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A Handbook for Lesson Study:

Including a *Research Lesson Proposal Template*

Maths Development Team

PDST Professional Development Service for Teachers | An tSeirbhís um Fhorbairt Ghairmiúil do Mhúinteoirí

Maths Development Team **PDST**

Lesson Study IRELAND

Foireann Forbartha Mata Maths Development Team

Lesson Study is a structured process where teachers work together to discover solutions to shared teaching & learning challenges. This Handbook is a guide to how Lesson Study can be used to develop, refine and promote the teaching of Mathematics through structured problem solving.

Introduction

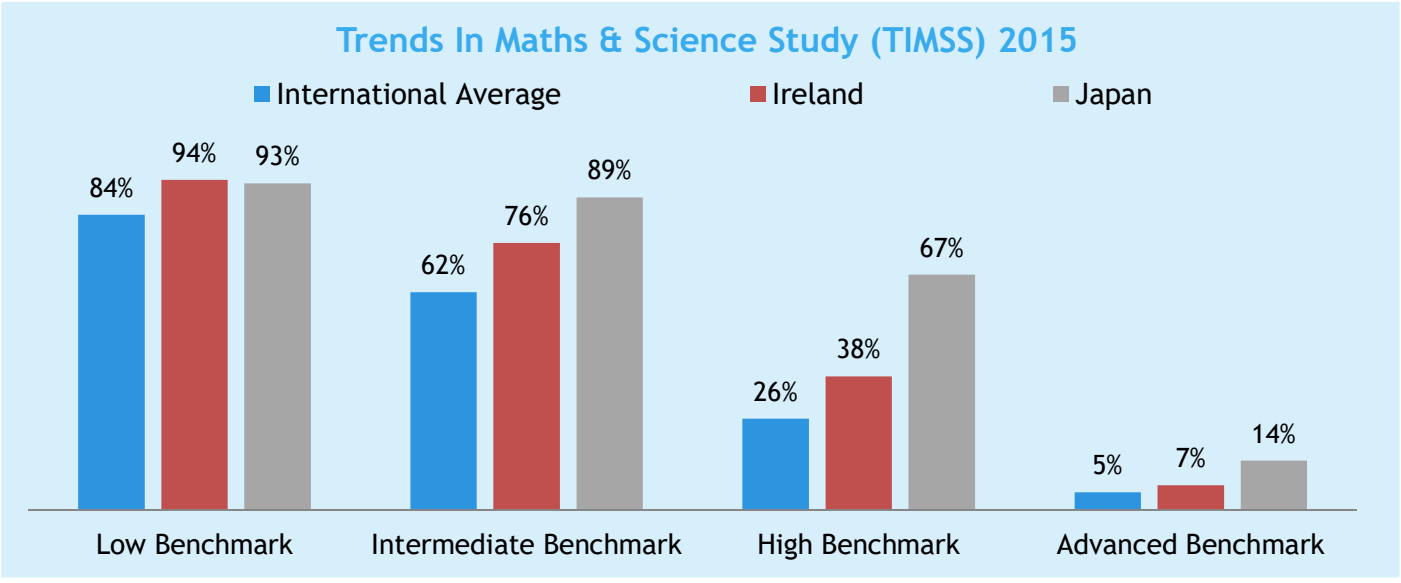
"Lesson Study" is a translation of the Japanese phrase *jugyoukenkyuu*, which refers to a set of practices that have been used in Japan to improve teaching and learning for over 100 years (Makinae, 2010). *Lesson Study* was introduced to the international education community primarily by the publication of *The Teaching Gap* (Stigler & Hiebert, 1999). Since then, many Mathematics educators around the world have been involved in introducing *Lesson Study* as an approach to teacher professional development. *Lesson Study* is credited with enabling profound changes in Mathematics and Science teaching in Japan in recent decades – a fact evidenced by Japan's high levels of achievement in international assessments over the past 20 years (TIMSS 2015, 2011, see *Figure 1*).

While the focus of this document is on utilising *Lesson Study* to improve Mathematics teaching and learning, Japanese teachers use *Lesson Study* to hone teaching in all content areas, including Physical Education and modern foreign languages. In Mathematics, *Lesson Study* is used as the mechanism to improve:

- teaching of Mathematics through problem solving
- students' confidence and experience as problem solvers.

Lesson Study was introduced nationally to Ireland in 2014 by The Maths Development Team and since then the number of Mathematics teachers choosing it as a means of professional development has increased year on year.

Figure 1: Comparative performance of Irish Post-Primary students at each Mathematical Benchmark Level in TIMSS 2015



Mathematical content knowledge alone is not enough to be a highly effective teacher.

What is *Lesson Study*?

Lesson Study is a structured process where teachers work together to formulate solutions to challenges they encounter in relation to teaching and learning. At its heart, it aims to improve teaching and learning by developing successful approaches to teaching.

The major characteristics of *Lesson Study* are: collaborative planning of a research lesson, teaching the research lesson, collecting data by observing the lesson as it unfolds and reflecting on what has been learned to inform the design of future lessons.

As these lessons respond to identified needs and inevitably involve student-centred learning, inquiry and problem solving, *Lesson Study* contributes in a practical and meaningful way to the implementation of *School Self-Evaluation, The Literacy & Numeracy Strategy, Junior Cycle Key Skills & Statements of Learning* and The *Digital Strategy for Schools*.

Why *Lesson Study*?

Mathematical content knowledge is an important facet of being a mathematics teacher, however this alone is not enough to be a highly effective teacher. Japanese mathematics educators typically characterize teacher expertise according to three levels (Sugiyama 2008, see *Figure* 2):

Level 1: Teachers *tell* students important basic ideas of Mathematics such as facts, concepts, and procedures.

Level 2: Teachers *explain* the meanings of and rationale for the important basic ideas of Mathematics in order for students to understand them.

Level 3: Teachers *provide* students with opportunities to understand these basic ideas, and support their learning so that the students become independent learners.

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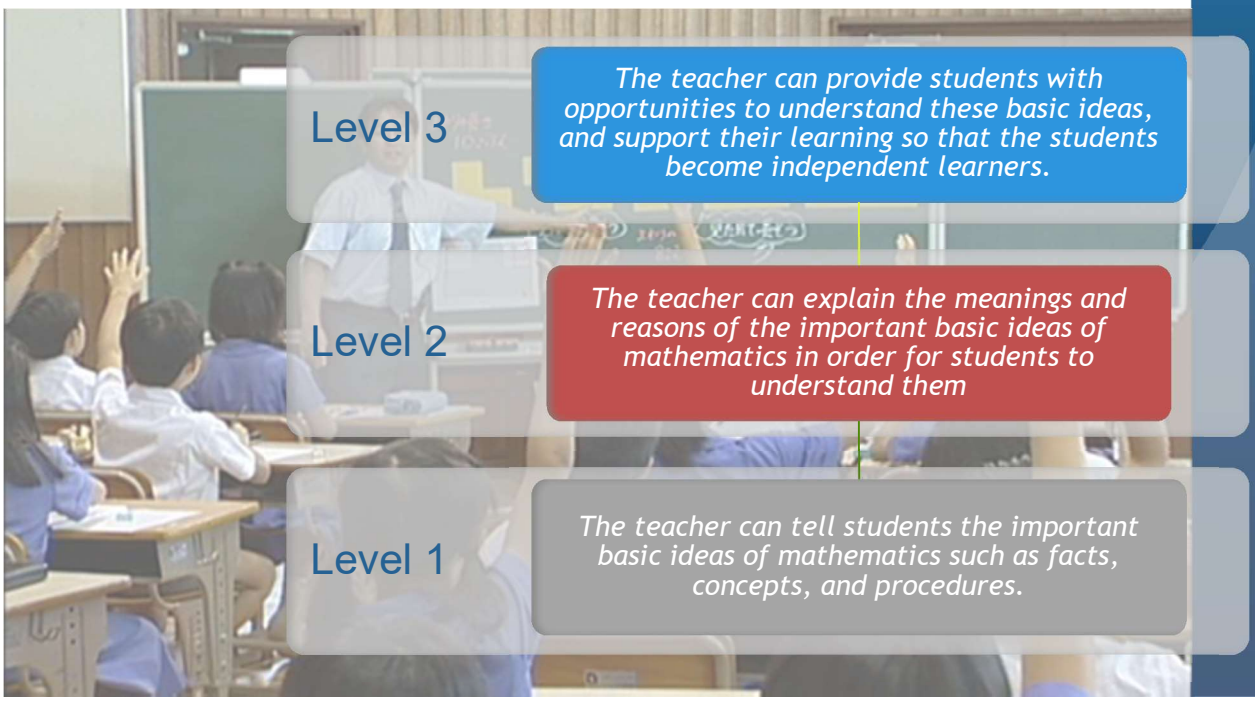
Three levels of maths teaching expertise

Sugiyama 2008

Figure 2: Three Levels of Expertise in Mathematics Teaching



Borrowing from Takahashi's description (Takahashi, 2010), the differences between Level 3 teaching and other levels can be understood by looking at how teachers might use a problem in a textbook. At Level 1, the teacher presents the problem and shows the steps for solving it. At Level 2, the teacher shows the steps and explains why they are correct and useful. At Level 3, the teacher, presents students with the same problem, providing structure and guiding the conversation so that students arrive at a new understanding as a result of their own efforts in solving it. The philosophy behind Level 3 teaching is that students should engage in reasonable independent work, such as problem solving, in order to develop Mathematical knowledge, understanding, and skills (Lewis & Tsuchida, 1998; J. Stigler & Hiebert, 1999; Akihiko Takahashi & Yoshida, 2004; Yoshida, 1999).

The difference between Level 1 and Level 3 teaching may also be thought of as the difference between "teaching the textbook" and "teaching Mathematics using the textbook." Level 3 teaching clearly requires greater knowledge and expertise that goes beyond knowing, to include the application of Mathematics in practical and context-rich situations. *Lesson Study* is an approach to continuing professional development that can help teachers to develop such knowledge and expertise.

Characteristic components of the *Lesson Study Cycle*

Based on our experience of teachers participating in *Lesson Study* in Ireland, certain aspects of *Lesson Study* are critical for improving teaching and learning. If any of these are missing, then the activity will not be as effective as it ought to be and, strictly speaking, should not be called *Lesson Study*.

The characteristic components of *Lesson Study* are:

A. **Clearly defined research themes and learning goals**
B. ***Meitheal Machnaimh*** (Irish translation of the Japanese *Kyouzai kenkyuu*)
C. **A written research lesson proposal**
D. **A live research lesson**
E. **A post-lesson discussion**
F. **Contributions by knowledgeable others**
G. **A process for sharing outcomes.**

Figure 3 below shows how these components fit together to form a complete *Lesson-Study* Cycle.

We will now provide an explanation of each key component of *Lesson Study*.

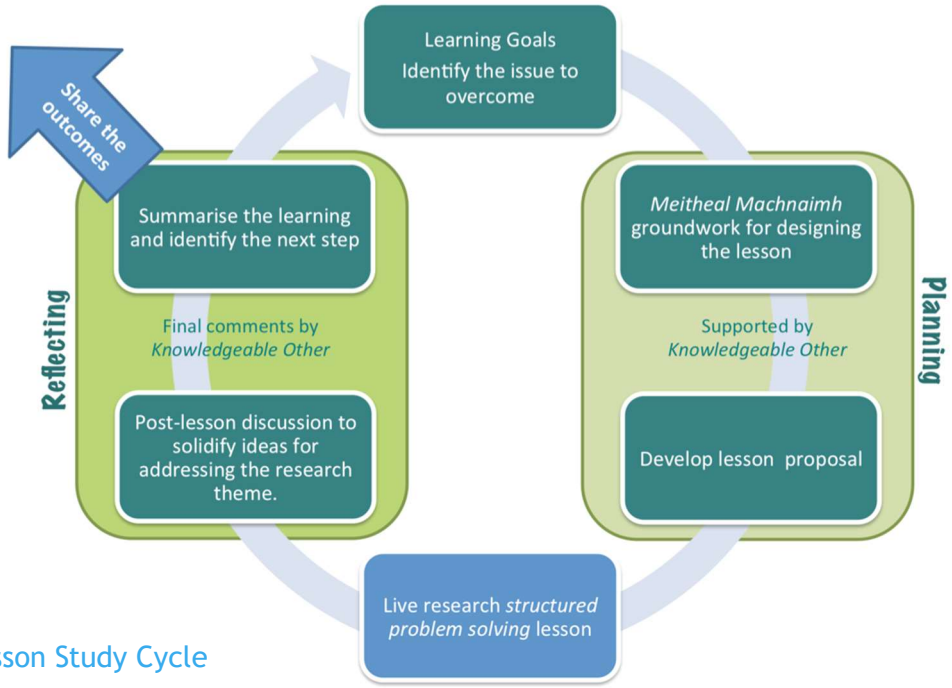


Figure 3: The Lesson Study Cycle

A. Clearly defined research themes and learning goals:

To participate in a *Lesson Study* is to conduct research. The goal is to seek a solution to a teaching/learning problem. *Lesson Study* usually has two research objectives for student learning and development.

- One objective involves a broad teaching/learning goal that is shared by the *Lesson Study* group (e.g. all of school's mathematics teachers), and that goes beyond any particular topic or year level and may even be cross-disciplinary. This broad objective is chosen from the standards outlined in *Looking at our* Schools *2016* and is referred to as the *long-term goal*.
- The second goal relates to the teaching of a specific topic: How can a lesson be designed so that students learn a given concept or skill better than they did in the past? Thus, the topic of the research lesson should usually be one with which students or teachers have previously struggled.

Ideally, a research theme describes (a) a desired outcome for students, and (b) practical steps for teachers to take on a day-to-day basis for achieving that outcome in the mathematics classroom.

B. Meitheal Machnaimh:

Meitheal Machnaimh translates roughly as "the collaborative study and research of problems and materials for the research lesson". It is a routine part of lesson planning for many teachers, but in *Lesson Study* it is done with extra intensity. *Meitheal Machnaimh* may also be thought of as an in-depth discussion of the key factors that determine the effectiveness of a lesson. One such factor is an understanding of the learning paths related to the topic, that is to say an understanding of students' prior knowledge relating to a topic and an understanding of how this topic will be utilised in future learning. This is achieved through study of the relevant Mathematics curricula (including the primary-school curriculum) and should also include research into common misunderstandings around the topic. Since we, in Ireland, are using *Lesson Study* to implement the teaching of Mathematics through structured problem solving, a major focus of Meitheal Machnaimh is in choosing problems that are appropriate to achieving the goals of the research lesson.

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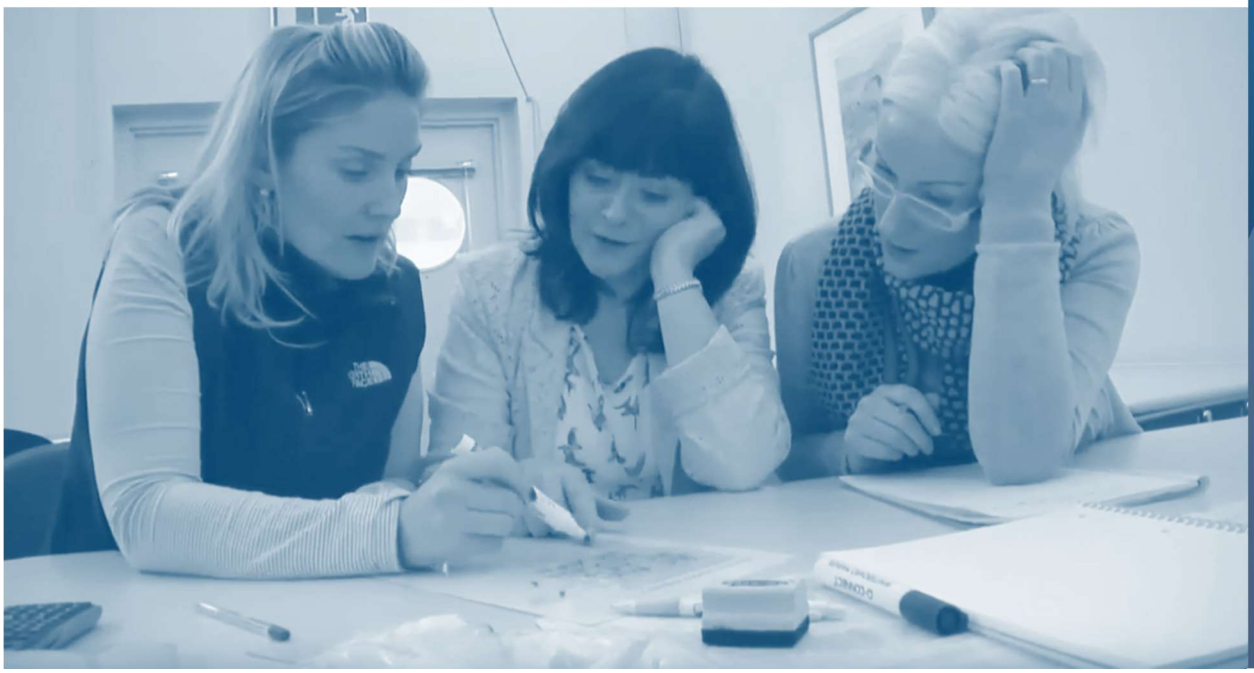
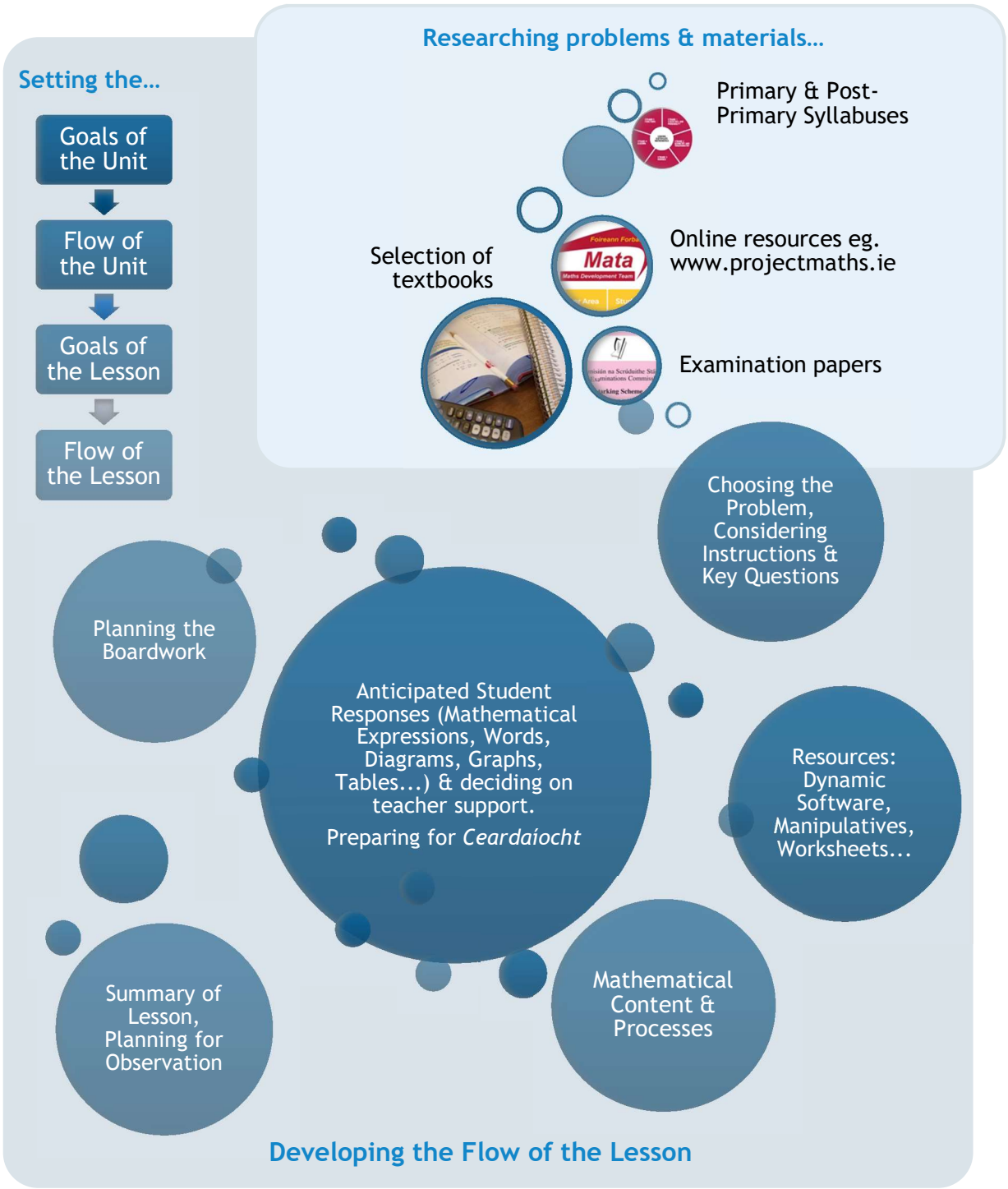


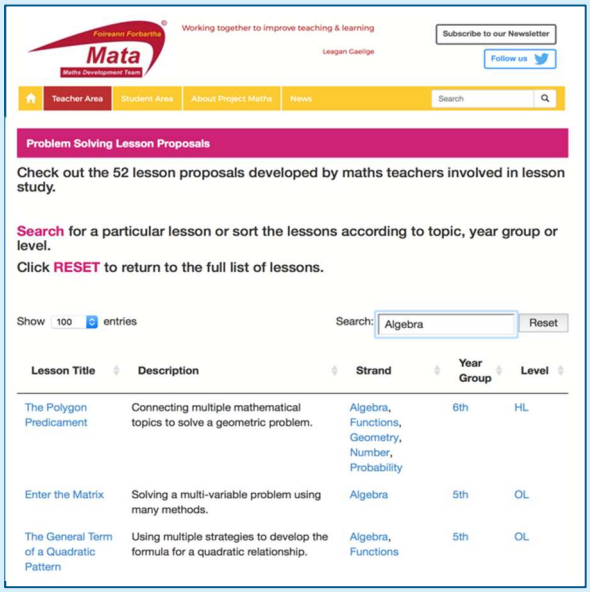
This process involves the study of a range of textbooks and lesson proposals. In choosing a problem, it is commonplace for teachers to study ten problems but to only choose the one that they deem most suitable for the goals of the lesson. Meitheal Machnaimh also includes consideration of possible tools e.g. dynamic software packages, manipulatives, or materials that may aid students' understanding (see *Figure 4*).

A major focus of *Meitheal Machnaimh* is in choosing problems that are appropriate to achieving the goals of the research lesson.

Figure 4: *Meitheal Machnaimh*: A Critical Step in Teaching Mathematics through Structured problem Solving



Whilst there is a need to develop more quality materials to support teachers in partaking in Meitheal Machnaimh, some progress is already underway as Lesson Study continues to grow in Ireland. A library of lesson proposals developed by Irish mathematics teachers that support teaching through problem solving is already available on **www.projectmaths.ie.**



C. Written Research Lesson Proposal:

The *Lesson Study* team (usually 3 to 6 teachers) creates a written document, called the research *lesson proposal,* the goals of which are to communicate what the team learned from their *Meitheal Machnaimh,* and to explain their pedagogical thinking. In addition to a detailed teaching/learning proposal for one particular lesson (the *research lesson*), the research proposal includes an overview of the unit in which the research lesson will reside, the rationale for the design of the unit and research lesson, and a clear statement of how the research lesson aims to address the research theme and the learning goals of the lesson. In our experience, a thorough research lesson proposal may be nine pages long.

To guide teachers in writing a lesson proposal, The Maths Development Team have designed an appropriate template. This template is based on Japanese Lesson Proposals but adapted for the Irish context (*Appendix*).

D. Live *Research Lesson:*

Based on the lesson plan in the research lesson proposal, one member of the team teaches the research lesson, observed by the entire planning team and by additional members of the *Lesson Study* community. The structure of the Live Structured Problem Solving *Research Lesson* is detailed in the next section.

Observers from the research team are responsible for collecting data on how the lesson impacts the students, relative to the research theme and the learning goals. (A free iPad app developed by Akihiko Takahashi called *LessonNote* is ideally suited to support this work. At present it is only available for the iPad.)

E. Post-lesson Discussion:

As soon as possible after the research lesson, observers share the data and discuss its implications, especially with respect to the learning goals of the lesson and the research theme. The primary goal of the discussion is to gain insights into teaching and learning and to inform the design of future lessons, not to revise the lesson plan. These discussions generally benefit from a moderator (someone not on the planning team) who helps focus the discussion on important issues and keeps the conversation grounded in the evidence gathered during the lesson observation.

F Contributions by knowledgeable others:

A knowledgeable other is someone from outside of the planning team with experience of *Lesson Study*, who provides a broader perspective and challenges the team to extend their thinking. Ideally a *Lesson Study* community needs two knowledgeable others: one for supporting development of the research proposal and another for providing the final comments at the end of the post-lesson discussion. To date in Ireland, Associates working with the Maths Development Team (MDT) support the development of the lesson proposal.

During planning, a knowledgeable other such as an Associate may help the team identify teaching examples to review and valuable resources from, amongst others, the MDT website and may also give feedback on the lesson proposal.

Another knowledgeable other is needed at the research lesson. In final comments at the end of the post-lesson discussion, he or she is expected to highlight important events from the research lesson that were not discussed, and make connections between the lesson and new knowledge from research and requirements of the syllabus. The knowledgeable other also provides suggestions to the research team of possible steps they could take toward accomplishing their research theme. Where possible, personnel from MDT provide this final commentary.

G Process for sharing outcomes:

Lesson Study can be informative not only for the team of teachers who plan the research lesson but for other teachers as well. For others to benefit from a *Lesson Study*, a structure or process for disseminating what is learned from each research lesson to the larger community is required.

A simple way to enable others to learn from a *Lesson Study* is to invite teachers from a school outside of the planning team or teachers from neighbouring schools to observe and discuss the research lesson. This can also benefit the research team, through insightful and critical feedback provided by these guest teachers.

In addition, the research lesson proposal encapsulates the team's research and reflection. This reflection describes what was learned from the live-lesson observation and post-lesson discussion about the effectiveness of the lesson in terms of the team's research and content goals, students' thinking etc.

Why is it practical to spend so much time planning a single lesson?

Participating in *Lesson Study* is not like attending a workshop - it is a continuing, locally based, professional development programme which focuses on developing expertise in teaching Mathematics. This includes the expertise needed to develop lessons to achieve both short and long-term goals, to facilitate the implementation of SSE, JC Key Skills, Digital Strategy for Schools, and Numeracy & Literacy (Component A). It also develops the expertise to use questioning techniques (refer to *Figure 5*), to implement assessment for learning, to anticipate student responses to questions and tasks (Component B and Component C) and to make purposeful observations during a lesson (Component D). For teachers to develop such expertise for Level 3 teaching, they need opportunities to reflect on their teaching and learning based on careful observation (Component D and Component E). *Lesson Study* provides these opportunities through an intense process; one cycle typically spans 6 evening meetings. You may ask: "How can you spend so much time on just one lesson?" *Lesson Study* is not about just one lesson; a good research theme ensures that what is learned from *Lesson Study* applies to many lessons, perhaps to all lessons. Teachers who have gone through *Lesson Study* with us often say that the process leads them to think differently in planning their everyday lessons.

Effective Questioning for each step of a structured problem-solving lesson

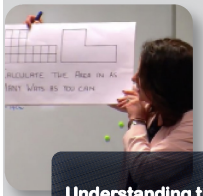
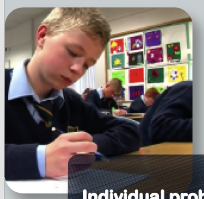
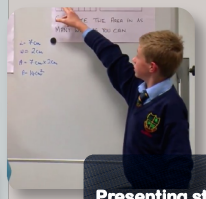
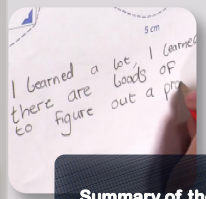
	Presenting the problem		Individual problem solving	Presenting solutions and Ceardaíocht			Summing up
	 Understanding the problem	 Having insight into the solution	 Individual problem solving	 Presenting student solutions	 Understanding solutions	 Ceardaíocht	 Summary of the lesson
Student Activities	**Capturing the problem situation mathematically**	**Thinking insightfully and having one's own ideas**	**Expressing one's own ideas**	**Explaining their ideas**	**Understanding others' ideas**	**Comparing and contrasting solutions, deciding which is 'best'**	**Reflecting on the lesson**
Preferable Student Behaviour	**Understand the problem clearly and correctly**	**Looking for the differences between problems they have previously learned** **Recalling prior knowledge to solve the problem** **Thinking insightfully of how to solve it** **Thinking insightfully of the answer**	**Trying to solve the problem using knowledge previously learned** **Expressing their own ideas in a way everyone can understand** **Always looking for a better way of thinking- "faster, easier, more precise "etc.**	**Trying to explain their ideas in a way everyone can understand** **Speaking in front of the board with their face and body looking toward the class** **Explaining using diagrams and equations etc. "I did this first because..then I did because..."**	**Listening to others presenting their solutions and understand it (read body language nodding etc..)**	**Looking for differences and similarities between their ideas and their peers** **Thinking of what is the best, most efficient way of handling the problem mathematically** **Thinking in a connected and integrated way**	**Do the students' written reflections show what they have understood from today's lesson?** **Has the student written down in the form e.g. "Today I understood A because of B.."**
Effective Questioning and Support	**"What are the relevant and necessary numbers in the problem?"**	**"What is different between this problem and other problems you have studied?"** **"What have we been learning/learned that is relevant here?"** **"What do you think the answer might be?"**	**"Let's think of other ways to solve it"** (seeking various ways to think) **"Let's express it in a different way"** (urging various ways to express) **"Let's draw a diagram, graph, write an equation".** (specify how you expressed it) **"Let's think about which way is the better way".** (identifying what is good about handling problems mathematically)	**"What do you think?"** (ask without repeating student's idea at the board.. then ask another student) **"Why is that?"** (looking for evidence) **"So?"** (Use when you want the student to continue speaking) **"Is there anyone who solved it the same way?"** **"Let's have another student who solved it the same way explain it"**	**"Can you understand this way of thinking?"** **"Do you agree?"** **"Can you explain it?"** (Have another student other than the student at the board explain what is written on the board) **Praise good oracy skills on the spot**	**"Is there anything you noticed by looking at these ideas? What are the similarities? What are the differences?"** **"Which way of thinking do you understand best?"** **"Which way do you think you can use all the time?"** **"Why do you think this way is better?"**	**"What did you understand from today's lesson?"** (conclude using the students' reflections) **"Write three sentences that sum up what you learned in this lesson"** (What they understood? What they noticed? Questions they have? What they learned from their friend's ideas?)

Figure 5: Effective Questioning for each step of a Structured Problem Solving Lesson

A Structured Problem-Solving Lesson

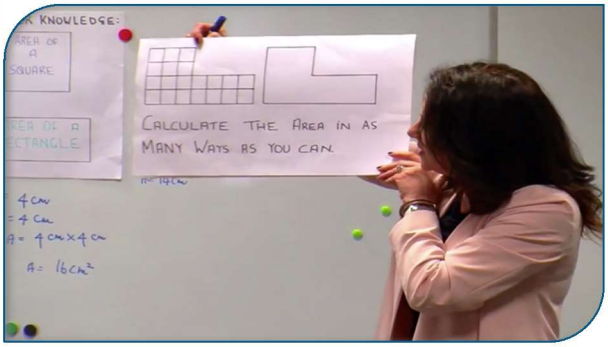
When teaching the problem-solving research lesson, the aim of the lesson is not only to develop or deepen students' content knowledge but also to foster students' mathematical thinking and disposition towards Mathematics. The critical pattern and features for a structured problem-solving lesson is seen as a teaching method (refer to Figure 6). These lessons can be described as having a clear style with the following framework and structure:

1. Presenting the "problem for the day". (5 to 10 minutes)
2. Problem solving by students (10 to 20 minutes)
3. *Ceardaíocht* - comparing and discussing solutions (*Ceardaíocht* is the Irish translation of the Japanese term *Neriage*) (10 to 20 minutes)
4. Summing up by the teacher (5 minutes)

(Fujii, 2017)

The following section outlines the teacher's and students' roles in each of the stages of a structured problem solving lesson

1. Presenting the problem for the day

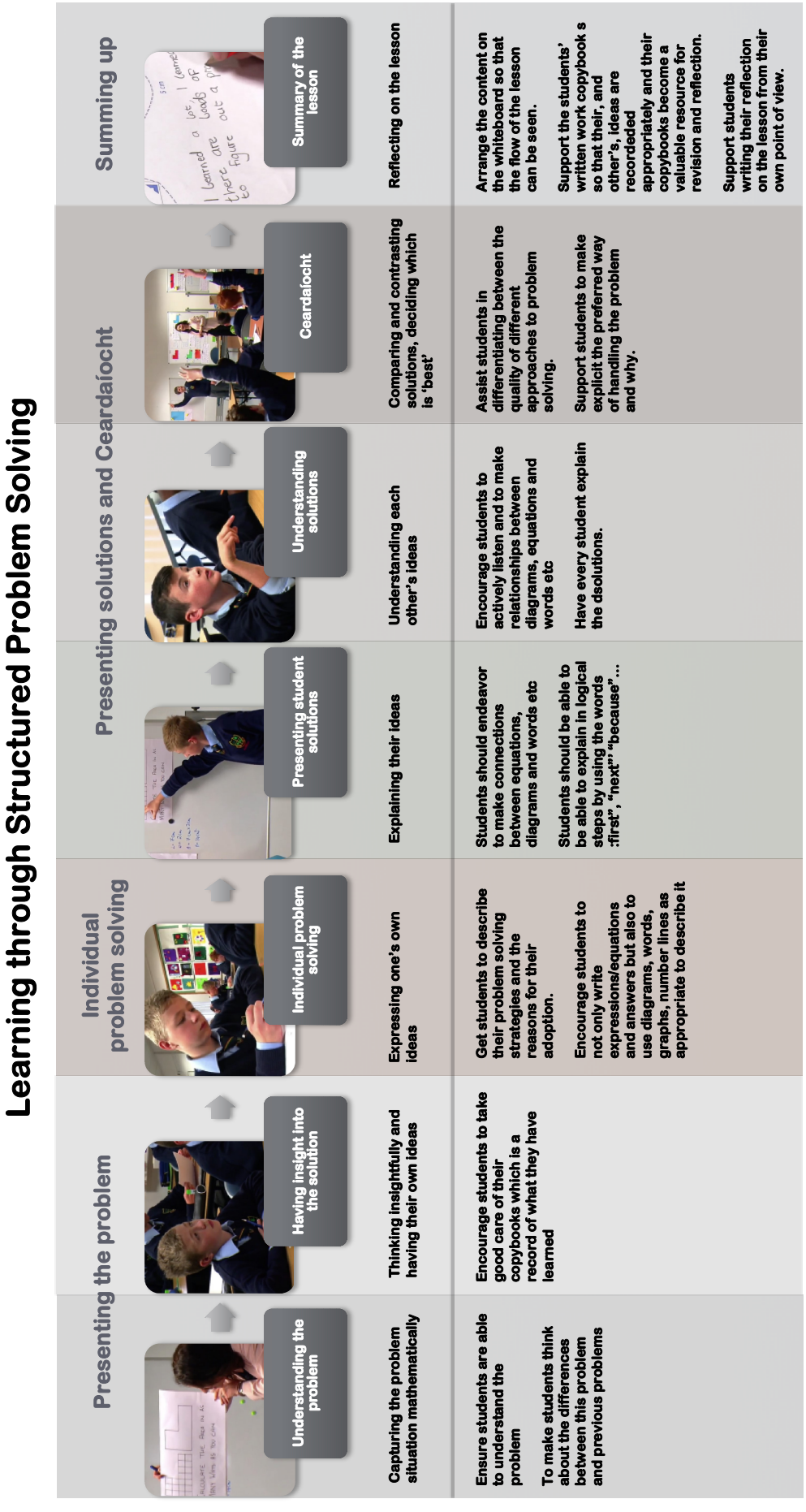


At the start of a problem-solving lesson the teacher presents a problem to the students without demonstrating how to solve the problem. (From the students' point of view, this activity could be renamed "Introducing the Problem") The teacher helps the students understand the context of the task then stops, even though the task has an unfamiliar aspect to it. Students are expected to use their prior knowledge to find the solution. The processes the students use in solving on the problem, rather than the solution itself, is the focus of the lesson. During Ceardaíocht students are expected to learn new Mathematics. This is why a structured problem-solving lesson focuses on a single task, allowing for the important new mathematical idea(s) identified as the goal of the lesson to emerge during *Ceardaíocht*. Ideally the task incorporated into a problem-based mathematics lesson should:

i. be appropriate and mathematically valuable in terms of the aims of the lesson.
ii. capture students' interest and generate curiosity
iii. be at the appropriate level of difficulty.
iv. be capable of being solved in several ways.
v. have the potential to elicit valuable basic wisdom (Fujii, 2015)

For students to appreciate that mathematical processes are more important than just getting the answer, they need to experience strategies that differ from their own. This is why a problem-based mathematical lesson includes a comparison and discussion phase (*Ceardaíocht*) for students to compare or experience their peers' strategies and discuss similarities, differences and merits among strategies in a whole-class setting. It is important to note that *Ceardaíocht* is where students' appreciation for the processes inherent in mathematics is cultivated. Thus the task chosen and prepared during the critical step of *Meitheal Machnaimh* is crucial, as it must elicit various strategies from the students to have an effective *Ceardaíocht* (see iv. and v. above).

Figure 6: Learning through Structured Problem Solving



2. Problem-solving by students

While students are working individually to solve the problem, the teacher performs *in-between deskwork*. This means circulating, checking and monitoring students' work in preparation for *Ceardaíocht*. In-between deskwork entails the teacher using a seating chart to identify which solution method(s) each student is using (including both correct and incorrect approaches). When planning the lesson proposal the research group has already anticipated these solution methods during *Meitheal Machnaimh*. The teacher determines which solution methods are favoured by the majority of the class and gives a hint to students who are having difficulty without divulging the complete solution.

Students who have solved the problem are encouraged to find another way of solving it. The teacher does not spend long with any one student, as the intention of the in-between deskwork is to plan what to do during *Ceardaíocht*. Sometimes a student may produce a method that was not anticipated by the research group. If so, while doing in-between deskwork, the teacher should ask the student to explain this method and record it on the seating chart. The teacher must now decide which solution methods to utilise and the order in which these should be presented during *Ceardaíocht* so that students reach the goal of the lesson.

3. Comparing and discussing (*Ceardaíocht*)

Ceardaíocht is where students' mathematical processes and ways of thinking are fostered. This phase of the lesson focuses on comparing and discussing the different solution methods arrived at by students. In a classroom, students' thinking is often invisible and a structured problem-solving lesson allows the invisible become visible. According to Fujii (2017), "the teacher who teaches the lesson needs to grab a tail of thought when it first becomes visible, and use that tail as a concrete example to teach or suggest how to think mathematically". The teacher showing and telling the students "how to do it" is not an effective way of cultivating students' mathematical thinking skills; this is best accomplished through students actively engaging in problem solving activities. Therefore, problem-solving lessons allow students to practice mathematical thinking, and promote independent learning. This is not a new idea:

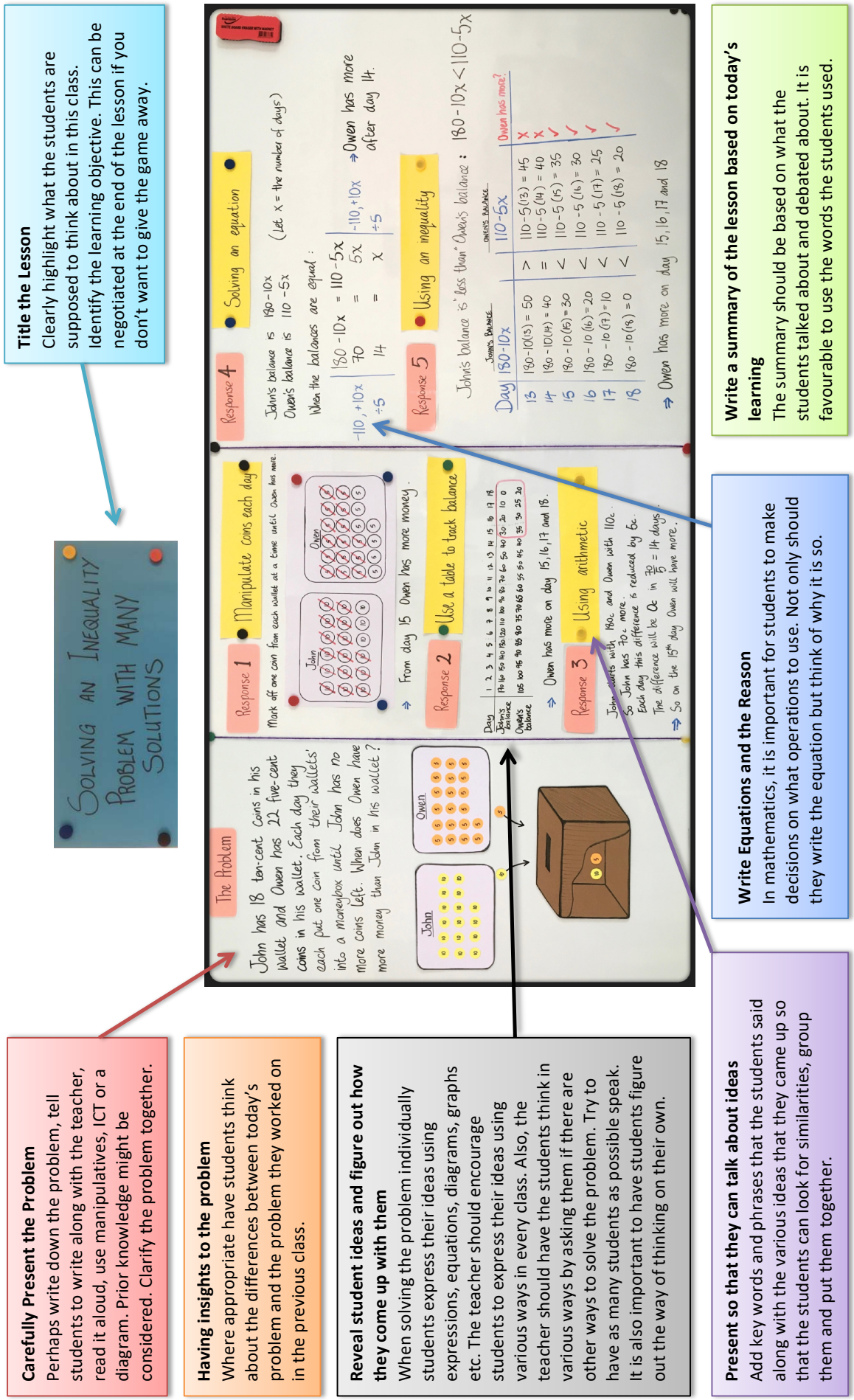
> *Ten pages of mathematics understood are better than a hundred memorized and not understood, and one page actually worked out independently is better than ten pages clearly passively understood. The question is not how much? But how? The object is mastery, attainment of the spirit of the subject, and not to train the memory, or to ingest a large bulk of mathematical fact and formulas* (Young, 1908).

Students present solutions at the whiteboard starting with the most naïve and working up to the most sophisticated method. The whiteboard is a key tool for *Ceardaíocht* as it is used to record the thought processes of the students and progression of the lesson. The research group plans Boardwork very carefully before the lesson is taught (see *Figure 7*).

4. Summing Up

This phase of the class is a short but critical to what students take from a lesson. The teacher should not conclude the lesson with a summary of a procedure. If so students may feel that instrumental knowledge is the most important element of Mathematics. Instead, the teacher should point out how the students constructed their knowledge by using prior knowledge and highlight for students that *how we think* is what is important and fundamental to Mathematics. Students should then write a brief reflection on the lesson itself where each student can express their own thoughts.

Figure 7: Planning the Boardwork for a Structured Problem Solving Lesson



Introductory notes on the *Research Lesson Proposal Template*

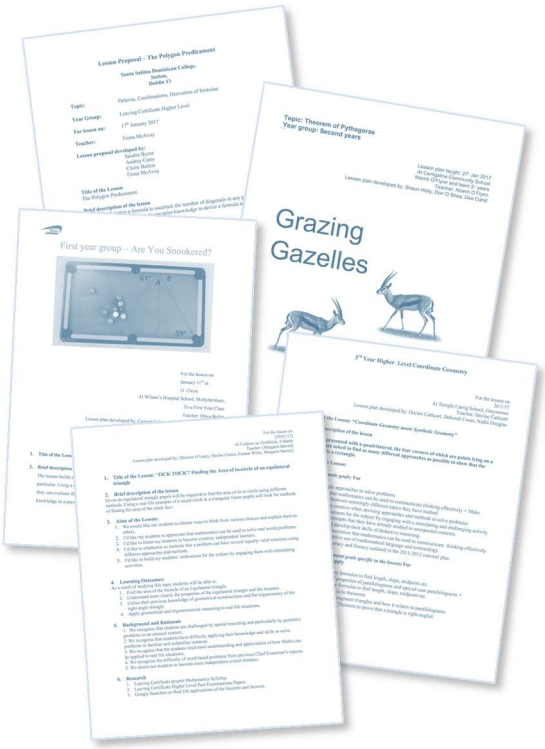
This *Research Lesson Proposal Template* document has four purposes:

- to guide the planning team through the Lesson Study process
- to help the team think clearly about their goals and their theories about how to achieve them
- to prepare observers to collect data, and then discuss that data, in a way that helps the team understand whether their theories are correct
- to document the entire research process for the benefit of other educators.

Experienced Lesson Study practitioners use a variety of formats, but this template identifies important considerations of Lesson Study. It is based on a template originally introduced to Chicago by Dr. Akihiko Takahashi, and has been refined by the Maths Development Team to reflect National Strategies[1,2], Teaching and Learning Standards[3], Key Skills and Statements of Learning in our system[4].

Lesson Study is not a clean, linear process, but we recommend that when writing your Research Lesson Proposal that you focus on sections of this document in approximately the following order:

1. Background and rationale (Section 4)
2. Research theme (Section 3)
3. Relationship of Unit to Syllabus (Section 5)
4. Goals of the unit (Section 6)
5. Unit plan (Section 7)
6. Goals of the Research Lesson (Section 8)
7. Flow of the Research lesson (Section 9)
8. Board plan (Section 10)
9. Title of the lesson (Section 1)
10. Brief description of the lesson (Section 2)
11. Evaluation (Section 11)
12. Reflection (Section 14) (after the lesson)



[1] Department of Education and Skills. (2020). *Literacy and Numeracy for Learning and Life: The National Strategy to Improve Literacy and Numeracy among Children and Young People 2011-2020.* DES, Dublin.

[2] Department of Education and Skills. (2013*). Digital Strategy for Schools 2015-2020.* DES, Dublin.

[3] Department of Education and Skills (2016). *Looking at our School 2016: A Quality Framework for Post-Primary Schools.* DES, Dublin.

[4] Department of Education and Skills. (2015). *Framework for Junior Cycle*. DES, Dublin.

Note: The blue text in this *Research Lesson Proposal Template* is there to guide you through each section and all blue text should eventually be deleted and replaced with the content of your own Research Lesson Proposal (preferably in black).

Research Lesson Proposal on Topic
For a Level, Year Class

the lesson on date
At name of the school, teacher's name class
Teacher: name
Lesson plan developed by: names

1. **Title of the Lesson:** This can be a catchy title that captures the imagination.

2. **Brief description of the lesson**

Just a few sentences about what students will do and learn during the lesson

3. **Research Theme**

A *Lesson Study* usually has two research objectives: (1) Teaching of specific content and (2) A broad teaching/learning goal. **This broad teaching/learning goal is usually referred to as the research theme.** While (1) focuses on specific concepts or skills, (2) is concerned with a broad teaching/learning goal that has been identified by the *Lesson Study* group (or the school's maths department or the whole school) as a priority for the improvement of teaching and learning. Generally, the research theme goes beyond any particular topic or level and may be cross-disciplinary.

For maths teachers in Ireland, the research theme should be taken from the teaching and learning standards specified in the document: *Looking at our Schools 2016 – A Quality Framework for Post-Primary Schools* (see Appendix 1). Circular 0040/2016 *Continuing Implementation of School Self-Evaluation 2016-2020* states that schools should select a minimum of two and a maximum of four aspects of teaching and learning as the focus for their self-evaluation process from 2016 to 2020. Accordingly, the research theme of the lesson should be based on a minimum of two teaching and learning standards. For example, you might use the following two standards: "We want our Students to:(i) grow as learners through respectful interactions and experiences that are challenging and supportive and (ii) enjoy their learning, feel motivated to learn, and expect to achieve as learners".

4. **Background & Rationale**

a) Why you chose the topic

Justify your choice of theme and topic. Frequently this is expressed in terms of a contrast between the current state of students (or students in previous years) and what you and your colleagues want to accomplish. Reference should be made to the Year Group and Level at which this lesson is aimed.
Sometimes teachers want to use a favourite lesson for a research lesson - one that will favourably impress the observers. Sometimes teachers will conduct multiple iterations of a research lesson, in order to perfect it. Both of these approaches miss the purpose of *Lesson Study*, which is to conduct research: to seek a solution to a teaching/learning problem.

b) Your research findings

Include details of your discussion on the approaches currently used to teach the topic and research findings on more-productive approaches to teaching the topic.

5. Relationship of the Unit to the Syllabus

Describe how this unit relates to Syllabus/Learning Outcomes from prior years, for this year and for later years. Do not quote Learning Outcomes/Junior Cycle Statements of Learning in their entirety, rather excerpt the relevant clauses or strike through any parts of a learning outcome that are not being addressed. For mathematics, the Primary Curriculum and Post-Primary Syllabuses can be accessed at:

Primary: http://www.ncca.ie/uploadedfiles/Curriculum/Maths_Curr.pdf
Junior Certificate: http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Project_Maths/Syllabuses_and_Assessment/JC_Maths_English_2013.pdf
Leaving Certificate: http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Project_Maths/Syllabuses_and_Assessment/LC_Maths_English_2013.pdf

Related prior learning Outcomes	Learning outcomes for this unit	Related later learning outcomes
Refer to learning outcomes from the primary-school curriculum if writing a Junior-Certificate Lesson Proposal. *Refer to Junior-Certificate learning outcomes if writing a Leaving-Certificate Lesson Proposal.*	*Refer to learning outcomes that will be addressed by this unit.*	Refer to future learning outcomes which this unit will lay the foundations for. This may help inform discussion on the most-productive approach to use when teaching the learning outcomes mentioned in the second column.

6. Goals of the Unit

Academic learning goals should describe cognitive or emotional changes within the student. Avoid "Students will be able to…" statements; instead, say what students need to know or understand in order to be able to….

7. Unit Plan

The Unit Plan shows how the research lesson fits into a larger unit. It helps the reader understand what students have learned and experienced recently and what skills or concepts will be addressed later. Units vary in length, but a typical unit might be 10 lessons, including practice days. You should indicate clearly where the research lesson falls within the unit.

Do not include details of classroom tasks or homework assignments unless they are important for understanding the progression of learning.

Lesson	**Learning goal(s) and tasks**
1 The Research Lesson	*Brief overview of the Research Lesson*
2	*Brief overview of other lesson in unit*
3	*Brief overview of other lesson in unit*
4	*Brief overview of other lesson in unit*
5	*Brief overview of other lesson in unit*
etc.	

8. Goals of the Research Lesson:

The Goals of the lesson should refer to:

a) Mathematical Goals

Describe cognitive or emotional changes within the student. Avoid "students will be able to…" statements; instead say what students need to know or understand and how that will enable to do…

b) Key Skills and Statements of Learning

Refer to how the work carried out during the lesson targets key skills and statements of learning from the Junior Cycle framework.

9. Flow of the Research Lesson:

THIS SHOULD NOT BE A SCRIPT but it should clearly communicate the team's ideas for how the lesson will help students learn, in sufficient detail that a teacher reading this plan could adapt and teach the lesson to his/her own students.

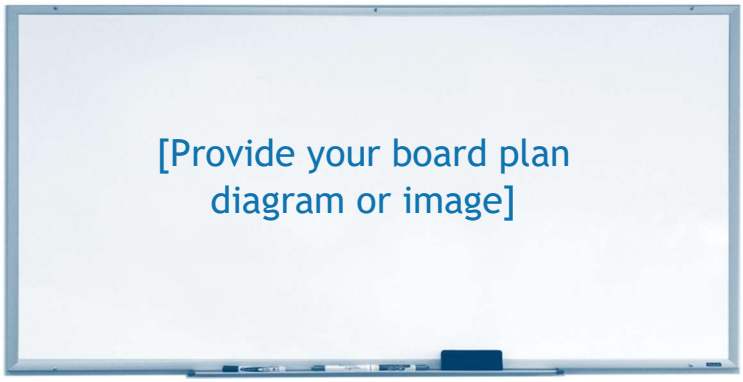
Steps, Learning Activities, Teacher's Questions & Expected Student Reactions	**Teacher Support**	**Assessment**
This column shows the major events and flow of the lesson.	*This column shows additional moves, questions, or statements that the teacher may need to make to help students.*	*This column identifies (a) what the teacher will look for (formative assessment) that indicates it makes sense to continue with the lesson, and (b) what observers should look for to determine whether each segment of the lesson is having the intended effect.*
Introduction This section may set up the main task, e.g. by providing a contextualized problem out of which a pure mathematical problem will arise. Or, it may review previous prior knowledge if needed (but don't give the game away). Beware of making the intro too long. Sometimes it's best to skip an intro and dive right into the problem.		What is the pedagogical purpose served by this introduction?
Posing the Task This section describes a problem or task as it will be presented to students. Give the exact phrasing of the problem and the specific numbers used. You may want to help students see the relationship between the specific problem (whether contextualized or not) and the concepts or skills that will be learned. You should also use this time to clarify the problem and ensure that students understand what is being asked. **Clarifying the problem:** When clarifying the problem it may be helpful to show more-concrete examples than those given in the statement of the problem but be careful not to provide examples that restrict student's ways of thinking about the problem and student response(s).	Indicate here whether the problem will be written on the board, posted, handed out as a worksheet, or glued into student notebooks.	

Steps, Learning Activities, Teacher's Questions & Expected Student Reactions	**Teacher Support**	**Assessment**
Student Individual Work Give anticipated student solutions, starting with the most likely. Include sample graphs or diagrams, if the reader would need them to understand. Unlikely solutions do not need to be included.	Describe how the teacher will handle the different student responses, especially incorrect solutions, students who get stuck, or students who finish early. Beware of tutoring. Sometimes there is overlap, and a back-and-forth between this section and the next and can and they may be combined. Sometimes the best way to handle a misconception is to let it go until the *Ceardaíocht* discussion.	
***Ceardaíocht*/Comparing and Discussing** This section may identify which student solution methods should be shared and in what order or generally how to handle the discussion. You may choose erroneous/incomplete solutions to identify commonly-held misconceptions. Effective questions to ask during *Ceardaíocht* include: "What do you think"? (ask another student(s) other than the presenter) "Why is that"? (Looking for evidence). "Did anyone else solve it the same way? Can you explain this method" It is important that the whole class is engaged and that students understand they may be called on at any stage to reflect on what another student said. When responding to students' efforts, try not to adopt the opinion of particular students, as this can funnel all students down a particular path to solving the problem.	What are the ideas to focus on during the discussion? Put in hints for questions.	The assessment questions here usually focus on whether students recognize why a certain solution is incorrect, or understand some key point, or appreciate the merits of one solution over another. Questions may also relate to the research theme; e.g. "Are students defending their ideas? Are they responding to each other's ideas?"
(If needed, repeat 2, 3, & 4 above for additional tasks. Otherwise delete this row.)		
Summing up & Reflection This section describes how the teacher will summarize the main ideas of the lesson. It may also include an assessment activity. A good strategy is to look back at the opening problem and to remind students of what was new or difficult about it. Guidelines for writing a reflection: One to three points of view Today I understood... Today I noticed... Today the questions I have… Today I learned from my friend's ideas…	The teacher may use the layout of the boardwork to help provide students with a summary of the progression in their learning.	

10. Board Plan

In planning the research lesson it is important to understand in advance how the board will be used to support learning. If board work is planned and executed well, it should provide a clear record for students of how learning progressed throughout. Furthermore, well-thought-out boardwork can help students recognise prior knowledge that they lacked, new concepts and skills that they have been introduced to and connections across disparate areas of mathematics.

When planning for displaying student work on the board, approaches should be arranged in order from least sophisticated to most sophisticated. During Ceardaíocht, student solutions may be re-ordered to reflect similarities between their core mathematical ideas. This can be a powerful way to consolidate student learning. Such actions should be planned for in advance. In planning the research lesson it is a good idea to run a simulation of the lesson and to reflect on whether the board plan supports learning in the way envisaged by the lesson. A photograph of the board can be taken as a record of the board plan.



11. Evaluation:

This section should include questions, to be discussed after the lesson, about the effectiveness of the lesson in terms of the team's research goals. It should include at least one question specific to the research theme and at least one about the specific content goals. For example:

a) Did the lesson successfully promote student-to-student discussion? (i.e. the theme)
b) Do students understand that…? (i.e. a content goal)

Include any other questions that the planning team hopes to explore through this lesson and the post-lesson discussion.

In preparing for evaluating the lesson it may be useful to:

- Have a written record of responses, approaches and solutions
- Identify the approach used by each individual student
- Collect student work at end of lesson for assessment
- Identify students who do not understand the problem

12. Reflection

After the research lesson, the team should write a reflection, which will normally include:

a) what the team had hoped to observe during the lesson
b) what was actually observed during the lesson, by the team members and others;
c) major points raised during the post-lesson discussion, and the team's own opinions;
d) points made by the knowledgeable other; and
e) ideas for future study.

This may be a few paragraphs in length. A good reflection makes the final document much more valuable to an outside audience.

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If you wish to join the growing number of teachers involved in Lesson Study please visit **www.projectmaths.ie** and pick from a wide variety of schools and Education Centres where you can access it locally to you. Teachers involved in Lesson Study are enabled to observe research lessons in their own schools and in other schools thanks to substitution provided by the Teacher Education Section of Department of Education & Skills. All Lesson Proposals developed under the guidance of MDT are available at www.projectmaths.ie where they are organised by Junior and Senior Cycle topic. Our annual conference **Maths Counts**: Engaging Mathematics Teachers in Lesson Study showcases research lessons through live teaching and interactive workshops.

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