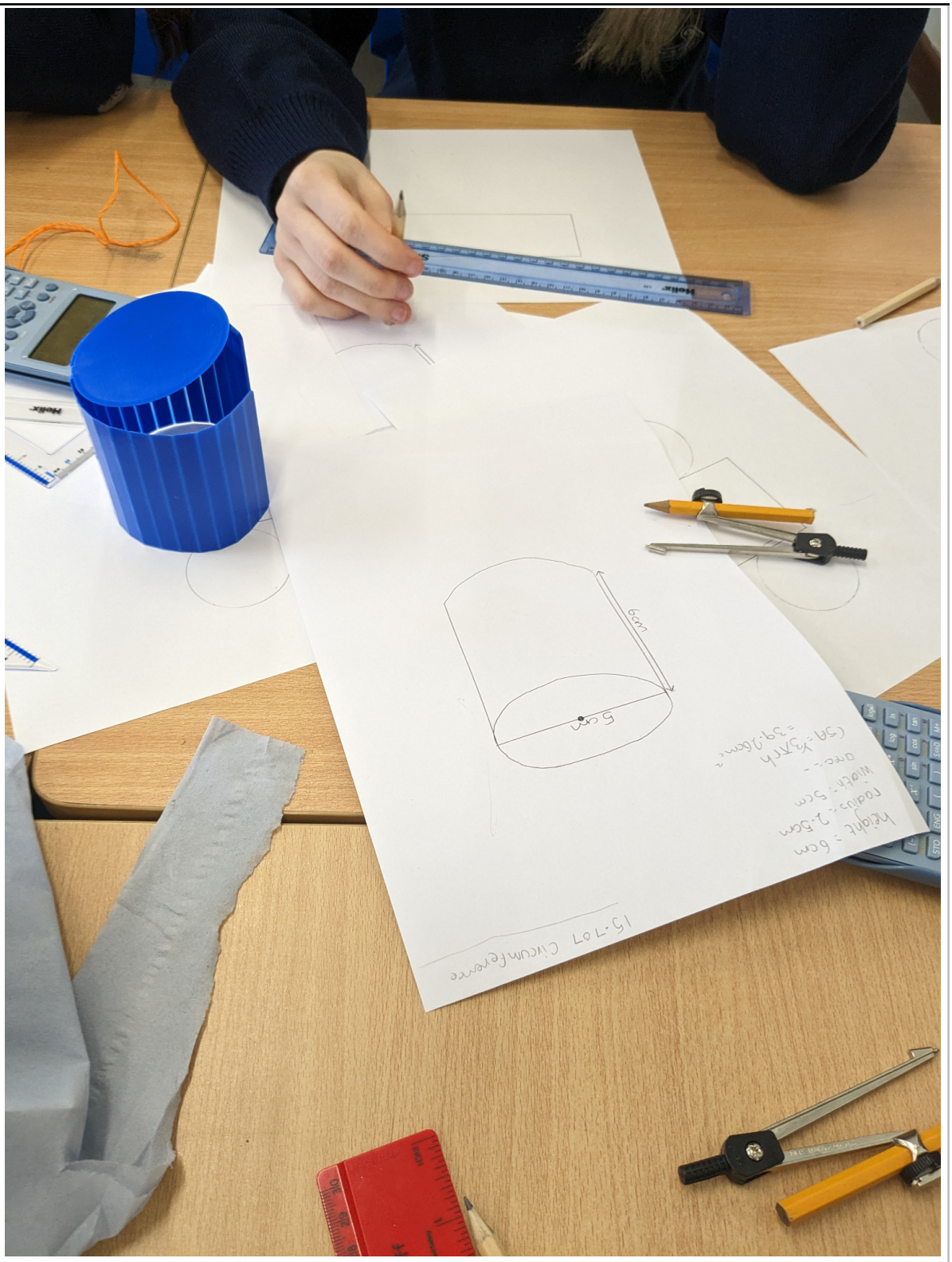
From previous Lesson Study work we found that students when brought up to the board will write the answer without communicating or explaining if they are not encouraged to do so. Therefore when preparing the lesson we placed particular emphasis on the need for the students to communicate and explain their work when at the board. This was the basis of discussions on the solutions. The teacher took particular care to ensure that this happened and it worked well to the point where classmates were interacting and asking useful questions seeking further explanation from the person at the board. Most students seem to enjoy their time at the board. This was very positive. In the feedback we found that students said that they liked it.

We anticipated only a small number of substantially different solutions from the students, and this proved to be the case. In hindsight we could have modified our boardwork to ensure students wrote everything large enough, and in clear marker, to be more clearly visible to everyone in the classroom.

The teacher felt after the lesson that perhaps she could have sought feedback at different stages of the class, rather than at the Ceardaíocht stage only. We might look at this in future. It was very productive to give adequate time to students to explore and deal with difficulties and misunderstandings. They made their own progress. More time is also needed for discussion of potential solutions at the board. We should accept slow or very little progress, as long as there is productive thinking. There is a time for the teacher to intervene, but perhaps more slowly and mainly to help undo some fundamental confusion. We were satisfied that the teacher got the balance reasonably well here. Students taking a wrong path is not a bad thing and can be very useful but we don't want students to be very confused in basic ideas.

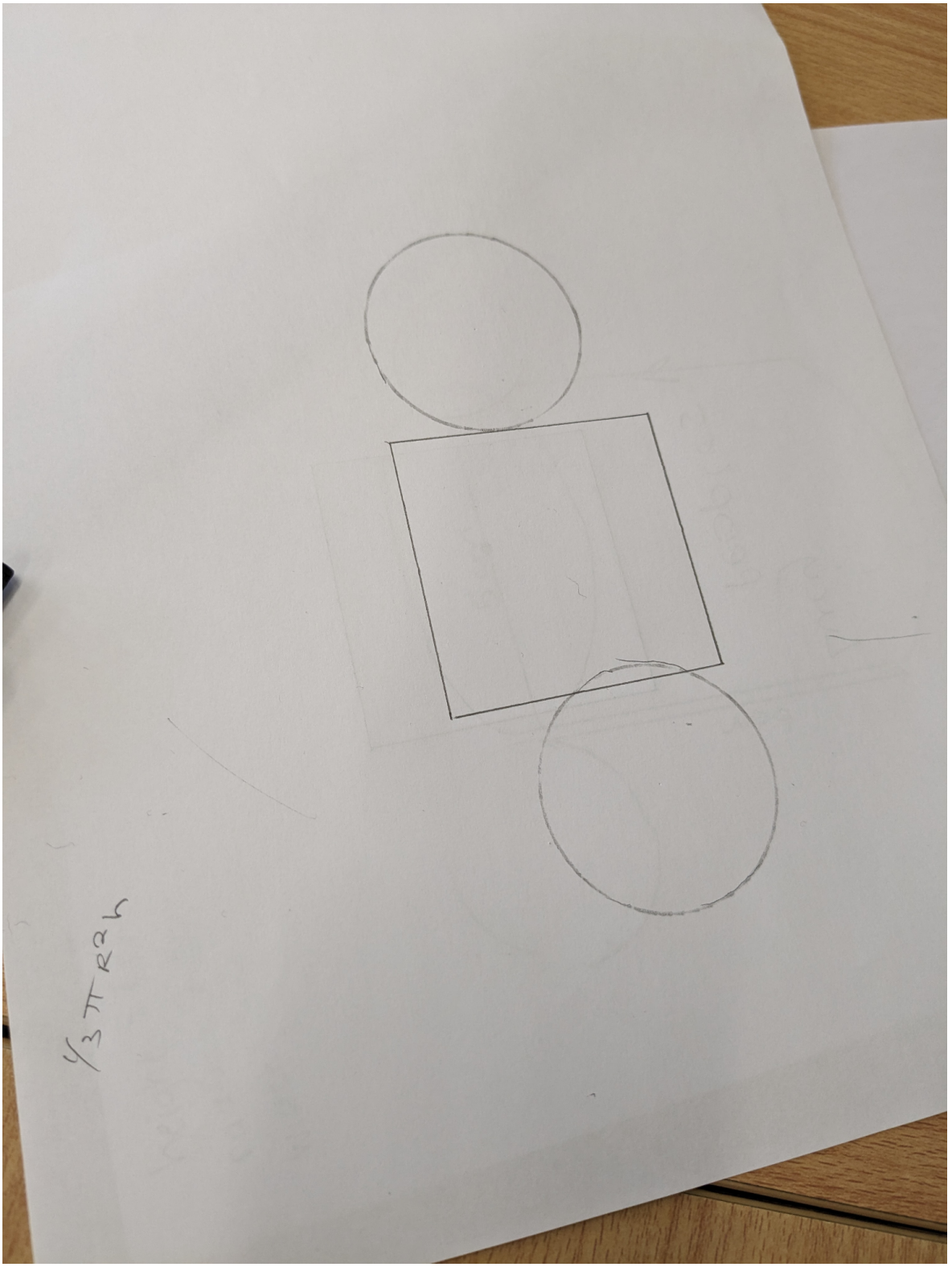
In previous years' Lesson Studies we felt we did not devote enough time to the importance of the observation of students' work. This year we focussed more on this. We discussed exactly what each observer should be doing and what they should be looking out for. We watched how the students progressed through the problem, looking for the key moments in their discussions where development and understanding occurred and gathering evidence to demonstrate these steps.

As always the students provided a number of very interesting moments in the class. The blue foldable model led to a lot of productive debate on accurately developing the net of the cylinder.

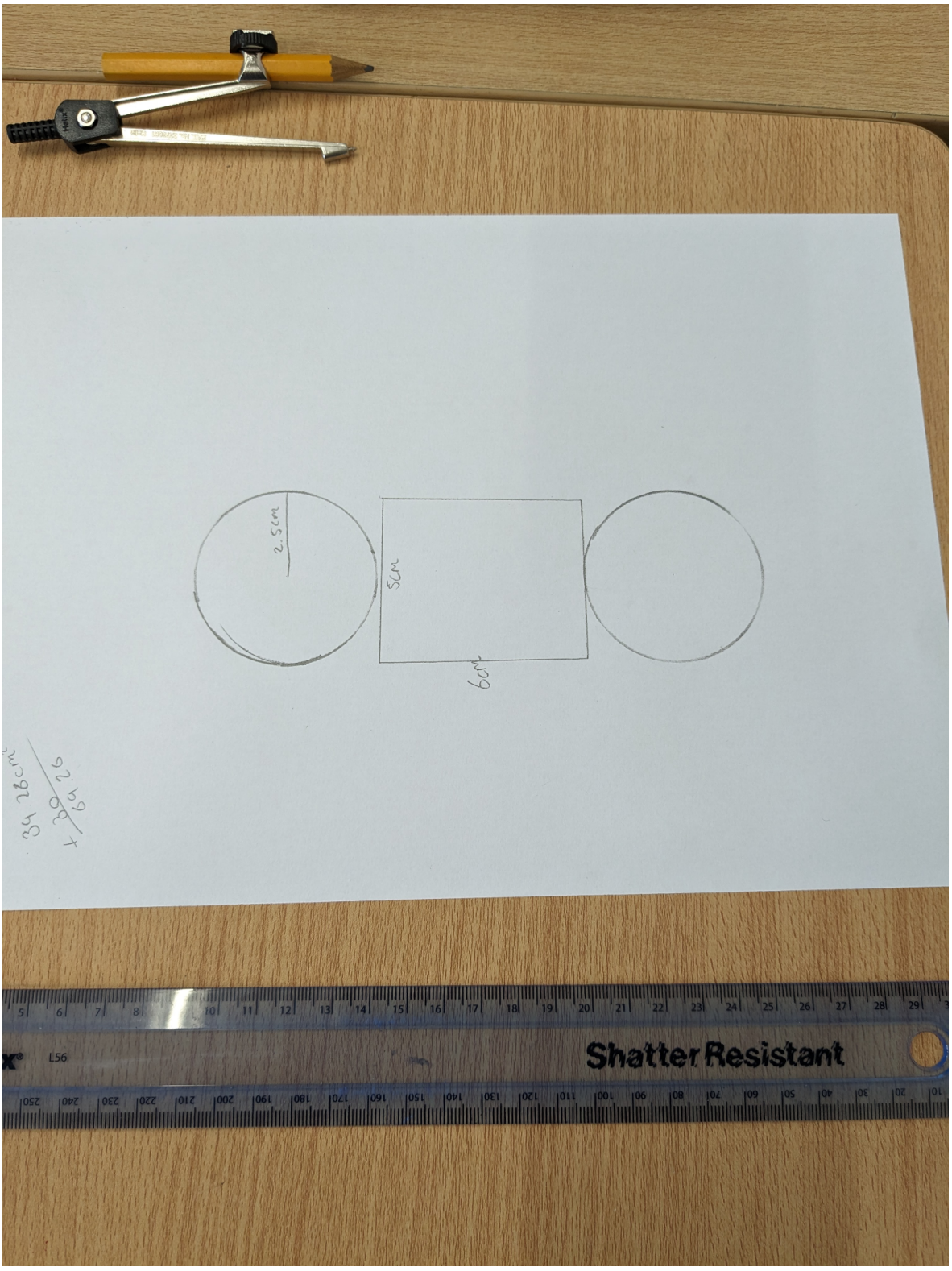


One student used the toilet roll to explain to her group how she saw the net, and how to link the measurements of the 3-dimensional shape to the dimensions of the 2-dimensional net. This was very interesting and creative.

While most students made the connection between the circumference of the base circle and the length of the rectangle in the net, a number of difficulties arose consistently. Firstly, getting the correct measurement of this length proved surprisingly challenging for many.



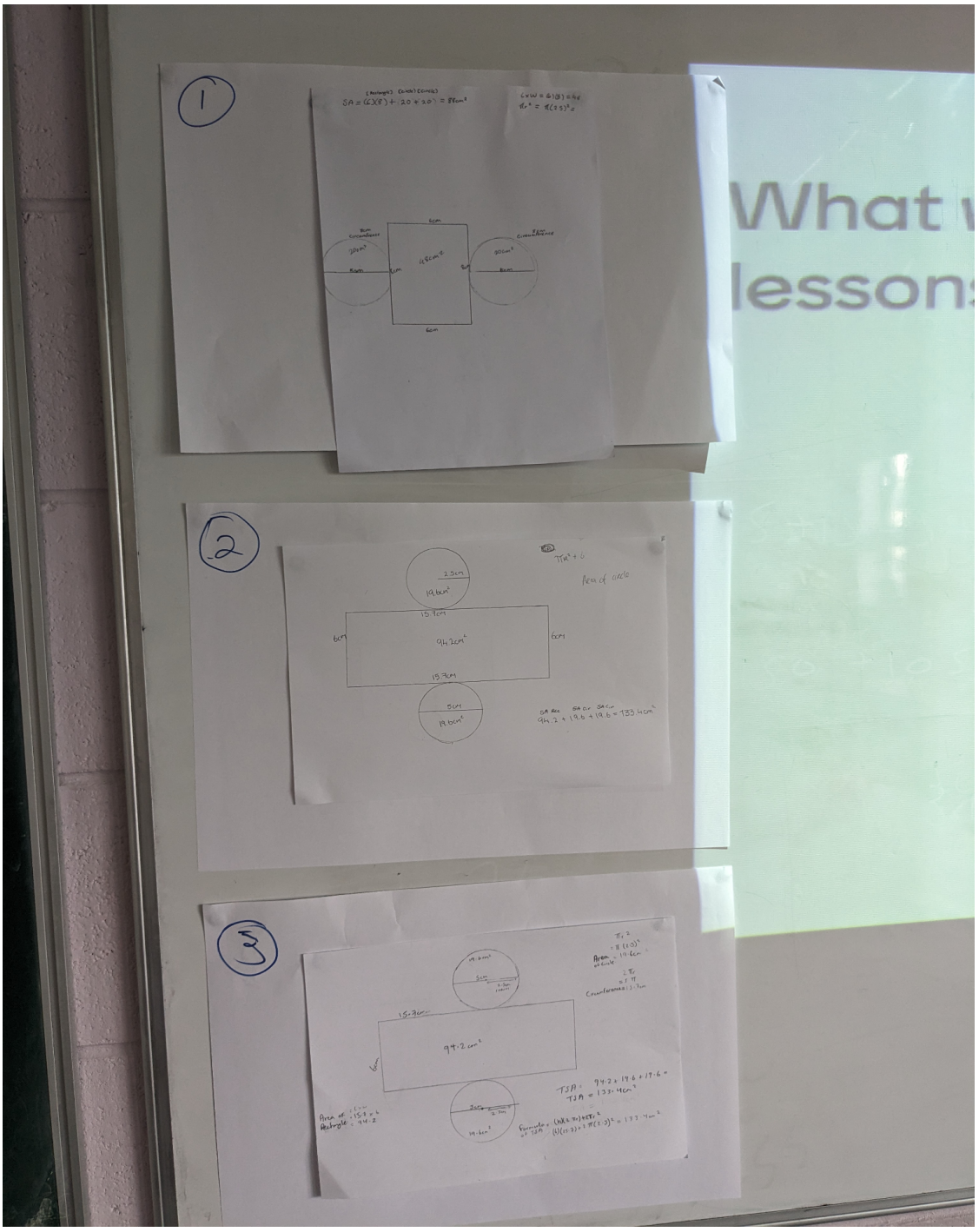
Secondly, a small number of students placed the circles in incorrect positions in the net.



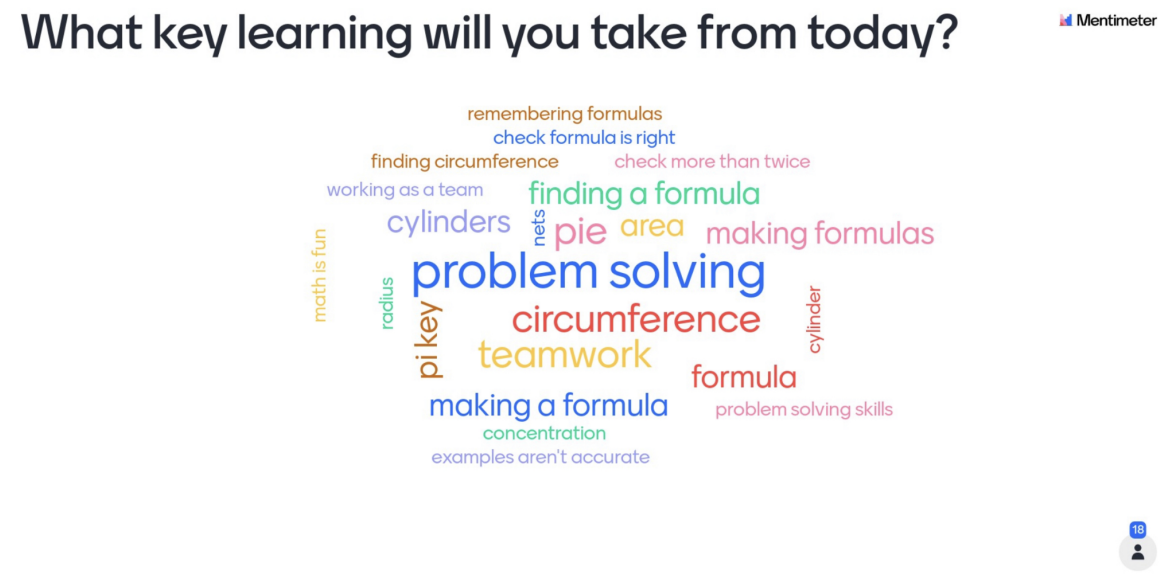
Finally, and most commonly, students frequently struggled to use a compass properly, to draw properly measured diagrams or to deal accurately with units of

measure. For good 5th Year Ordinary Level students this was surprising. Handling π also needs to be practised. Teachers observing felt that they would incorporate these problems into their work in future.

We used a camera to show the question being done at the board more clearly to the students in the classroom. This had the drawback of making student solutions on the board seem slightly less visible.



Another possible use of IT would be to use Lesson Note to keep precise track of exactly how much time is being spent on each activity. For example, for how much time is the teacher talking, how much time has been spent at the board, how much time has been spent with class interaction and questioning while working on the board. Use of Mentimeter to get student feedback at the end worked well, although we could put a bit more thought into exactly what questions we could ask in this feedback to get the best possible data. Feedback from the students was generally positive. They enjoyed the class. They specifically enjoyed the interaction between the class and the person at the board and the communication. Almost all felt that they had learnt something from the lesson, whether it was getting an understanding of the net of a cylinder, finding some elements of the surface areas or deriving parts or all of the required formula for the total surface area of a cylinder. In future planning, we must ensure enough time is given to the feedback stage. Also we must ask students to be specific about what they felt they learned, not just offering generalities. Students need help to develop this skill.



Summary of Key Learning	
Point 1	We must emphasize the importance of observing how students move through a problem, looking for the key moments in their discussions where development and understanding occur and gathering hard evidence to demonstrate these steps. Otherwise we cannot adequately assess their progress and give feedback.
Point 2	We should plan to give adequate time for the students to explore and fail before they can make their own progress. More time is also needed for discussion of potential solutions. We should accept slow or very little progress, as long as there is productive thinking.
Point 3	Directly and explicitly linking suitable concrete models to essentially algebraic formula work has the potential to help students to understand scenarios more deeply. This type of work could form the basis of better formula use, which many students find tricky.
Point 4	Differentiation of work is something we must consider in Lesson Study and in our work in general.
Point 5	We must practice the use of geometric equipment and the drawing of accurate scaled diagrams thoroughly. These are real weaknesses in students.

Final Reflection
In Deele College Maths Department we continue to find Lesson Study a valuable process. It gives us a chance to meet and talk about issues around our teaching methods and how our students learn. The most enjoyable and productive part of the experience was informally sharing ideas and making suggestions to each other. Every year we take part in Lesson Study we learn new things. We see areas of strength and areas to improve. Without exception, every year we have our eyes opened by our students, who offer new creative ideas that may not have occurred to us. As a collective department we benefit hugely from Lesson Study. A final thanks for all the support from the PDST, which helps us get the most we can from the process, and from the management in our school who wholeheartedly back us and see the benefits for teaching and learning.

APPENDIX 1

Observation Template

Observation Template

School: Deele College Raphoe

Title of Lesson: Explain That Formula

Date:

Introduction and Prior Knowledge	
Posing the Task	
Student Individual Work	• What methods did the students use to solve the problem? • **How well did students manage their work and develop strategies?** • **Did each student develop at least one approach?** • Did students explain reasoning behind choices? • Were any anticipated solutions not used? • What comments or questions did the students have? • Did students show a good ability to organise work? • Were students able to move from one approach to another and, if so, how independently of the teacher? • To what extent were students able to use various approaches and link them? • **What were the common misconceptions and misunderstandings?**

Collaborative Paired Work	• **How and when did students' understanding change?** • Did any students demonstrate a continued lack of understanding or progress? How could this be addressed? • How well did students collaborate at paired work stage? • How successful was differentiation of students' work?
Unexpected Outcomes	• Did students develop any solutions or ideas that had not been anticipated?
Ceardaíocht	• Did the students' presentation and discussion promote their thinking and learning? • How well did students communicate solutions and answers during discussions at the Ceardaíocht stage? • Did students critically compare approaches or evaluate appropriateness of using different types of strategies? • Did students demonstrate an understanding of solutions developed by other students?
Extending Students' Learning	
Summing Up	• Were the goals and research theme of the lesson met? • What did students learn? • What teacher approaches worked well? • What teacher approaches did not work well? • Was time used well? • How can we improve our approaches and methodologies?

Student Reflection and Feedback	
Evaluation	• To what extent were students able to use various approaches and link them? • What were the common misconceptions and misunderstandings? • How and when did students' understanding change? • Did any students demonstrate a continued lack of understanding or progress? How could this be addressed? • Was the flow of the lesson coherent? • Did the students display a positive disposition? • Did the activities support the goals?
Other Observations	