Erasmus+

3DiPhE
Three Dimensions of Inquiry in Physics Education

PRACTITIONER INQUIRY IN THE CONTEXT OF INQUIRY BASED LEARNING

Textbook, guide and tools

2

Jan De Lange

Volume 2: Building Professional Learning Communities
Textbook, guide and tools

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3DIPhE
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ABOUT THE PROJECT:

The ERASMUS + Project KA2 2017-1-SI01-KA201-035523 Three Dimensions of Inquiry in Physics Education (2017-2020) focused on commonalities and differences between inquiries at three different levels and the final results are comprised in an e-book in four volumes. These dimensions are.

- Inquiry by students who use the inquiry-based learning approach to learning physics;
- Practitioner inquiry of teachers inquiring the processes in their classrooms;
- Inquiring processes in collaborative professional learning communities of teachers; and in addition
- Inquiring and evaluating all processes in the project using educational design research.

The project actively involved seven partners from four different countries (Slovenia, Belgium, Ireland, Poland), more than one hundred teachers from all partner countries and indirectly more than one thousand students taught by these teachers. The acquired knowledge was shared with several teachers who were not involved in the project and we hope that they will benefit from the presentation of our results in these volumes.

Mojca Čepič, the project leader

PREFACE

This volume is about doing a practitioner inquiry (PI) in the context of inquiry based learning (IBL). Two dimensions of the 3DIPhE project are present in the title of this volume, but conducting a practitioner inquiry is best done in a group of teachers, a learning community. In this way this volume links PI with other volumes about IBl and coaching a PLC, so as a matter of fact the 3 dimensions are present.

It contains some theoretical background and important information about conducting a practitioner inquiry in the context of inquiry based learning. After the theoretical background a course on how to coach a group of teachers is proposed, including a corresponding guide that supports someone how to coach a group of teachers doing a Practitioner Inquiry in the context of IBL. This 'someone' can be a teacher coaching other teachers (who already have a bit of expertise in PI and IBL), a pedagogical adviser, a university staff member, a head of schools, etcetera. The second part explains how to 'deliver' the course. It contains some background planning, the structure, a proposed agenda and timetable, goals, tips, examples from 3DIPhE experience and references to extra protocols and literature.

In such frames you will find teacher's quote from 3DIPhE

GLOSSARY

This refers to the glossary of definitions for the purposes and context of the 3DIPhE project.

Title	Description
Professional Learning Community	A professional learning community is considered to be a group of teachers and/or educators working together in a supportive, collaborative and positive environment. It is characterised by a shared vision, responsibility and values, and equitable participation.
Practitioner Inquiry	Practitioner Inquiry refers to the professional learning of coaches, teachers/educators who are engaged in a planned study on their practice leading to recommendations enabling evidence informed changes
Inquiry Based Learning	An active learning method in which students, in order to develop knowledge or find solutions (e.g. to discover trends, measure quantities of objects or quantities related to phenomena, find out the limits etc.), follow a scientific method used by researchers in science studies. IBL emphasizes the students' role in the learning process in which they are encouraged to explore the scientific issues, ask questions, and share ideas. Instead of memorizing facts and rules students discover them by doing. The teachers' role is to support students in their learning process, and not to instruct them.
Educational Design Research	Educational Design Research (EDR) is an iterative process where learning is systematically studied in the context in which it happens. The EDR process allows researchers and educators (often the user of EDR acts as both) to design, develop and evaluate educational programmes and interventions. By systematically studying this development, the EDR process can generate knowledge and theory relevant to the educational settings in which it is used.
Cycle	A clearly defined phase of the project in the context of the EDR Framework.
Iteration	This refers to the implementations of the PLCC and PLCT courses during the 3DIPhE project. These happened during Cycle 3 and Cycle 4 of the EDR framework.
Partner	Partner institution or its representative that is officially involved in the project.
Coach	Individual who designs, organises and guides activities in professional learning communities.
Facilitator	Individual who facilitates an activity or protocol as part of a workshop. A facilitator can be a coach or teacher in a workshop.
Participant	Individual attending an event e.g. course, conference, meeting,... This can refer to partners, teachers, future 3DIPhE coaches or external stakeholders
Teacher	In-service teacher who practices in a formal school setting
Student	Child, aged 10-18, in a formal school setting
Course	A coherent set of workshops aimed at a targeted learning process for participants
Workshop	A single meeting of a course with clearly defined goals.

Tool	A specific teaching and learning material used by coaches and teachers
Activity	A general noun for a part of a workshop where some action takes place, e.g. following a protocol, group discussion, watching an instructional video, etc. An activity is more general than protocol.
Protocol	A set of instructions, used during a workshop, with clearly defined goal(s), that has a strict order of actions and timing of those actions.
Worksheet	A learning support material e.g. used by participants of workshops or students in a classroom.
IBL Unit	A collection of inquiry based learning activities centred around a theme, topic or concept.
Information sheet	Additional background information to support an activity.
Course Guide	A guide book for coaches that details the structure, activities and rationale for planning and implementing a course.
Course Workbook	A complete collection of all teaching and learning materials that is used by participants of a course.
Inquiry	Inquiry (IBL): In the context of Inquiry Based Learning, inquiry refers broadly to the activities that students carry out in the classroom. Inquiry (PI): In the context of Practitioner Inquiry, inquiry refers to the planned study that coaches, teachers/educators carry out in the context of their own practice.

Table of Acronyms

Professional Learning Community	PLC
Professional Learning Community of Teachers	PLCT
Professional Learning Community of Coaches	PLCC
Practitioner Inquiry carried out by a teacher	PIT
Inquiry Based Learning	IBL
Education Design Research	EDR
University of Ljubljana, Faculty of Education, *Slovenia*	UL
Jagiellonian University in Kraków, *Poland*	UJ
Dublin City University, *Ireland*	DCU
Catholic Education Flanders – vzw VSKO, *Belgium*	CEF
Artevelde University College, *Belgium*	AHS
UC Limburg, *Belgium*	UCLL
National Education Institute, *Slovenia*	NEI

CONTENT

PART A:
Practitioner inquiry in the context of inquiry based learning

Chapter 1: Theoretical background and learnings from 3DIPhE-project

Section 1: Practitioner Inquiry - developing an inquiry stance

- 1.1.1. Practitioner Inquiry: why & what?
- 1.1.2. Inquiry is about collecting data.
- 1.1.3. Look at the students for the data first.
- 1.1.4. The process of a Practitioner Inquiry... towards an inquiry stance
- 1.1.5. Practitioner inquiry and academic research

Section 2: Conducting Practitioner Inquiry within a Professional Learning Community (PLC)

- 1.2.1. Collaborative learning in PI
- 1.2.2. Collaborative learning space
- 1.2.3. Different types of inquiry in a PLC

Section 3: Conducting PI in the context of IBL

- 1.3.1. How PI and IBL are interrelated and the added value of bringing them together.
- 1.3.2. How promote PI towards IBL in a training course?

Section 4: 3DIPhE in action and what have we learned from it?

- 1.4.1. Three Dimensions of what?
- 1.4.2. Design principles and learnings from the iterative design of this course
- 1.4.3. Key learnings and design principles for the course on conducting PI in the context of IBL

Chapter 2: How to structure the course on Practitioner Inquiry in the context of Inquiry Based Learning?

Section 1: training aims for the course

Section 2: From the key design principles and training aims towards a structure of this course

Section 3: a 5-day course or a PLCT?

Chapter 1: Theoretical background and learnings from 3DIPhE-project

This chapter contains some background for the coach. *What do you need to know about coaching a course of teachers conducting PI in the context of IBL?*

Section 1: Practitioner Inquiry - developing an inquiry stance

1.1.1. Practitioner Inquiry: why & what?

Teachers are continuously faced with challenges about the impact of their teaching. However, finding out systematically what works in one's professional practice is generally not regarded as a part of the teaching job description[1]. Education is about students' learning. More specifically, in science education students learn about science content, develop skills and attitudes related to Inquiry Based Learning (IBL). A theoretical framework and 3DIPhE examples of IBL are thoroughly described in Volume 1. The project Linpilcare proposes the concept of 'evidence-informed teaching' that helps teachers facing these challenges by making their practices more evidence-informed. Teachers must develop an inquiry stance at their level, about their teaching practice… Their inquiry is about their profession, their practice, their daily work with students. This inquiry leads to a lot of learning of the teachers, and is what we call their 'practitioner inquiry'.

"The course on practitioner inquiry gave me the opportunity to actually work on something that had been bothering me all along. The problems were there already, but making time to deal with it, was very important for me."

Practitioner Inquiry (PI) is **a form of professional learning** defined as the **systematic intentional** study by teachers **on their own practice**[2].
The teachers (=practitioners) engage in systematic reflection and take action for change by asking questions ("wonderings"), gathering data to explore their wonderings, analyzing the data, making evidence-informed changes in their practice, and sharing their learnings with others[3].
Eventually PI leads to an inquiry stance that provides a kind of grounding within the changing cultures of school reform and even competing political agendas (pp288-289, Cochran-Smith and Lytle 1993). **Ownership** is maybe one of the most important conditions to start a successful PI. The teacher must be wondered and challenged so that he is willing to improve his practice!

[1] http://www.linpilcare.eu/images/WEBMASTER/Documents/CCFR/TTP_Final.pdf
[2] Cochran-Smith, M., & Lytle, S. L. (Eds.). (1993). Inside/outside: Teacher research and knowledge. Teachers College Press.
[3] Dana, N. F., & Yendol-Hoppey, D. (2014). Teacher inquiry defined. The Reflective Educator's Guide to Classroom Research: Learning to Teach and Teaching to Learn through Practitioner Enquiry. Third Edition. Thousand Oaks: Corwin, 5-28.

In literature many names have been given to this kind of inquiry like action research, professional inquiry, teacher research, self-study, practitioner research, … as examples of practice-changing models of research. Action research, for instance, usually refers to research that is intended to bring about change of some kind, usually with a social justice focus, opposed to a teachers' inquiry which quite often has the goal only of examining a teacher's classroom practice in order to improve it, or to better understand what works[4]. Further in this guide the term practitioner inquiry will be used.

Example from 3DIPhE: Teacher X inquires Y

Chemistry teachers Maggie inquires how she can motivate her students for abstract stoichiometry.
Maggie is a chemistry teacher with over more than 25 years of teaching experience. She teaches students in the fourth grade (15 years old) of a technical school on agriculture. Every year she notices students having lot of difficulties with chemical arithmetic (stoichiometry) and certainly those students with less mathematical knowledge and skills. It is a problem of all time, but the last ten years it is becoming more and more problematic. Maybe students' achievements are decreasing over the last decade? She's not sure, but it is a fact that the topic of stoichiometry is perceived as very abstract and not meaningful. Conversions about molar mass, the amount of substance and units corresponding these quantities like mole are very difficult. Stoichiometry is thus a very challenging issue to discuss in class. Students need more context and intrinsic motivation to achieve deeper learning.
So, Maggie choose the following inquiry question: "In what way can I increase the motivation for the lessons on chemical arithmetic among less mathematical students and thus achieve deeper learning?" She started reading some literature on how to motivate students for stoichiometry and at the same time she discussed her problem with the math teacher. Eventually she found an interesting study on 'arithmetic of reactions, an intervention in which deep learning is central' and the specific teaching materials from a project-based course on the topic Eco-travelling. Maggie didn't exactly copy it but adapted this project to her needs and context. In consultation with the math teacher extra attention was paid to mathematics about converting units and formulas, ... and using the context of environmental travel. The intervention eventually led to a key question in the project: "how many kg of CO2 is emitted by a car and airplane when travelling from Brussels to Marseille?" This was structured in the following steps: discussion, plan of action, calculate & exchanging results.
During the intervention Maggie collected data in diverse ways: students' notes to find out if students were able to solve the problem with chemical calculations, her own notes after each lesson and a student survey to find out how this new method was perceived by students (on motivation, self-evaluation of chemical concepts, …). Eventually a test in between on mathematical skills and a final test on chemical arithmetic was taken to examine the progress of students' achievements on stoichiometry.
Maggie was at first not excited about the results. She still noticed after the math test that 3 out of 14 students still could not apply the required mathematical skills. Starting with a key

[4] Dana, N. F., & Yendol-Hoppey, D. (2008). *The reflective educator's guide to professional development: Coaching inquiry-oriented learning communities.* Corwin Press.

question about ecotravelling clearly motivated students, but not always towards the correct chemical calculations. Making that transfer form context to abstract chemistry is difficult. However, after looking into the further results and discussing these results with science colleagues she became more and more enthusiastic. The motivation for stoichiometry by working with context is greater (students wanted an answer to the question of CO2 emissions). The results from final test on this subject are slightly better but not sufficient enough to make clear conclusions. The collaboration with the mathematics teacher went very well and it is important that teachers need to do this more often.
Eventually, Maggie is persuaded to continue her inquiry next school year, make new changes and collect new data to give her information about her teaching. She indicates that the collaboration and discussions with other colleagues are at least as important.

Example from 3DIPhE:
Hanna inquired how her students perceive the IBL method implemented in physics lessons?

Physics teacher Hanna was teaching a group of 4 boys and 14 girls with a humanistic and biological-chemistry profile. The course is an introductory physics at basic level, only 1 hour per week for one school year. The students got acquainted with IBL for the first time in their life, so a guided level of inquiry was advised.
Hanna wanted to find out how her students perceive the IBL method during this physics course. Therefore, she applied inquiry based learning in two topics: The Moon and centrifugal force. The students had a great time in class, were eager to engage in the experiments, conducted research, talked about the results and formulated conclusions. After completing two topics Hanna administered a test and right after the test (when students did not know the results yet) students were asked honestly to fill in an anonymous survey to answer the question: 'Did the method of IBL help you in taking the test?' It seemed that all students disagreed. An exemplary answer was that 'the IBL method did not fully help me prepare for the test, although I like that we could come to some conclusions in physics lessons and they were not boring'. Discussing these results with her students, it turned out that they did not believe using IBL could learn something. It was only a kind of having good time. That is why, when preparing for the test, students used the traditional methods: reading the book or even searching the internet. However, what they learned at home was not asked at the test, because the test examined inquiry skills like drawing conclusions, interpretation of the physics phenomena and laws. In fact, the students perceived they got lost during the test. The method of learning and the test were different from what they were used to. However, when Hanna corrected the test the results showed that the average result was 72% comparing the average score of 60% obtained in another, traditional test based on facts and administered after traditional lessons.
Hanna discussed these results with a group of colleagues. She was broken. She concluded that maybe IBL does not work. During the discussion, the group managed to convince her to continue with IBL, since it worked, but somehow students did not realize that. Indeed, students were very much surprised with the test results, but they somehow realized (and got convinced) that they had learned more, when developing inquiry skills, not only acquiring content knowledge as usually.
The IBL method was implemented a second time in a topic about radioactive decay. After completing the topic, Hanna ask the students again to fill in the survey about the perception of IBL and what they learned. The change was enormous. Many students now agreed when

they were asked if IBL helped them for learning. Again, Hanna was very surprised, this time positively. When she discussed this change of perception with her students, they admitted that they needed more time to get use to the method. Some exemplary answers were now like 'learning by playing, better acquisition of content knowledge, teaches how to "be up to", remember the lessons, doing experiment by themselves, cooperation between teacher and students.' Very few of them pointed out weaknesses: a slight chaos, there are a few students doing nothing, some problems with remembering part of the content

Hanna finally concluded that whenever you start with IBL, you should not give up after the first trial. If students are not used to the method, they may be very distrustful and lacking confidence in what they acquire. At first the method looks like only playing and having fun, and in a traditional school system of teaching with the most common method of learning facts and laws by heart, "playing" is a loss of time. Such an opinion is embedded also in students' minds. Only being persistent in using IBL method can convince students that they learn more with IBL than in tradition format. The method itself is so engaging and interesting that sooner or later the students realize that they learn a lot.

1.1.2. Inquiry is about collecting data.

If teachers want to learn something about their teaching, it is important to make the students' learning visible (as J. Hattie describes). Collecting data or evidence of that learning is crucial. The Linpilcare project suggests that teachers must **become comfortable with using data and evidence as tools in routinely and critically examining their own practice** (through the process of Practitioner Inquiry). However, teachers often have a misunderstanding about what is meant by this. It is not synonymous with statistics. Collecting data is an essential part of the teachers' work and they are doing it already but data must not only be seen as in numbers and percentages at the end of the school year. Data must be used in a learning-oriented manner in order to realize any valuable improvement in the learning, as an ongoing process: collecting, analyzing, new learnings, changes in practice. There should be a variety of data, both quantitative and qualitative.

1.1.3. Look at the students for the data first.

"It was an eyeopener for me to see how much information I got when I only presented and discussed my inquiry question at my students. It was surprising to see how many answers were already there, in my classroom..."

Improving your classroom practice must have a clear purpose and that is enhancing the learning of your students. Practice cannot be considered effective unless it is **responsive to the participating students** and promotes their learning. The worth of the co-constructed criteria in practice, therefore, needs to be judged in terms of how students are responding and learning (Timperley, 2011).

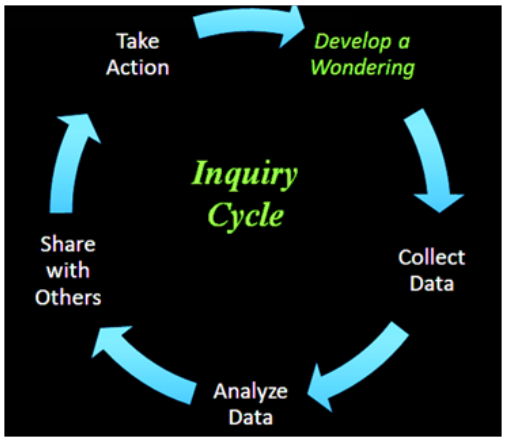
Students' involvement in inquiry makes it immediate, relevant, differentiated, active, and engaging, therefore it makes sense to share it with the students they teach (Dana et al., 2011).

There are numerous strategies for collecting data: student work, test scores, notes, interviews, focus groups, pictures, journals. The teacher should begin by articulating what 'it' means to them, then use the tools to enable them to explore the issue.

1.1.4. The process of a Practitioner Inquiry... towards an inquiry stance

In order to have a basic reliability of the data, teachers should collect them in an intentional, planned and structured way.

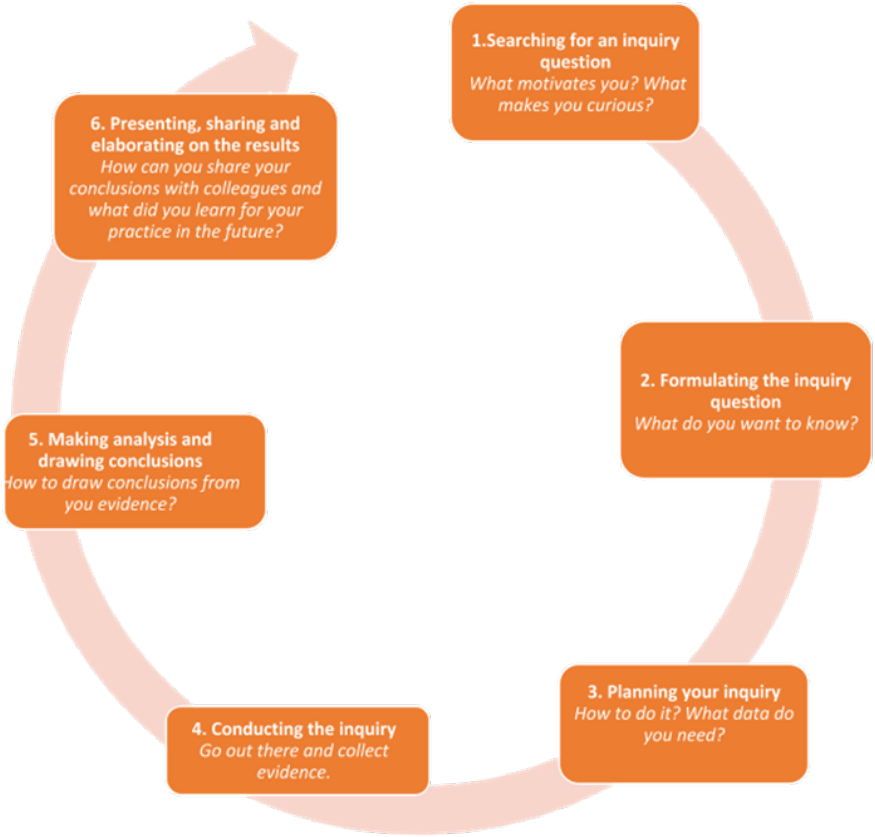
This figure is an example how to structure a Practitioner Inquiry. Dana (2013) describes the process as follows: develop a wondering – collect data – analyze data – take action – share.



It is important to use **this inquiry cycle** not as a linear process but more as a circle. The process is **ongoing** because as soon as we reach a provisional point where the teacher feels the situation is satisfactory, that point itself raises new questions and it is time to begin again[5].

Based on this kind of literature and the learnings in the 3DIPhE project, the project partners have developed an adapted cycle how to conduct a PI in the context of IBL. This is described at the end of this chapter in section 5 on the page 13.

"Through engaging in ongoing cycles of inquiry and building knowledge, teachers develop the adaptive expertise required to retrieve, organize and apply professional knowledge when the old problems persist, or new problems arise." [6]
Looking at different literature, you will notice that many different cycles exist. The cycle chosen depends on the inquiry itself, the researcher and the context. The bottom line is that the inquiry initially should follow a provisioned scheme, however, it can be productive- but not necessary to make changes as the inquiry progresses. Based on different models of PI in the 3DIPhE project the project partners used this model as a guideline to structure the inquiry. A general advice is not to be a slave of your plan. Change it if it leads to better results!



[5] Whitehead, J., & McNiff, J. (2006). Action research: Living theory. Sage.
[6] Timperley, H. (2011). Leading teachers' professional learning. Leadership and learning, 118-130.

Eventually teachers should do this continuously (in a cyclic manner) and not as a one-time shot, always systematically (according to a certain plan).
In the end, practitioner inquiry is about developing an inquiry stance!

> *People with an inquiry habit of mind develop a mindset of being in charge of their own destiny and creating or locating the knowledge that will be useful for them along the way. They engage in questioning, reflecting and decision-making, using data and evidence as critical elements in the process. We consider inquiry to be a habit of mind; it is a dynamic iterative process with feedback loops that organize ideas towards clearer directions and decisions. By drawing on information in this way, inquires move closer and closer to understanding the phenomenon of interest.*

Earl, L. M., & Katz, S. (Eds.). (2006). Leading schools in a data-rich world: Harnessing data for school improvement. Corwin Press.

1.1.5. Practitioner inquiry and academic research

The project Linpilcare but also Nancy Dana[7] describe two types of research: academic research and practitioner inquiry. When talking with teachers about doing research in their professional lives, they often feel a bit reluctant and have a stereotypical view on what research is about. There are differences between them but more importantly they have also a lot of similarities. It is important to stress that both are **equally valid** and **important in the field of educational research**.
Research is a concept that is often reserved exclusively for the academic (or scientific) world: a type of research conducted by scientists, whose job it is to add to the academic body of knowledge in a certain field. They do this primarily by publishing their work and findings in peer-reviewed academic journals, that are available to other academics, but mostly not to practitioners, e.g. teachers. In most cases, academic research is designed in ways that enable the researcher to generalize conclusions to different schools, teachers, or (groups of) students. It is important however to notice, that this is not always the case. Academic research can sometimes also be aimed at describing very specific individual practices.
Like many others have done before us, we consider 'practitioner inquiry' a different, but certainly no less valuable, type of research. In fact, teachers use the same principles as 'academic researchers. This kind of research involves collecting and analyzing data as well as presenting it to others in a systematic way. The validity of findings following from practitioner inquiry are therefore in principle also restricted to this practice, although it can serve as a source of inspiration for other practitioners. Teachers are surprised and delighted to realize that research can focus on problems they are trying to solve in their own classrooms. At its best, this kind of research is a natural extension of good teaching.

The Linpilcare project made this table on how academic research and practitioner inquiry are different on seven characteristics.

[7] Dana, N. F., & Yendol-Hoppey, D. (2008). The reflective educator's guide to professional development: Coaching inquiry-oriented learning communities. Corwin Press.

Table 1: Comparing academic research and practitioner inquiry (based on tables from Fichtman Dana & Yendol-Hoppey, 2014; Bolhuis & Kools, 2012)

	Academic research	**Practitioner inquiry**
Goal	Expand academic body of knowledge in a certain field	Provide insight into teaching in an effort to make change
Conducted by	Scientists	Practitioners
Conducted in	Controlled settings (labs) or in vivo (in schools)	A specific educational practice
Impact on the academic community	Broad on the academic community trough publications in peer-reviewed journals	Very limited
Impact on educational practice	Very limited	Profound on the practice at hand
Scope of findings	Generalizable; valid for and transferable to different contexts	Limited to specific practice at hand.
Involvement of practitioners	Source of data and/or actor in implementation of intervention	As researcher or as critical friend in practitioner inquiries of colleagues

Earl, L. M., & Katz, S. (Eds.). (2006). Leading schools in a data-rich world: Harnessing data for school improvement. Corwin Press.
Dana, N. F. (2013). *Digging deeper into action research: A teacher inquirer's field guide.* Corwin Press.

Take home messages

PI is…

…**intentional**: purpose of improving classroom practice with the focus on students' learning, more specific on skills, competences and attitudes of Inquiry Based Learning.

… an **inherent part of the professional practice** of the teacher. It is something he is already doing, and with somesmall changes he can easily inquire his professional practice. **Ownership** is very important to ensure enough motivation to start the inquiry.

… about **collecting data**: teachers need to make the learning of the students visible by collecting data as tools to examine and improve their classroom practice.

Systematic: PI uses a prepared scheme, not linear but cyclic. It is continuously ongoing process of learning in close collaboration other stakeholders (students, colleagues, school leaders, parents, …).

1.2.1. Collaborative learning in PI

Conducting a Practitioner Inquiry can be done on your own. There are several handbooks and guides that will help you structuring and processing the inquiry. However, it is a lot more motivating, interesting and sustainable if this process of learning takes place in a group of peers like other teachers & colleagues. Nancy Dana[8] defines a professional learning community (PLC) as "a group of teaching professionals who meet regularly to learn from practice through structured dialogue and engage in continuous cycles of inquiry". Volume 3 on Building Professional Learning Communities, elaborates much deeper on this topic, specifically on how to facilitate a PLC.

In the 3DIPhE project, teachers collaborated together while conducting a PI. Such a group was called a professional learning community of teacher or in short, a PLCT.

Teachers appreciate sharing especially when they realize that other members of the PLC are having similar problems as them, not just PI problems. It is important to allow sufficient time for teachers to talk about these things in workshops. It helps to build community.

There is a lot of evidence that this process of improvement of students' learning has the most impact if it's done collaboratively. Therefore, almost all activities described in this guide are meant to do in groups of 4 to 6 peers, whether you are coaching a 5-day course with 25 participants or a PLCT at a school that meets each other at a regular base.

1.2.2. Collaborative learning space

It is described further in Volume 3 on Building Professional Learning Communities: to have an effective professional learning community there must be an atmosphere for collaboration, based on trust and positive relationships. This is important for a group that intends to work together on difficult issues, or who will be working together over time. Without attempting to be exhaustive, we list up a few conditions of a collaborative learning space:

- The working space of the group is **informal**, but members of a group should work together **as colleagues** and not just friends. It is not like a teachers' room in a school with a lot of small talks where everybody can enter and leave the room whenever they want.
- It is important to **stay on topic** and not just a talk where it changes form one theme to another. The objective is to examine and improve the professional practice of the teachers, specifically to the topic of IBL. This should always be a priority during the meetings.
- An **open** and **positive mindset** is important. Peer feedback is crucial so there must be an atmosphere that is open for critical remarks in order to have constructive contributions.
- Make sure to have a specific but **feasible time scheduling** and try to follow this time schedule. A lot of protocols and activities have fixed time slots and participants' roles (facilitator, presenter, giving feedback, …). Participants must respect these roles to ensure that every member has sufficient time to talk about his professional challenges and problems.

[8] Dana, N. F., & Yendol-Hoppey, D. (2019). The reflective educator's guide to classroom research: Learning to teach and teaching to learn through practitioner inquiry. Corwin.

- Participants must not be afraid to take action and so they must be encouraged for **this call for action**! When practicing PI, it is very much like learning how to ride a bike. You can read about biking, but until you sit on the bike, fall, and get back up again, you won't develop the muscle memory. Likewise, until you practice the methods, you won't experience the difference between "just" following the script vs embodying the critical mindsets required for successfully developing a practice of PI.
- Participants must have a stance for noting as much as they can, not only about their PI's but also other learnings from other PI's. **Constantly taking notes** enables the PLC to capture and synthesize important learning and to do's for the future.

1.2.3. Different types of inquiry in a PLC

There are different types of PI approaches in a PLC: PLC that focus on:

1. '**Shared inquiry**' means that all PLC members work together on conducting a single inquiry. They are trying to find an answer to one specific question together.
2. '**Intersecting inquiry**' are adequate when all PLC members have an interest in the same topics, but each conducts his/her own inquiry based on this topic. The topic is defined by all the members of the PLC group. The inquiry processes, outside the PLC meetings, are basically individual.
3. '**Parallel inquiry**': All PLC members conduct individual inquiries on individually chosen topics.

The choice of type of inquiry depends on the circumstances, the context, the group of teachers. It is their choice and it is important to choose the best option. In a shared PLC all the members are involved in the same inquiry with the same inquiry question. All members could, for example, bring data to the PLC meeting from their own classrooms, consequently establishing rich images of the practices at hand, including their similarities and differences. By doing so, it is very easy to really get a grasp of the content of the inquiry during PLC meetings. There are however also some disadvantages of a shared inquiry: there is always a risk that the topic and inquiry process are not (fully) the concern of all the members. This could be harmful to the involvement and professional learning of these PLC members.
The advantage of parallel inquiry is that all the members of the PLC chose topics that they are (likely) really committed to. There is also a risk: the absence of involvement on the content of inquiry can cause a lack of interest in the inquiry of others and therefore less motivation to contribute. An intersecting PLC, as a middle ground between the other types of PLCs, seems to be preferable in a lot of cases: there is a balance between engagement on content and distance to be a critical friend, there is a shared topic, but with individual corresponding questions.

Doing a PI in the context of IBL will probably lead to a shared or intersecting inquiry. A well functioning PLC is a real asset for the teachers, especially when they are supposed to collaborate on integrated subject matters, each teacher from his/her specific expertise and background. From that point of view moments where teachers can exchange concerns and ideas are an added value to a workshop.

Below you will find some examples of PLC's doing different kinds of inquiries. There are some differences, but it is important to see that all of the inquiries have the same purpose, namely improving the classroom practice of IBL in science education. This common ground of inquiries was important during the 3DIPhE project.

3 examples of inquiries of conducting a PI in the context of IBL:

A shared inquiry:
A shared inquiry was performed in a secondary school where teachers chose to completely reorganize the courses of sciences, geography and technology for the students of the first grade (12-14 years). Before, these subject matters were offered in separate courses, but now a STEM-course was organized in which these 3 subject matters are taught in an integrated way.
All science teachers were triggered by the same wondering: Do we have to give clear classical instructions, or should we give the students room for exploring themselves? And wat will be the difference in learning outcomes? This wondering resulted into a more specific inquiry question: 'Does the amount of classical scaffolding influence the learning outcomes of the students performing an integrated IBL-project?'
This inquiry was conducted in 3 different classes by different teachers. In this way, the inquiry could be done in different classes and led to more detailed information an specific classes.

A intersecting inquiry:
Several STEM teachers shared basically the following inquiry question: " In which ways do we need to adapt our future STEM course in order to make it more inquiry based?" The three teachers were building a STEM course, consisting of different modules, which they wanted to become really inquiry based. They have used the booklet "Inquiry in Science Education" (an outcome of the Fibonacci project) as a inspirational framework and drawn several indicators for IBL from this framework. Each of them focused on two or three indicators, considering how they can implement this aspect or element of IBL in their lessons expressed in the preliminary versions of a STEM module. They separately gathered data and provided feedback to their two peers. The idea was to implement the lessons learned in all modules, making them more inquiry based.

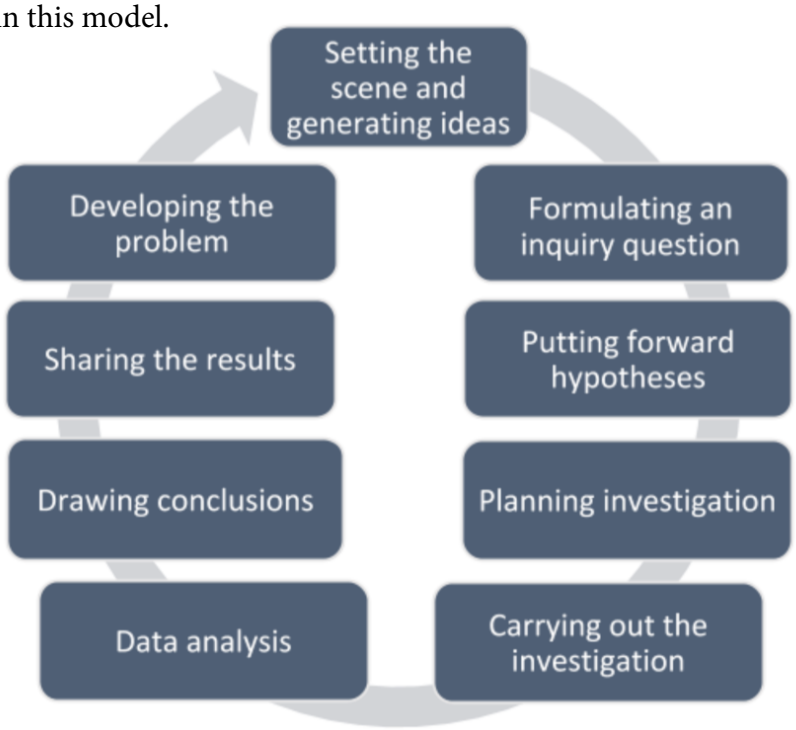
A parallel inquiry:
3 science teachers are working on different topics and inquiry questions.

- *A chemistry teachers was examining ways how she can motivate her students for the difficult and abstract topic of stoichiometry.*
- *A physics teachers was facing problems in giving feedback during practical work and she wanted to test new ways of giving feedback in a more efficient way.*
- *A biology teacher noticed that 2 of her students that were excellent, needed more challenging tasks in order to prepare them better for higher education. She was looking for ways how to challenge them in a distance learning module.*

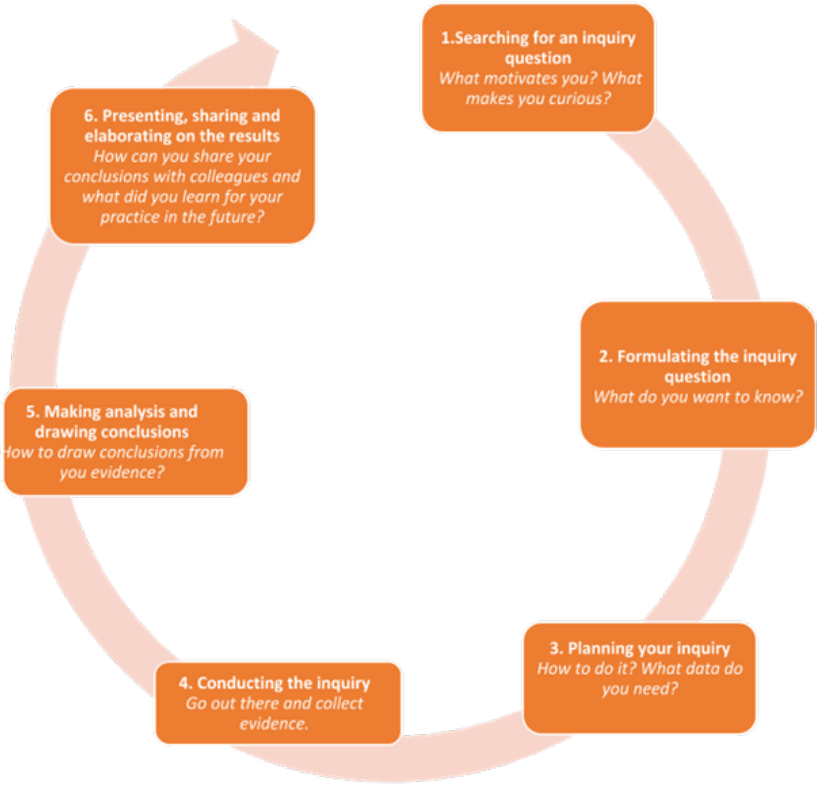
However, they were working all on a different subjects and topics, all teachers were also interested in the inquiries of other teachers because the challenges others were faced with, were also relevant for them. There were very interested in the results from each other and at the end, they all mentioned they were going to use these learning from others also in their own practice!

1.3.1. How PI and IBL are interrelated and the added value of bringing them together.

Inquiry Based Learning at student level is thoroughly described in Volume 1. The Inquiry cycle of the student using IBL is visualized in this model.



The inquiry cycle of a teacher doing a practitioner inquiry is described in section 1 of this chapter on page 8.



Looking at these two cycles of inquiry, you can not 'not notice' that both inquiries, at a student's and teacher's level, are very alike! It enhances **the inquiry stance of both teachers and students**. They both use **the same skills** like generating ideas, asking questions, developing hypotheses, planning inquiries, gathering data and evidence, analyzing and making conclusions, working collaboratively and presenting/sharing/elaborating results. As Stiles (1999) describes a teacher-inquirer as someone who searches for questions as well as answers. Learning means that saying, "I don't know" is not an admittance of failure, but a precursor of positive change. They have become comfortable with the expressions: "I wonder …," "I think …,"and "What if …?" Replace the word teacher with the word students and you will identify the rationale for Inquiry Based Learning.

"After a short history about flying objects, students were challenged to build their own paper plane. They had to use their prior knowledge and decided on choosing the right paper and best folding method. They gathered data on time and distance the planes fly and made comparisons. They worked together to choose paper plane showing they understood physical quantities about the pitch and directional stability.
Then they gather data on time and distance the planes fly."

However, the **purpose** of the inquiry and **context** in which the inquiry is being conducted, is **different**. The IBL of the students and the PI's of teachers are using the same kind of inquiry skills, but IBL is being done in the context of natural sciences, giving students opportunities for making sense about the physical world surrounding them. Through IBL students strengthen their scientific reasoning and literacy. In this box there is an example of a possible IBL activity, but there are many more in Volume 1 of the e-book.

However, the purpose and context of the teachers' Practitioner Inquiry is not about making sense of the physical world but making sense about what happens in the classroom. More specific, the emphasis is on the learning of the students (Inquiry Based Learning), which is crucial! Using the same inquiry skills that teachers expect from their students, they have to direct inquiry questions, collect data for evidence of inquiry-based learning in class to make this learning visible. In the box below, you will find a short description of a teacher conducting a PI within the IBL example of paper planes.

The module about paper planes was given first in a traditional way, extremely structured. The teacher was very unhappy because the results were poor, and the timing was a disaster. After feedback of peers he adapted his unit. This time the teacher had a small preliminary inquiry on this 2 hour-unit, asking himself:

How do students evaluate and improve their own aircraft?

How can the timing contribute to a better focus on the inquiry question?

He went through the module with the students, giving them more freedom during the work with the paper planes, however trying not to lose time by imposing a strict timing. At the same time, he still provided scientific input in several phases, forcing students to consider the theory in making a better plane.
Students claimed afterwards they could improve their plane, the collaborative work was considered useful and the timing was perceived rather positive, leading them to real results in the given time.

1.3.2. How promote PI towards IBL in a training course?

Practitioner Inquiry can tackle various topics and challenges that teachers are faced with. This kind of inquiry is even not limited to an educational setting. It is often used as a kind of action research in organizations where employees (= practitioners) want to improve their professional practice.

In the 3DIPhE project, two dimensions of inquiry, IBL & PI, **reinforce** each other by **conducting PI in the context of IBL**. Though it is not a necessity, the project partners experienced an added value of bringing the two together. By making PI more specific in the context of IBL, you give teachers direction and focus and, at the same time, amplify their teaching methodology of IBL.

Implementing Inquiry Based Learning into my class only worked when added Practitioner Inquiry to it!

An important aspect of PI is that the teachers must have ownership about their inquiry and therefore, are free to pick a topic they see as relevant. Yet, within the project it was desirable that their inquiry topic would be somehow related to IBL. This contradiction is actually not uncommon in inquiry driven projects, as teachers will probably find this very relatable when they design an inquiry based projects for their students. The freedom of choice during inquiry by the students is also limited by practical or time constraints, or by the fact that it should fit in the curriculum and lesson goals.
The only way around this apparent contradiction, without harming the teachers' ownership, is by promoting IBL in an indirect way during the coaching course. Use examples of IBL as inspiration, talk with them about problems they are faced while implementing IBL and how they feel when using IBL in class, … In this way, you motivate them so that they choose IBL related inquiries themselves.

This **steering towards IBL** must be done intermittently. Some **suggestions** are described below:

- Use **modified versions** of more general **protocols** used in PI cycles that relates wonderings and questions to IBL. For example, the passion protocol includes mainly passions about the challenges of teaching IBL. Another tool to search for good wonderings is the Fibonacci Self-assessment tool as a very good way to reflect on their IBL practice.
- Let **teachers come up** with **IBL design principles** for a good lesson **themselves**, without defining them as IBL in se. For example, discuss with them "What is the best IBL lesson you have ever given? Describe, and why was it the best?" Other teachers note key elements that are transferable to other lessons. In this way, together with your teachers you can build **a shared vision** on the quality of Inquiry Based Learning and teaching, without being pedantic by saying what IBL is and what it is not. This ensures a non-hierarchic way of working together.
- Confront the teachers with IBL approaches on a regular basis during the course. At fixed moments you can show an IBL lesson to them. While discussing the benefits of this approach thoroughly afterwards, it is highly likely that these examples will influence their practitioner inquiry itself. So, **diversify** your workshop activities by doing **some IBL activities**, **reflect** on these activities and **connect** their reflections **to their own professional practice.**
- Ask **teachers** to **bring** in an example of a **practical class IBL problem**.
- Use **examples from 3DIPhE teachers in PLCT's** (see Volume 1) and discuss it with teachers.

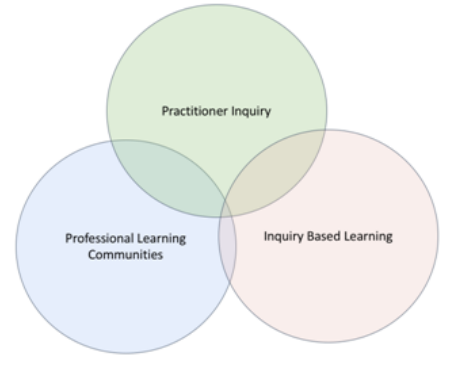
All these suggestions were incorporated into the design of this course on conducting PI in the context of IBL.

What if there's confusion between Inquiry Based Learning and Practitioner Inquiry?

While teachers were coached in the 3DIPhE project, Inquiry Based learning (IBL) was already a well-known method but many teachers did not have much experience with it. Practitioner Inquiry (PI) on the other hand was a rather new method of working on professional development. In the professional learning communities (PLC) getting familiar with both inquiries was quite challenging. Coaches experienced some confusion amongst teachers in distinguishing inquiry questions that students are supposed to deal with (IBL) and the inquiry questions that the teacher were supposed to tackle in their PI inquiry.
Therefore, it is good to provide an activity starting from a real example where both kind of questions – IBL and PI questions, are discussed. The differentiation between the inquiry questions for IBL and PI will be clarified from this example.

Section 4: 3DIPhE in action and what have we learned from it?

1.4.1. Three Dimensions of what?



The rationale of the 3DIPhE project lies in the **combining** of **different goals** each of them aimed at **different target groups**. It is about…
- …students using IBL in class;
- … teachers inquiring their own professional practice;
- … coaching of teachers in a Professional Learning Community

You will notice that the e-book is built up according to this structure: Volume 1, Volume2 on PI (this volume) and Volume 3 on Building Professional Learning Communities. But why are we talking about 3 DImensions of Inquiry? This is slightly different than the goals described above. In the previous sections of this chapter two dimensions of inquiry (**PI** and **IBL**) are already explained and linked with each other because this is what this course is about: conducting a PI in the context of IBL. The third dimension of inquiry is called Educational Design Research (**EDR**). This level of inquiry is used for the project partners as a formative evaluation instrument. One of the aims of the project is developing a course for teachers on using Practitioner Inquiry (so to speak, this course!). EDR uses a methodological approach to design, test and improve. This level of inquiry is less relevant for coaches delivering this course (and certainly for teachers participating this course). On the other hand, it gives you some background information how this course has been developed and **how the learnings are incorporated** in the structure of this course. Volume 4 on Educational Design Research elaborates much more on the specific methodology and data collected during this project.

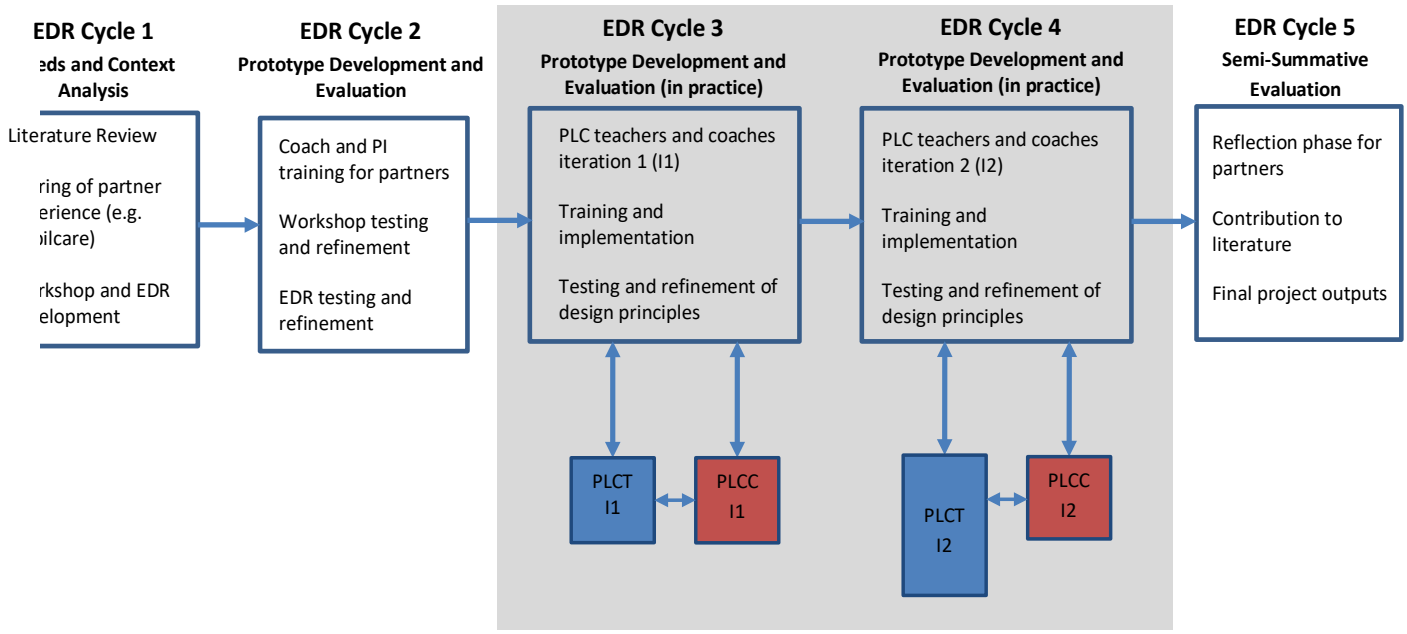
1.4.2. Design principles and learnings from the iterative design of this course

During the 3DIPHE project several iterations have taken place which eventually led to several outputs, in specific the development of this course. This figure shows visually the timeline over the 3 years of this project.
In 4 countries several Professional Learning Communities of teachers (PLCT's) have been implemented, tested and evaluated by 2 iterations in practice. The general goals for teachers are:

- Learn about and conduct a PI
- Become active member of a PLC
- Learn more, feel more confident about IBL

All learnings from these experiences have been collected, discussed and captured in design principles and key learnings.

EDR Framework for 3DIPhE



1.4.3. Key learnings and design principles for the course on conducting PI in the context of IBL

A coach should also keep in mind...

- The combination of activities on PI – IBL within a PLC is very powerful. All workshops in the course should be **devoted** to these **3 course pillars**: 1) building the PLCT group, 2) development of PI competences, and 3) development of the competences of teaching with use of IBL.
- Emphasize that it is all about **the learning of your students**! That is crucial! You have to **direct teachers to** inquiry questions, data collecting for evidence related to the learning in class, specifically on Inquiry Based Learning (and making this learning visible).

- The course should be **dynamic while approaching these pillars.** Time devoted to the different pillars should not be distributed equally though. At the beginning of the course, special attention should be paid to build the PLCT and work with IBL good examples of learning units. In the middle of the course, much more time can be anticipated to activities on development of PI competences, while IBL should be limited and focus on more specific skills in teaching IBL.
- Make a **fixed agenda** and set **clear goals** for every workshop (maybe together with your teachers). You must have a good **balance** between following a **strict time schedule** when using protocols and activities **but be flexible** with the time anticipated in protocols as well as training schedules. The protocols proved to be useful and effective tools, but if more time is needed e.g. for discussion, then additional time must be secured, since the overarching aim should be the development of teachers' competences, not rigor of the protocols and time.
- **Don't overload!** You have a wide range of possible activities and protocols but choose and select the appropriate protocol. Less is more.
- Keep an eye on **engagement** of **all teachers**. If somebody lags behind, individual talk one-to-one can be proposed to the teacher. Teachers have different coaching needs. Some need additional input or inspiration, others refinement of the goals or rules, and still others encouragement.
- Make sure you **wrap up** each workshop **properly**. **Provide time** to capture learnings from your teachers explicitly through **reflection exercises** and encourage them to take personal **notes**. This should happen immediately after each meeting with the teachers in order to enable the teachers to come back to the issues raised during the workshops. Teachers need to have the opportunity to reflect in order to move on effectively. A report of the workshop can be made in a collaborative way, so the teachers can add their opinion and learnings too and even materials and links can be shared this way.
- **Small changes and steps are the best**. A Practitioner Inquiry will not solve the big educational challenges all teachers are faced with. Emphasize that PI is about their own practice and taking small steps and changes will lead to better results and satisfactions of your teachers. A big step forward is often a small step back
- Teachers often **struggle with self-confidence** in PI. You could ask teachers to do a small inquiry (a pilot) which they could share during the next workshop. You could ask them to focus on more or less the same question/ topic (e.g. planning skills during lab work) with a small and feasible tryout in their class, with the students. The result of such a "pilot inquiry" informs the teacher on specific issues of the PI.
- The last workshop devoted to discussions within the group is an indispensable part of the course. **A good "ending"** is a capstone of the entire course based on three pillars - PLCT group building, development of PI competences and development of IBL skills.
- It is very powerful to **link the course with other participants from previous courses**. This can be done in several stages during the course, for example at the beginning to inspire novice teachers with the work other teachers have done or further in the PI process during discussions and peer feedback.
- The organization of **a multiplier event** (if possible to organize) sets a deadline to the teachers and encourages them to work according to the course schedule, not lagging behind at any point. A proposed format is: 1) short presentation of the course and its principles, 2) oral presentations given by teachers, 3) a break with a poster session, 4) IBL workshops.

Important note: these key learnings have an impact on the course in general. That's why they are mentioned here. However, we have learned a lot more while implementing and testing protocols & activities during the PLCT's. Learnings that are related to more specific protocols and activities are considered further in the course outline and described as advice and tips for the coach.

Chapter 2:
How to structure the course on Practitioner Inquiry in the context of Inquiry Based Learning?

Section 1: training aims for the course

The aims and learning outcomes of the course are considered in three aspects:

Aspect 1: Learning Intentions – Learning about and conducting a PI

- Develop a question linked to IBL in their classroom
- Identify problems and conduct research questions
- Develop a plan to address their question
- Gather data on their question
- Analyze and critique data based on their PI
- Self reflect and per evaluate their PI's
- Make evidence informed conclusions and recommendations linked to their question to enhance their teaching

Aspect 2: Becoming an active member of a PLC

- Work collaboratively to support members of the PLC to conduct a PI
- Set up a method of communication to collaborate and communicate with members of the PLC

Aspect 3: Learning about IBL

- Become confident using IBL approaches
- Use IBL more frequently
- Improve their IBL teaching based on evidence generated through their PI
- Recognize IBL as an effective strategy to motivate students learning and interest in physics

Section 2: From the key design principles and training aims towards a structure of this course

Looking at the Practitioner Inquiry cycle from chapter 1, the course consists of 6 elements of training and is also structured in this way. It is not recommended but it is possible to follow this training individually. However, teachers will miss the power of working collaboratively so it is better to do it in a group of colleagues as a Professional Learning Community with the help of a coach. This guide is therefore written to support the coach while he/she is facilitating this course.
How long an element will take and what the exact actions are for each element will depend on context and organization. But there are some shared learnings that are essential, and these design principles are considered in the 6 elements of the course.

Every element preferably should have the following aspects:

1. Building PLC
2. Facilitating Practitioner Inquiry
3. Promoting Inquiry Based Learning
4. Reflection

Time spent to each aspect can vary slightly during the process.

Goals are often achieved through activities that focus on two or more goals at the same time. While a certain protocol can have as a main goal to facilitate Practitioners Inquiry (for example constructing an inquiry plan), it encourages at the same time collaborative work and peer feedback, so this will focus also on the PLC building. Another example is the very way of approaching a certain problem about a teacher's professional practice (focus on PI) may be inspiring for a more Inquiry Based Approach in the classroom at any time.

Yet, sometimes it can be useful to unmingle these interactions and to classify certain goals or activities as being either PI, either PLC or either IBL. That's why each of the elements are a bit more elaborated in this section. We are using the word 'elements' and not steps because it is not a fixed chronological order to follow. These elements guide you during the PI process and as a matter of fact, it is not a bad idea to follow these elements as steps, certainly when it's the first time. But doing a PI does not have a strictly fixed order. Some will start gathering data and ask specific inquiry questions later. Some have visited a presentation of a colleague and are intrigued and motivated to start a new PI. These elements should be present during the PI process.

The general approach in our PLCT, how we worked together, taking notes, making summarizations, refine our questions, give feedback, etcetera, is an approach I can use with my 17-year old students during laboratory work when they are working on a specific IBL unit.

3DIPhE	**Motivation Element** *Searching for an Inquiry Question*
PI	Familiarizing with PI
PI	Discover your motivations for your context
PLC	Building a PLC
IBL	Familiarizing with IBL

3DIPhE	**PI Development Element** *Planning your inquiry*
PI	Exploring solutions to the problem
PI	Different types of data collection
PI	Creating and refine an inquiry plan
PLC	Strengthening PLC bonding
IBL	Applying IBL to your own context

3DIPhE	**Inquiry Element** *Formulating the inquiry question*
PI	Exploring the problem space
PI	Formulating your inquiry
PLC	Finding your Critical Friend
IBL	Recognizing examples of IBL

3DIPhE	**Conducting PI Element** *Go out there and collect evidence*
PI-IBL	Testing PI on IBL in your own context
PI	Collecting different types of data (including observation)
PI	Refine inquiry plan
PLC	Giving Feedback on the design of others

3DIPhE	**Analyzing PI Element** *Drawing conclusions from evidence*
PI	Drawing conclusions from data
PLC	Analysing conclusions of others
IBL	Strengthen IBL skills

When, where and how is not described here, but is much more elaborated in chapter 3 where you can find an example structure. The general structure of this guide follows these 6 elements.

3DIPhE	**Sharing Element** *Sharing is the start of something new*
PI	Learning how to create a poster / presentation
PI	Presenting and Sharing
PI	Lessons for your practice in the future
PLC	Learning from others
IBL	Lessons for approaching IBL in future

Section 3: a 5-day course or a PLCT?

An important output of the 3DIPhE project is delivering a 5-day course for teachers on using Practitioner Inquiry in the context of IBL. Part 2 has been developed as a guide for facilitating this course. However, this guide can also be used as a manual for coaches guiding a PLCT over a longer period of time. After all, this is what several partners in the 3DIPhE project have done. Hence, this course can be delivered in an intense 5-day course for one week or spread over several meetings and workshops over a longer period of time. The target group and expectations, the goals and structure are the same for both. Probably, as a coach, you will not have the freedom to choose between these two formats, but each of the formats have some advantages and disadvantages.

- The ideal setting is a group of teachers that work together on the same topic. If teachers are from the same school, you will have a deeper impact at school level. During an (international) course you will have more diverse teachers, which allows more exchange from different perspectives.
- A 5-day course will not allow you to actual conduct the Practitioner Inquiry of the teachers because of lack of time. After the course, participants should go home with a better understanding of IBL, an individual inquiry plan that allows them to conduct a PI in their school and a basic framework for starting a PLC at their own school with colleagues.
- Spreading out this course over a period of time allows teachers to do an actual PI in their own professional practice. However, the course is pretty time consuming and it is important to be as time efficient as possible while planning a series of workshops. A workshop every two months is not so efficient. Therefore, it is better to plan the first series of workshops in a quicker succession, starting from the motivation element up to the development element. A bigger time interval after these workshops is recommended so teachers have time to conduct their inquiry and collect data. A new series of workshops can proceed afterwards, also in a quicker succession. Do not try to give them too much homework but provide time for actual work during the workshops. Organize a multiplier event of 1 day to share results with other teachers that have done a PI, with colleagues from the same school to extend and validate results within the school and list up follow-ups for the future.

PART B:
Guide for the course on PI in the context of IBL

Motivation element

- Pre-course survey
- Introduction to 3DIPhE course
- Icebreaker: 'Different cultures, getting to know each other'
- Structured IBL unit 'melting point of chocolate'
- Generic tools for supporting IBL: poster, worksheet and guide
- Passion protocol
- What is practitioner inquiry?
- What did you learn?
- What do you want more of?
- Next steps and planning
- Alternative activities and protocols

Development element

- Using quotes
- Subtle Shifts
- Getting familiar with literature about IBL
- Looking for specific practice-based literature
- Different ways to collect data
- Refining your inquiry question: What, so what, now what
- Designing the inquiry plan: Manual for inquiry brief
- Peer review of the inquiry plans
- Barometer
- Alternative activities and protocols

Analyzing element

- Comfort zones (revisited)
- Report on the data driven dialogue
- Alternative activities and protocols

Inquiry element

- Compass points protocol (PLC)
- Asking questions with plasma spheres
- Choosing the right question
- Litmus test on the inquiry question
- PI on IBL activity
- A critical friend
- Plus - works better if...
- Alternative activities and protocols

Conducting element

- Comfort zones
- Developing data analysis skills for a PI
- Paper twitter
- Alternative activities and protocols

Sharing element

Proposed agenda and specific timetable

1. 5-day course for 20 participants: How to conduct PI in the context of IBL
2. Professional learning community of teachers doing a PI in the context of IBL

The general structure of this course, and its rationale, is thoroughly described in chapter 1 and 2 of this guide. The guide and coursebook consist of 6 elements, each of them with parallel goals about building a PLC, facilitating the Practitioner Inquiry of the teachers and promoting and enhancing Inquiry Based Learning.

This chapter elaborates more on these elements and provides a specific example structure of activities and protocols. This includes:

- A proposed time schedule for each activity
- Goals for the coach
- Reference to step by step instructions and materials (listed in the appendix)
- Boxes with rationale for the participants (what are the key learnings from this activity)
- Tips and advice when doing this activity. These are specific learnings from the 3DIPhE project.
- If available, examples from 3DIPhE experience like sample inquiry questions, data collection tools, etcetera.
- Alternative protocols and activities (not elaborated in this guide but with reference to the appendix)

Concluded from our design principles, the elements include activities/protocols about PI, and have also goals for promoting IBL and building the PLC. Sometimes this guide refers to activities/protocols from the other volumes, Volume 1 and Volume 3.

At the beginning of the course, more attention is needed to build the PLC and explain what IBL is (and show good examples of learning units). Searching and formulating good inquiry questions also need a lot of time. It all depends on the background and experience of your group of teachers, whether they have already done a PI, or they already have a lot of experience using IBL in class, or they are used to working in PLC… In the experience of 3DIPhE, when working with a novice group of teachers, much more attention and time will be spent on the first two elements of this course.

As a coach you must think and select appropriate activities and protocols that fits your group of teachers. Set clear goals, do not overload and be flexible during the course. If, for example, your teachers need more examples of good IBL units, make sure you provide these during the course (see Volume 1 on IBL for many examples).

The example structure of this guide is designed for a group of novice teachers who didn't participate in a PLCT before. Getting to know, familiarize with PLC building, PI and IBL are therefore important. As mentioned before, please adapt this structure with other activities. At the end of each element alternative protocols and activities are listed with reference to the appendix or other volumes of the e-book.

Motivation element

Searching for an inquiry question – *What motivates you? What makes you curious?*

This element is broader than only a motivation for doing a Practitioner Inquiry. It must be seen as an overall motivation for the course, which not only includes wanting to conduct a PI but also willingness to work in a PLC and familiarize with IBL. Finally, it is all about the heart of all motivation which is better learnings of the students.

PI	Familiarizing with PI
PI	Discover your motivations for your context
PLC	Building a PLC
IBL	Familiarizing with IBL

Example structure		
3DIPhE Pillars	**Motivation Element**	**Time**
IBL-PI-PLC	Pre-course survey Goal: collecting data, understanding who teachers are.	15
IBL-PI-PLC	Introduction to the 3DIPhE course Goal: express aims and objectives of the course	15
PLC(-IBL)	Icebreaker: 'Different cultures, getting to know each other' (within the context of IBL) Goal: getting to know each other	15
IBL	Structured IBL unit 'melting point of chocolate'	60
IBL	Generic tools supporting IBL: poster, worksheet and guide.	15-60
PI - PLC	Passion Protocol to reflect on own teaching and develop a first question.	60-90
PI - PLC	What is Practitioner Inquiry?	60
Reflection	What did you learn? What do you want more of?	15
PLC	Next steps and planning	10

Pre-course survey

Goals:
Collecting data about your participants concerning different topics.
- details and background of your participants
- general approach when teaching science
- challenges faced when teaching that specific subject.
- (dis)agreements to statements on practitioner Inquiry, professional learning (communities) and inquiry based learning
- getting to know the different pillars of the 3DIPhE course.

Materials
See appendix, page 67.

Time
If possible, before the first workshop.
15 minutes to fill in (optional: 10 minutes discuss first challenges and clarify terminology)

Tips & advice:
- The survey can be done on paper as well online. For example an online google form (in Dutch) here.
- To save time this can also be done beforehand. And if possible, you can summarize these results so it is not just a data collection tool, but it can be linked to the workshop activities. For example, the list of challenges from the group of teachers can be used as input for 'motivations for your context - passion protocol' and will help teachers develop a question to start their inquiry.
- Use the statements of this survey to introduce some of the ideas and terminology. that teachers would encounter during the course. These are also present in this survey and can be clarified (and even discussed, if time is available) a bit during the introduction (see next activity). In later workshops the teachers will learn that data collection in practitioner inquiry is usually gathered as a natural part of classroom activities. This baseline survey as an activity reinforces this idea as a normal mindset throughout the whole course.
- During the 3DIPhE project a separate questionnaire about inquiry based learning (Inquiry based learning - Questionnaire on page 82) was developed. This can be used as input and discussion during the IBL activities and the passion protocol.

Introduction to 3DIPhE course

Goals:
- providing information on the origins and rationale of the 3DIPhE project. This course is a specific output of this project and therefore some background information is helpful.
- Introducing the core elements (PI, PLC and IBL) in the context of the 3DIPhE project and this course.

Materials
See an example from partner DCU.

Time
15 minutes

Tips & advice:

- Try to make direct links to the questions of the pre-course survey during this introduction. Teachers are in need of information on the course, so they must have a clear understanding of what they will be doing and what is intended.
- Adapt and change this presentation in the context of your participants. If your participants are all teachers from the same school or from the same country, try to set it in their context. For example, in the Irish context, this presentation was further contextualized in relation to the Teaching Council of Ireland's framework for teacher education and their funding of research that involves teachers as professionals and reflective practitioners.
- Please keep this short and beware of time. Your teachers will not be able now to see the whole picture and rationales (that's rather impossible). It is just an introduction where the core elements (PI, PLC and IBL) were introduced in the context of this course.

Icebreaker: 'Different cultures, getting to know each other'

(with a link to IBL)

Goals

- Getting to know each other a little bit better.
- Talking about different countries and cultures if teachers are coming from different countries and schools
- Finding out participants' first impressions about IBL
- Discuss first impressions of challenges/issues teachers are faced with.

Time

15 minutes

Materials-instructions

See Volume 3 on Building Professional Learning Communities, Part 3.

Adaptations to steer towards IBL:

1. Pair with someone you don't know
2. Introduce each other, ask questions and note
   a. three things about each other, e.g. what did you do during the summer (3mins)
   b. one specific 'aha'-moment she/he has while students were doing IBL.
3. Reverse and repeat (3 mins)
4. Report back to group (2 mins each pair)

Tips & advice

- Keep it short. There will be enough time to discuss challenges teachers are faced with in other protocols. This is only as a first impression so don't waste too much time.
- You can easily summarize key elements about IBL from the 'aha'-moments on the blackboard.
- It's a good idea that coaches should participate as part of the group. In this way you can emphasize that all involved in this course are part of the learning community.
- Encourage your teachers to gather information that is beyond typical introductory questions such as where you live, where you work, etc.
- When using activities for teachers to get to know each other, it's a good idea to ask them to discuss something more personal such as hobbies. Moving it away from work better helps to develop the community.

Structured IBL unit 'melting point of chocolate'

Goals

The goals for the IBL unit 'melting point of chocolate':

- To train/improve the observation skills
- To encourage predictions
- To design testing experiments
- To draw conclusions
- To study melting point (temperature)

Participating teachers experience this IBL unit as if they were the learners. In this way they

- Familiarize with IBL, more specific with different inquiry skills.
- Get to know tools supporting teachers and their students through activities introducing IBL (see also next activity Generic IBL tool)

Time

60 minutes

Materials-instructions

All materials and instructions are described in Volume 1 of e-book (IBL), coaches' examples of good IBL practices, chocolate. This includes:

- Unit description 'Which chocolate is the best?' structured following different stages of the inquiry process.
- Worksheet on chocolate
- Guide for using the worksheet.

Tips & advice

- Use reflecting questions to gather pre-knowledge about IBL with your participants like
  - What do you think IBL is?
  - What are essential characteristics for IBL?
    If you have used the separate Inquiry based learning - Questionnaire on page 82, you can use this information to start a discussion about IBL. A lot of background information can be found in Volume 1.
- This unit on chocolate is an example of a structured IBL unit and a very good introduction for teachers who aren't familiar with using IBL with their students.
- Other units also using the same structure (and are good alternatives that can be used during coaching) are listed in Volume 1. These are units on *double shadow*, *penumbra* and *pressure*.
- It must be said that this structure is only one example of how to implement IBL in class. More experienced teachers with IBL will have their own structure or template or will use a more open structure during IBL. It is important that you as a coach also acknowledge that other approaches can also be powerful. When reflecting on this unit and these documents, we hope that also experienced teachers will be inspired by this unit and use some elements of this approach in their own worksheets and courses.
- It is strongly recommended to do immediately after this activity the next protocol on generic tools supporting IBL.

Generic tools for supporting IBL: poster, worksheet and guide

Goals
These tools
- support teachers and their students through activities
- effectively plan and carry out an IBL lesson
- encourage conscious planning and other actions needed in inquiry and systematic inquiry notes.

Time
15 - 60 minutes (depending if you let teachers use these tools in their own context)

Materials-instructions
All materials are described in Volume 1, coaches' examples of good IBL practices, Generic tools. This includes:
- description of the tools
- Generic worksheet for students (in word or pdf)
- Generic guide on the worksheet for teachers (in word or pdf)
- Poster inquiry guide (pdf)

Tips & advice
- Provide time for teachers to get to know these documents.
- Link these documents with the activity of melting chocolate.
- Discuss with teachers how they would use these documents with their students. Ask questions like 'What if they have no experience? What if they are already experienced?'.
- Encourage teachers to use these documents on their own topics. Discuss with them if they will use these tools and how? Find out with your group what is feasible for them. It is always good that you have more specific examples. An example used by a facilitator used during the 3DIPhE course was 'plants in space'. Here you find a short presentation of this IBL activity. Students had to investigate the best conditions for successful growing plants. Show this activity with your teachers and try to summarize the IBL activity on the poster.
- Do not forget these documents are generic. This means that teachers must adapt this to their own context. Depending on the topic, the experiments and the goals you want to achieve with your students, some steps must be skipped, others will take more time or should be more elaborated, etc. This is part of the professional learning of the teacher while trying to implement IBL.

Passion protocol

This activity followed a protocol developed in the EU Linpilcare project (Wonderings ripped by passions) and is the first step to conduct a Practitioner Inquiry. However, this protocol not only focuses on PI but is also a good PLC building exercise because through sharing passions about education in a PLCT a sense of community can be developed.

Goals
- Discover passion in education
- Delve deeper into the passion to come to a question to start the inquiry.
- Creating a shared responsibility in the PLC, listening to each other and giving peer feedback about their passions.

Time
60-90 minutes

Materials-instructions
Print the pages in appendix (page 70), recto verso, so that the passion (nr1) fits the corresponding exercise (nr1). Cut the frames. Make stacks of the 8 passions. Ensure that every participant has a stack with the 8 passions .
Instructions are described in Wonderings ripped by passions - protocol and also in Volume 4.

Tips & advice

- This is a very important protocol to start the practitioner inquiry of the participants. The main objective is to generate questions starting from the passion of the teachers. Sometimes this is called a 'wondering' and is the first step towards an inquiry question for the practitioner inquiry. Every teacher should take home his/her own question linked to their passion.
- To inspire and motivate your teachers, it is good to have some specific examples of questions from other teachers (however, sometimes they can influence them too much and distract them too much from their passion). Finding this balance is a difficult exercise. We advise to formulate your own questions from the coach' perspective. Here you can find 50 examples of questions from the Linpilcare project.
- Emphasize that this question is not their final inquiry question yet. In the next element the group will refine and formulate a more specific inquiry question. Point out that it is very normal that teachers still have some doubts about their inquiries. There is no such thing as a right choice in this process.
- In chapter 1, section 3 on page 18 we addressed the difficult issue about steering the group of teachers towards the context of IBL. Ownership while conducting a PI is crucial in order to motivate the teacher, so it can be possible that one of your teachers has other questions, not related to IBL. Some tips and advice to steer them towards IBL:
    - Refer to the IBL activity you have done in the first part of this element (IBL on chocolate or other if have used another)
    - Two very interesting protocols can help as an alternative or as an extra: Passions for IBL - Fibonacci Protocol and My priority/preferred ambition in IBL (my passion in IBL) available also as pdf. The Fibonacci protocol uses a self-assessment tool and the second protocol starts, likewise the passion protocol, from 7 ambitions that are related to IBL. Both protocols encourage teachers to reflect and discover gaps and needs in their IBL practice.
- It is important to stick to a time schedule otherwise not all teachers will have sufficient time to talk about their passions and questions. This is a very strict protocol and therefore, the role of the timekeeper is very important. This ensures a good (working) pace in the group.
- The role of the notekeeper is to capture and summarize important issues and findings. The attitude of constantly taking notes as a kind of reflection is very powerful. You can provide whiteboards, markers and big flip-over sheets, that encourage them in taking notes.
- The implementation of roles creates a mindset of shared responsibility and in doing so they have to develop a working relationship with other members of the PLC. This mindset is important in all activities and protocols. More tips and tricks you will find in Volume 3 on Building Professional Learning Communities.
- In some PLCT's during the 3DIPhE project the coach split up this passion protocol. Splitting up this protocol can have a positive effect on the focus during this activity because it is a rather long and intensive protocol. In between you can do an IBL activity or the Farming vs gardening protocol.

What is practitioner inquiry?

This activity is derived from two protocols from the Linpilcare project. The silent chalk talk protocol is used to introduce and close this activity and enhances the PLC building. The Farming vs gardening protocol focuses more on what PI is.

Goals

- Develop participants' understanding of PI,
- Express participants' concerns and uncertainties about conducting PI,
- Learn about each other's perspectives and levels of understanding,
- Using a metaphor visualizing differences and similarities between academic research and practitioner inquiry.

Time

60 minutes

Materials-instructions

Images, table and some background can be found in the appendix, on page 74.
Blackboard, white board or papers on the wall + markers

1. Explain very briefly that Chalk Talk is a silent activity. No one may talk at all and anyone may talk as s/he please, only with marker or chalk. You can comment on other people's ideas simply by drawing a connecting line to the comment.
2. Write the key question in a circle on the board: What do you think Practitioner Inquiry Is? Below the key question, make two categories: What are you certain of? | What are you uncertain of?
3. Everyone can add comments at the board. Participants write, as they feel moved. There are likely to be long silences—that is natural, so allow plenty of wait time before deciding it is over. (10 min)
4. After participants identified their initial ideas and concerns on PI, provide images of a garden and a farm. Tell them these images are a metaphor for academic research and practitioner inquiry. Ask at your group the following question and encourage discussion (the silent part is over now) (15 min)
    - What image would you link with academic research? Why?
    - What image would you link with practitioner inquiry? Why?
    - What key ideas/words would you relate to which picture?
5. If necessary, present information that clarifies what PI is/can be. It is important that participants have a better understanding what PI is. (15 min) Some suggestions:
    - The table on 'generalized' differences between academic research and practitioner inquiry.
    - Provide a clear and not too complex description of PI (see chapter 1 of this volume). Suggestion in this box

> *It is a form of professional learning defined as the systematic intentional study by educators on their own practice. Cochran-Smith and Lytle (1993)*
> *Educators engage in systematic reflection and take action for change by asking questions or "wonderings", gathering data to explore their wonderings, analyzing the data, making changes in practice based on knowledge constructed, and sharing learning with others (Dana & Yendol-Hoppey, 2014)*
> *...an inquiry stance provides a kind of grounding within the changing cultures of school reform and competing political agendas (pp288-289, Cochran-Smith and Lytle (1993)*

    - Some examples of PI questions to better demonstrate the type of work associated with practitioner inquiry. In the appendix there is a list (on page 83) of some examples of PI questions that were addressed during the 3DIPhE project. This is an exhaustive list but gives a good overview. Please do

not show this list to your participants but select a few to discuss with them what kind of questions are possible to deal with in a Practitioner Inquiry. From the 3DIPhE experience it was felt that the use of examples (from previous courses of PI's) were very helpful in setting the expectations of the participants.

6. Review the chalk talk activity from step 1 – 3, again in silence. Ask the participants to update or modify their responses from the first exercise, if possible with another color (10 min)
7. Conclude with a group discussion to address any uncertainties regarding understanding and conducting PI, but also the expectations of the course. (10 min)

Tips & advice

- Don't lose focus on the main goal which is understanding what PI is and discussing issues, uncertainties about PI. Find out what and why they are feeling insecure without just telling them what to do.
- The farmer versus gardener protocol is useful to overcome the fear of the teachers who taught at first we were talking about a big academic research. However, enough attention should be given to the transfer from the farming versus gardening protocol to their own teaching practice.
- When working with an experienced group who has already done a PI, you can talk about earlier experiences and try to synthesize what PI is from this.
- Be careful with the farming versus gardening activity. In some cases of the 3DIPhE course it created confusion about the relation between PI and academic research. One partner recommended not to use the farming versus gardening research activity. Decision on the merits of practitioner inquiry on its own would be more beneficial especially supported by examples that were generated in the 3DIPhE project. This approach should give added value to PI in the minds of the teachers and also reduce any anxiety they may hold about conducting their own PI.

What did you learn? What do you want more of?

Goals

- Reflect and evaluate the process
- Collect data for the coach to keep in touch of the PLC

Time

15 min

Materials-instructions

1. Each participant individually writes down on post-its (1 post-it/answer), starting from these questions:
    - Something that you have learned;
    - Something you would like more of, or you would to know more about;
    - Any questions that you have.
2. Collect all post-its on a large paper sheet, on a wall or on a table.
3. Discuss the answers in group, if necessary ask clarifying questions.
4. You can categorize them according to the 3 pillars of 3DIPhE: IBL, PI and PLC.
5. Synthesize the most important learnings by marking them in red color.

Tip & advice

- It is important that you do this kind of reflection activity after each workshop, whether or not you have full or half day workshops. The motivation element can last more than one day (depending if you have a novice or experienced group), so this exercise can be done several times during this element.

Next steps and planning

This is only important when working in a PLCT over a longer period, not if this course is delivered in a 5-day intensive course (because all planning and communication is already scheduled).

Goals

- Discussing next steps and planning
- Creating shared responsibility

Time

10 min

Materials-instructions

1. Give an overview of the course, planning and workshop dates. Discuss with all participants if they agree on the planning and content. Are they any modifications that is needed? Do they prefer condensed full days or multiple half day workshops?
2. If necessary, you can go more into detail of the next workshop about the content. Are there interesting learnings coming from the reflections during the previous activity that is important for the next workshop? E.g. maybe the group decided to work more on IBL activities because they are not familiar yet with IBL, or most of the participants have problems finding a good question to start with, etc. It is important that you agree with the whole PLC about changes.
3. Discuss on the best communication approach.

Tips & advice

- The shared responsibility is very important. Give your participants opportunities to take this responsibility, e.g. in a PLC of teachers who didn't know each other before, one of teachers created a WhatsApp group.
- A good way to 'end' this element is give your participants some advice from other teachers who have been involved in a PI in the past. It will keep your group motivated and engaged to continue their inquiry. See in the box below.

What advice would you give to a teacher starting a PI for the first time?

Do not be afraid
Be ready to make mistakes
Keep it simple
Do not think that your inquiry is not big or important enough
Choose a good question, be engaged! Take time for having a good question
Topic must be a passion
Start small, don't be too broad
Ask why something is not working
Keep an open mind
Sit with being lost - it's okay, you will find your direction
Stay positive
Be brave

Alternative activities and protocols		
PI	Discover your motivations for your context	• Passions for IBL - Fibonacci Protocol on page 76 • My priority/preferred ambition in IBL (my passion in IBL) on page 80 • 50 examples of wonderings • 10 mind frames passion protocol (J.Hattie-general/educational)
PLC	Building a PLC	- Consensogram on school context (Linpilcare)
IBL	Familiarizing with IBL	- Inquiry based learning - Questionnaire on page 82 - Discover many IBL units from Fibonacci and SAILS (see this map)

At the end of this element participants

1. should have a question to start the inquiry within the next element;
2. have had some inspiration about IBL;
3. must have enthusiasm to work together in the PLC.

Inquiry element

Formulating the inquiry question – *What do you want to know?*

Starting from the teachers' questions, this element formulates and refines the inquiry question of the PI. At the same time the group continues to work together in a PLC through peer feedback and reflections. To incorporate the third pillar some specific IBL skills are practiced in the group of teachers.
Because we experienced with some 3DIPhE teachers some confusion about the difference between IBL questions and PI questions, a specific activity at the end of this element (PI on IBL activity) is described to deal with this tangle.

PI	Exploring the problem space
PI	Formulating your inquiry
PLC	Finding your critical friend
IBL	Recognizing examples of IBL

Example structure		
3DIPhE Pillars	**Inquiry Element**	**Time**
PLC	Compass points protocol	30
IBL	Asking questions with plasma spheres	60-90
PI	Choosing the right question	35
PI	Litmus test on inquiry question	15-30
PI - IBL	PI on IBL activity (& the difference between PI & IBL questions)	60
PLC	Finding a critical friend	15
Reflection	Exit ticket	15

Compass points protocol (PLC)

This protocol is derived from Linpilcare project.

Goals
- Participants self identify own characteristics based on a compass;
- Mutual understanding of each other's strengths and limitations when working together.

Time
30 minutes

Materials-instructions
See Volume 3 on Building Professional Learning Communities, Part 3.

Tips & advice
- In reality people have overlapping characteristics but they are forced into selecting one for the activity.
- Teachers are really engaged with this exercise. Stimulate an open mindset.

Asking questions with plasma spheres

Goals
- develop teachers' questioning skills;
- turn general questions into investigable questions;

Time
60-90 minutes

Materials-instructions
All materials are described in Volume 1 of e-book (IBL), coaches' examples of good IBL practices, Plasma spheres. This includes:

- Volume 1: Information for coach (context, goals, description of unit, coach's advice and appendix)
- PowerPoint presentations on plasma phenomena & plasma introduction.

Tips & advice
- The skill of asking questions is important in IBL for students but also in the PI for the teachers. As a coach you can pay specific attention as the skill of creating/asking questions have a lot of parallels with Practitioner Inquiry. In general, we experienced during the 3DIPhE project that teachers had a lot of difficulties with the creation of their PI question. Therefore, it can be useful to do this exercise to place more focus on the development of this skill. A post-discussion reflecting on the activity and how it links to inquiry in the classroom helps teachers. More information on the important relation between IBL and PI is described in Section 3 of Chapter 1 on page 18 of this volume.
- Again, create openness in the group. Teachers must support each other through the task, and they must not be afraid to admit if there is something they are unsure of. The building of the community is feeling comfortable with each other.
- An important remark: be careful if there is confusion between PI and IBL questions teachers may have. At the end of this element an activity has been developed to use in case there is still a lot of confusion between PI and IBL questions.

After this activity, participants will start from their question (they have created at the end of the first element) to refine and adapt it to a specific inquiry question, using the protocols of 'choosing the right question' and 'litmus test'.

Choosing the right question

This protocol is also described in the Linpilcare project, see here.

Goals

- Participants develop their own (inquiry) question linked to chosen passion
- Participants present their own question in the group addressing specific reflections questions
- Participants reflect on their question after group members asked clarifying and probing questions.

Time

35 minutes

Materials-instructions

1. Review the questions from the passion protocol (done during the motivation element).
2. Each participant develops his own question linked to the chosen passion, addressing these four questions (5 min)
    - Why this question is important to me?
    - How is this question relevant to teaching and learning in my classroom?
    - What direct connections to student learning can I identify?
    - Does the question feel too specific or too broad?
3. Each participant presents their question to the group, addressing each of the questions, while the rest of the group listen (3 min)
4. The group can ask clarifying questions, and the presenter can answer (2 mins)
5. The group discuss on what they heard, they asked probing questions, while the presenter stays silent (2 mins)
6. The presenter reflects on what they have heard, and decides what they will do with their question (1 min)
7. Repeat this until everyone has presented

Tips & advice

- If the group needs examples of what is meant by clarifying and probing questions, you can use these examples. Especially asking good probing questions is rather difficult. If necessary, you will need to pay more attention at this.
- Not only the teacher who is presenting will learn something about his inquiry. It will happen that while listening to the peers' questions, teachers will wonder back to their own question and try to relate it to their own inquiry. Try to stimulate this reflective attitude.
- Sometimes teachers, instead of helping their peers tweak or develop their inquiry question, the discussion sometimes jumped to answering the question by sharing experiences. However this may be helpful, it isn't the focus of the activity! As a coach, it is not easy to facilitate this.
- In this feedback exercise, you can steer the PI of the teachers a little bit to IBL. You can add to the discussion some learnings from previous IBL activities, for example the link between questioning and plasma sphere completed earlier in the workshop. This can help teachers to see a link between their PI and IBL.

Litmus test on the inquiry question

This protocol is also described in the Linpilcare project, see here.

Goals
- Participants improve their question through individual reflection

Time
15-30 minutes

Materials-instructions
1. Complete the litmus test individually
    - The coach can give some explanation about each of the 7 criteria using the Litmus mindmap.

Tips & advice
- The main issue is the need to refine the participants' questions into a smaller (more manageable) inquiries that could be investigated. The use of the mindmap helps to achieve this.

PI on IBL activity

During the 3DIPhE project, the coaches experienced some confusion participants had about the differences between PI and IBL questions, especially with novice teachers. When developing inquiry questions from their passion (see previous protocols), there were always some teachers who developed an IBL question instead of a PI question.
This activity tries to deal with this 'problem'. Firstly, by showing an example of a PI that has been done within the context of IBL and secondly, by developing an inquiry question starting from a given IBL question/unit.

Goals
Participants…
- develop a PI question from a given IBL context;
- recognize differences between PI and IBL questions;
- reflect learnings to their own inquiry.

Time
60 minutes

Materials-instructions
See example presentation 'PI on IBL workshop on water rockets,' from 3DIPhE final conference (August 27th 2020).

1. Start with an example of an IBL unit (slide 3-7). It is just the intention of describing the unit, not doing it. (10 min)
    - The example of the IBL unit is plants in space (from FP7 project "Chain reaction"). This IBL unit challenges students 'how to grow plans in space'. Some theoretical background about space & growing plants (photosynthesis) was provided to the students., but also how to research and develop a research plan. All students constructed the same terrarium as an experimental setting for doing some research.
    - As a guidance tool, the poster inquiry guide was used, see blue part in the presentation. In the activity 'generic goals for supporting IBL' of the motivation element of this chapter you will find more info how to use this tool. It helps students in developing inquiry questions at their level (= **IBL questions**) by looking for independent and dependent variables. For example, students investigated the influence of the color of light on the growing of the plants.

2. Then the inquiry of the teacher could begin (slide 8, 10 min)). She asked some questions about how this IBL unit will be performed by students. To make the differences between IBL and PI questions, this part of the inquiry is colored in red (see slide). Some examples of **PI questions** (and the observations she made) were:
    - To what extent will students collect such variables that I did not anticipate?
      The teacher anticipated variables like color of the light, light intensity, fertilizer, the amount of plants and periodicity of illumination. In most cases, students chose to investigate those, but in every class there was always one group with an additional idea. Some of them also inquired about sound/noise, temperature, air changing/ventilation. The teacher was really surprised.
    - To what extent will students express a desire to continue research with improvements?
      All of the students reported additional ideas for improvement.
    - What ideas will they have for the dependent variable - what will they measure?
      Students were mainly measuring the area of the sum of all grown plants. Some of them tried to measure height, but after a talk with the biology teacher, they were advised to watch also at the color of the leaves. It was difficult for students to find an objective way of measuring the growth of plants.
3. After this example of plants in space, show them a new context of an IBL unit, the water rockets (10 min). Again, you can do the same as in the example 'plants in space'. The poster guide for inquiry (blue template) will help students **developing IBL questions**.
    - (slide 9) Challenge: Make the rocket fly as far as possible!
    - (slide 10-11) Some background information about the mechanism.
    - (slide 12-15) How to develop IBL questions by the students about the water rocket. Some typical examples are described in slide 15.
4. Now, the teachers' inquiry can start. Work in groups of 3-4 teachers and try to answer these questions: Imagine you will start with this IBL activity in your class tomorrow, … (see slide 16-18, 20 min)
    - … what concerns, dilemma's, problems would you have?
      Design a **PI question** based on this IBL activity.
    - … which kind of data would you collect, to find out more about your questions?
5. Present your PI questions (and possible ways to collect data) to the other groups. (slide 19, 10 min)

Tips & advice

- In step 4, participants are asked to think about possible data they must collect to find an answer to their question. This is optional. In the next element (development), participants will learn more about ways to collect data.
- This example is a real example from a 3DIPhE coach. As a coach, it is better to use own examples of IBL and PI. It is way more powerful to illustrate the differences between IBL and PI questions from your own experience.
- Try to exceed this and stimulate teachers to think about their teaching practice and the learning of the students.

A critical friend

This protocol is also described in the Linpilcare project, see here.

Goals

- Explaining the roles of a critical friend
- Building and supporting the PLC

Time
15 minutes

Materials-instructions

1. Discuss different roles of critical friends in the PI process. Use material described in protocol of linpilcare project.
    - For who, when and why?
    - Critique versus judgement
    - Critical friends group
2. What roles of critical friends are already implemented in this PLC?

Plus - works better if...

Goals
Participants evaluate of the process of their PI

Time
15 minutes

Materials-instructions

1. Make two columns on the blackboard and write down
    - Plus: what are the advantages/benefits of these meetings?
    - Works better if…: What can work better and how should we do this?
2. Each participant makes two columns on a piece of paper and writes down individually (5 min)
3. Sharing of findings in groups of 4 (5 minutes)
    - Each participant max 1 min to present his ideas.
    - Looking for consensus with the whole group
    - Facilitator notes the findings on the blackboard.
4. Group discussion: what actions will be made for the next meeting?

Alternative activities and protocols	
PI	Exploring the problem space • Exploring the problem space using 5W + 1H Formulating your inquiry • Inquiry question for PI (Practitioner Inquiry) • My PI for IBL
PLC	Building a PLC • Attributes of a learning community (Linpilcare)
IBL	Using more examples of IBL as an inspiration (both in Volume 1) 1. IBL unit on spectroscope 2. IBL activity speed (from SAILS)

Development element

How to do it? – What data do you need to collect?

Starting from the teachers' inquiry questions this element explores the problem further by looking at specific and relevant literature, but also at different types of data teachers can collect during their inquiry. Teachers develop their inquiry plan, receive peer feedback so they can start collecting data in their own practice. To incorporate the third pillar some specific IBL skills are practiced.

PI	Exploring solutions to the problem
PI	Different types of data collection
PI	Creating and refine an inquiry plan
PLC	Strengthening PLC bonding
IBL	Applying IBL to your own context

Example structure

3DIPhE Pillars	Development Element	Time
PLC	Using quotes	25
IBL	Subtle Shifts	60-90
PI-IBL	Getting familiar with literature	30
PI	Looking for specific practice-based literature	30
PI	Easy ways to collect data	45
PI	Refining your inquiry question: What, so what, now what	40-45
PI	Designing the inquiry plan: Manual for inquiry brief	40
PI	Peer review of the inquiry plans	30
Reflection	Barometer	5

Using quotes

Goals

- Using quotes to discuss several topics, in particular within IBL, PI and PLC.

Time

25 minutes

Materials-instructions

Derived from Volume 3 on Building Professional Learning Communities, Part 3, Protocols serving as icebreakers, Using quotes.

Write some quotes on small cards prior to the workshop. You may choose one quote per participant, or repeat some quotes. Some example

- Think big but act small.
- Small changes are the best.
- Education is about lightening fire, not filling buckets.
- The best way to find an answer to your inquiry question is by posing it to your students.
- IBL is only effective when students have enough pre-knowledge.
- Most answers to inquiry questions can be found in books!
- Do not look for solutions too quickly, first start looking at what's happening in class!

1. Participants randomly select a quote and spend a few minutes reflecting upon their quote's meaning for them and their practice (if relevant to their inquiry question); (2 min.)
2. Participants mingle and share quotes in groups of three. Participants are encouraged to share their ideas, using these guiding questions; (10 min.)
    - Do you agree with the quote? Why (not)?
    - How this quote is related to your work or your practitioner inquiry?
3. Whole group sharing of ideas and questions raised by the experience.; (10 min.)
4. Facilitator notes down some key ideas of the group discussion t (1 min.)

Tips & advice

- It is much more interesting if you use participants' quotes from your previous workshops during the course.
- You can also ask participants to bring on quotes they find very interesting that are related to professional development, IBL or science education.

Subtle Shifts

Goals

- To help participants recognize that students need to be given more responsibility for aspects of their own learning in order to develop science process skills necessary for inquiry.
- To help participants recognize that they can prepare students for doing inquiry by making small changes in activities they already do.

Time

60-90 minutes

Materials-instructions
All materials are described in Volume 1 of e-book (IBL), coaches' examples of good IBL practices, Subtle shifts. This includes:

- Information for coach (context, goals, description of unit, coach's advice and appendix)
- Worksheets: materials for chemistry activity, background science on chemistry activity, shifted activity, unshifted activity, responsibility, measuring shadows.

Tips & advice

- Use this activity to model an IBL task and to discuss the teachers' understanding of IBL. In the 3DIPhE course teachers came to the conclusion that the 'teacher way' is not always necessary and students should be given opportunities to be creative.
- Don't forget the key message that "teachers can make small shifts in existing activities to help learners strengthen the process skills needed for scientific inquiry and lessons can be modified in specific ways to achieve particular purposes". This can easily be linked with the fact that conducting a PI is also about making small changes in existing materials, and not doing everything in a different way.
- In the 3DIPhE course, we noticed that teachers have used these key messages and made some small changes in their class, but they didn't incorporate this in their inquiries of the PI. They thought a PI should be about something bigger than just making some small changes.

Getting familiar with literature about IBL

Goals

- Absorbing (a lot of) literature knowledge in a time efficient manner
- Getting familiar with literature on a specific topic (IBL)

Time
30 minutes

Materials-instructions
Select several (at least 3) scientific articles about Inquiry Based Learning. Some examples:

- Learning through inquiry (from Fibonacci project)
- Inquiry in Science Education (from Fibonacci project)
- Integrating Science Inquiry across the curriculum. (from Fibonacci project)
- Barriers to Authentic Science Inquiry in the Elementary Classroom
- Professionalizing Physics Teachers in Doing Experimental Work

1. You pose a key question: "*What makes Inquiry Based Learning good learning?*"
2. Each participant has at least one article that he must read and analyze according to the questions (15 min)
    - What are the key messages of this article?
    - Was this useful for your own practice? Why (not)?
    - What was new for you?
3. From groups of three and report to each other, using the questions above.
4. Now generate a kind of recommendation poster that gives tips on how to make inquiry based learning good learning (cf key question).

Tips & advice

- You can always use another key question that is more in line with the needs of your group and the literature you want to use.
- Teachers are not familiar when looking and reading literature about their problems. They often have the feeling that it is not for them or too far from their practice. Stimulate them to search and read for specific literature. This activity is a good exercise to read a lot of articles in an efficient manner.
- The articles are only examples you can use. Please look for better, more recent and relevant articles for your group of teachers.

Looking for specific practice-based literature

Goals

- Participants are supported in finding specific literature (related to their inquiry question)

Time

30 minutes, but it is better to do this as homework to save time during the workshop.

Materials-instructions

1. Provide several websites to your group of teachers. See appendix for Websites for specific based literature on page 94.
2. If you do this in a group during the workshop (not as homework), you can start with common search, for example '*look for specific literature on how to use IBL in the topic of optics.*'. Participants can use the portal sites above but are free to search however they want. (10 min)
3. Collection of interesting literature (5 min)
4. Participants then apply it on their own inquiry question. All interesting literature can be digital collected. (not a fixed time)
5. Review the literature (depending on the amount of literature)
    - Why is this relevant for me?
    - How does this help me find an answer to my inquiry question?

Tips & advice

- Teachers are not familiar when looking and reading literature about their problems. They often have the feeling that it is not for them or too far from their practice. Stimulate them to search and read for specific literature. This activity is a good exercise to search for specific literature that is relevant for their practice.
- The websites are some examples you can use as a search engine. Please look for a better, more recent and relevant website for your group of teachers, if available also in the native language.

Different ways to collect data

This protocol is based on protocol from the Linpilcare project. An updated version is available in Volume 3.

Goals

- Participants discover different ways to collect data
- Participants acknowledge that collecting data is a part of a normal class practice.

Time
45 minutes

Materials-instructions
Cards with Different ways of data collection methods, see appendix on page 95. Print them twice, cut out and put them on several tables. If the group number is bigger than six, work in groups of two. Give the following instructions:

1. Take your notebook, walk around, quickly look at the different data collection tools and choose four applicable tools you think we can use when doing Practitioner Inquiry. (6 min)
2. Read them more carefully and think how you would use them during the inquiry. (3 min)
3. Shortly present your selected tools at the other group participants. Others can give feedback. (5 min for each person/pair).
4. Now select at least three definite tools (these can be very different from the one you have chosen first). (3 min)
5. Discussion with the whole group about selected data collections tools, guided with these reflective questions (15 min)
    - Does your tool provide information for your inquiry question?
    - How much data do need to have an answer to your question?
    - Does it alter your normal teaching in a negative way?
    - If you will use a questionnaire, how long does it take to complete it? What kind of tips can you give to have a good questionnaire?
    - Which elements about your inquiry question are missing?
6. End and synthesize with the following take-home messages (5 min):

Data collection should be part of your normal class practice
Data collection should link directly to your inquiry question and provide information towards answering it
Multiple sources of data can be triangulated to help you make claims
Don't just focus on quantitative surveys and if using ensure that you can justify justify any statistics you may use.
Literature is a form of data as it provides you with information and can be used throughout your inquiry

Tips & advice

- There can be a lot of discussion on how much data to collect and the necessity to design your data collection based on the inquiry question. This discussion is very engaging and it is also a good way to reflect on their inquiry question. Some of your participants will change their inquiry question (again), and that is no problem at all.
- Time allocation can be a big remark that teachers will give. However, they often already collect a lot of data about their students' learning. In many cases it is already a normal part of their job, but they haven't collected it with the objective of finding an answer to a specific inquiry question.
- Maybe your group of teachers will ask a lot of questions how to deal with loose comments, observation notes or student responses in open-ended survey questions, how handle such a sort of data. In the next element a protocol for learning about data analysis is described. In the 3DIPhE project some PLCT's did this kind of exercise immediately after this protocol because there was a need for. They started from data that was a collected of notes taken by observers of an IBL lesson. It showed that the same data could be analyzed from different perspectives, depending on what the teacher wanted to examine.

Refining your inquiry question: What, so what, now what

This protocol is based on protocol from the Linpilcare project, see here.

Goals
- Refining and final clarification of the inquiry question

Time
40-45 minutes

Materials-instructions
Repeat for each person
1. Write down your answer to the following questions individually [3 mins]
    - What question/challenge do I have?
    - So what, why is this important for me?
2. Presenter explains their answers and other participants take notes [2 mins]
3. Group asks clarifying questions [2 mins]
4. Group talks amongst themselves while presented listens [2 mins]
    - What I heard the presenter say was..
    - What seems important to the presenter is..
    - What I wonder is..
    - The question this raises for me is
    - What I might suggest is
5. Reflection Now what? This means, after this discussion, what are the final options and adaptations the presenter will do to his inquiry question or wondering. [2 mins]

Tips & advice
- This protocol can be used in several stages during the Practitioner Inquiry. It is used here because the finalization of the inquiry question is important milestone in the PI process. T
- If there isn't enough time, or participants have already a clear idea about their inquiry question, you can give them some individual time to refine their questions. As a coach you can go to each person and give it a final check.
- This round on clarification of the inquiry questions can also be very short. At the end all participants must have ready-to-implement inquiry questions in their hands. In this a small and easy step to go to the next protocol about the designing of the PI plan.

Designing the inquiry plan: Manual for inquiry brief

Goals
- Develop a first draft of the inquiry plan using the manual for inquiry brief

Time
40 minutes

Materials-instructions
The manual for inquiry briefs is taken from the Linpilcare project. If possible, project on the screen the manual.

Participants individually work on this task.

1. Write your inquiry brief using this manual (see here). It is a one-two page outline for the participants' inquiry including
    - Background for your inquiry (motivation)
    - Purpose (why?)
    - Your inquiry question
    - The things you are planning to do (what do you want to do?). This can be a specific intervention or activities.
    - The ways you'll collect data
    - A timeline of your inquiry

Tips & advice

- There are different ways of how your teachers will write down their inquiry plans, depending on the availability of laptops and wifi. Large sheets of paper are useful to visualize a general outline of what they would like to investigate and how they want to do research. Google docs can be a better solution for this task. In this way each teacher has their own folder where they can write out their plans. Their folders can easily be shared with each other so peer feedback can be easily provided later in the next protocol. I
- Teachers need time within the workshop to develop their plans as they have limited time otherwise. As a coach you can add comments to each of the teachers' plans as they are writing them (online or on paper). This is a good way to really learn about the teachers plans and to provide individualized timely feedback. In some groups of the 3DIPhE project individual coaching moments were planned and were seen positively. However, this depends on the time and availability of the coach and participants

Peer review of the inquiry plans

Goals

- Give feedback on each other's inquiry plans
- Adapt and refine the inquiry plans

Time

30 minutes

Materials-instructions

1. Review one (or more) of your colleagues Inquiry plans and comment on the plan in relation to the following:
    - What match seems to exist (or not exist) between the data collection plan and inquiry question?
    - Are there additional types of data that would give the participants insights into his/her question?
    - Rate the "do-ability" of this plan for inquiry. In what ways is the participant's plan meshed with the everyday work of a teacher?
    - In what ways does the participant's proposed time-line for study align with each step in the research process?
    - What possible disconnects and problems do you see? (both in your own plan and others)

    Note: make sure that every participant reviews at least one colleague and every participant will be reviewed by one colleague.
2. (Individually) Then return to your own inquiry plan. Take 5 mins to scan the comments that were added to your plan.
3. Reporting back to the group
    - What have you learned?
    - What will you do next?

Tips & advice

- When the group is using large sheets of paper, stick the inquiry plans as posters on the wall. Give each participant post-its and a pen.
- When the group is using laptops (online google docs), everyone can easily give feedback at the same time at the same inquiry plan. All feedback, tips and suggestions are immediately being captured and written down. You can even involve teachers that cannot attend the course in vivo.
- Invite extra coaches to ensure a lot of feedback to all participants. Coaches are trying to review more than one plan. These extra coaches can be teachers from another or previous PLCT.
- This workshop is often the last face to face opportunity to engage with each other before they commenced their own practitioner inquiry. It is important that the participants feel more confident in their plans.

Barometer

Goals

- Participants evaluate the process of their PI.

Time

5 minutes

Materials-instructions

1. Hand out the sheets with the barometers, see appendix on page 98.
2. Ask the participants to scale the three questions in the barometer and think about an explanation for the given marks. (5 minutes)
3. Discuss the results in the group: (suggestions)
    - Per person: ask the mark they have given a certain question and let them explain why. (no reaction of other participants)
    - Calculate averages for each question and discuss the meanings of then calculated numbers.
    - Per question: invite everybody to react when your go over all the questions.

Alternative activities and protocols

PI	• My inquiry brief • Inquiry brief discussion protocol
PLC	Building a PLC • Chalk talk
IBL	Volume1: 1. IBL activity double shadow 2. IBL activity penumbra

Conducting element

Go out there and collect evidence.

From this moment the differences between an intensive 5-day of one week and a PLC of teachers over a longer period are becoming bigger. This is normal as teachers working in a PLC over a longer period of time will actually conduct a PI and collect data when participants of the 5-day course will not have the possibility to conduct their inquiry.
This element is about conducting a PI so mainly consists of the collection of data by the teacher in his classroom, following the inquiry plan he/she developed during the previous element. During the workshop teachers will analyze data using the data analysis protocol. As a preparatory exercise they will first use a fictional example of data (Tom Lonergan data set). Later, during the analyzing element, they will analyze their own data they have collected. If time is available and the group needs extra coaching on IBL, an IBL activity is also suggested in the alternative protocols.
When organizing a 5 day-course this element will be a bit shorter. Some field visits and more IBL activities can be good alternatives.

PI-IBL	Testing PI on IBL in your own context
PI	Collecting different types of data
PLC	Giving Feedback on the design of others

Example structure		
3DIPhE Pillars	**Conducting Element**	**Time**
PLC	Comfort zone	30
PI	Developing data analysis skills for a PI (+ last changes to PI plans)	120
Reflection	SWOT analysis	15

Comfort zones

This protocol is based on a protocol from the Linpilcare project, see here.

Goals
- To make participants feel more comfortable with certain challenges.
- To give participants insight in their own and others' reactions in situations which are not always very familiar.
- To have a guideline for setting up rules for a professional learning group and good communication

Time
30 minutes

Materials-instructions

1. Draw a diagram of 3 concentric circles on the blackboard or a large piece of paper. Explain that the circles on the board refer to levels of comfort where the inner circles represent most comfort.
2. Without talking indicate your comfort zone for the following statements:
    - Working in a PLC
    - Carrying out a practitioners' inquiry
    - I am ready to start my own PI
    - Other statements that are relevant for the group

Tips & advice
- This an effective way to discuss and identify areas that participants may feel less confident about. They will raise some fears about some topics like their inquiry question of the sharing event. It is important to reassure your group of teachers.
- Take a photo of the results in the group. You can use this in the next PLC activity 'Comfort zones (revisited)'.

Developing data analysis skills for a PI

This protocol is based on the data driven dialogue protocol from School Reform Initiative.

Goals
- give participants an experience in analyzing data collected as part of a PI.

Time
120 minutes

Materials-instructions
In this protocol PLCT members will be introduced to an inquiry question and an inquiry plan and will be presented with various types of data collected as part of the plan. They will get to analyze the data and draw conclusions based on the inquiry question.

Materials: Tom Lonergan`s Inquiry Plan on page 99, Overview of Tom`s Data Collected on page 100, large sheets of paper, colored pens/highlighters

Participants work individually through each of the phases but are encouraged to discuss with the group between each phase. The facilitator discusses each phase with participants throughout the activity.

1. Access the Tom Lonergan Data Folder and read Tom's Inquiry Plan, Inquiry Questions and Data Collection Plan (together these form Tom's Inquiry Brief) [5 mins]
2. Review the plan and the context [5 mins]
3. Complete Phase 1 of the analysis [10 mins]: **Predictions** (you should do this on your own, **without viewing any of the data**). During this phase you should reflect privately on the plan and context, and record your preliminary thoughts about the data. The following prompts may help:
    - I assume…
    - I wonder…
    - I predict…
    - My questions and expectations are influenced by…
    - Some possibilities for learning that this data may present are…
4. Review the data provided in the folder [45 mins]. Complete Phase 2 of the analysis: **Going Visual**. This phase consists of the following steps:
    - Make a map of the data on large sheets of paper
    - Color code the data, highlight trends etc.
    - Link relevant data together
    - The idea is to visualize the data in order to help you get a better sense of what the data might be telling you
5. Complete Phase 3 of the analysis [20 mins]: **Observations**. During this phase you engage with the data to note the facts that you can observe. Study the data you have visualized and record your observations. You should not make any conjectures, inferences, conclusions or explanations during this phase. The following observation questions will help you to record the facts:
    - I observe that…
    - Some patterns/trends I notice are…
    - I can count…
    - I'm surprised that I see…

Optional: Delving deeper into Phase 3 (Observations).The following may be useful to present to the group either before or in the middle of Phase 3.

Coding is a procedure that disaggregates the data, breaks it down into manageable segments and identities or names those segments. Coding requires **constantly comparing and contrasting** various successive segments of the data and **subsequently categorizing them**.

Memoing is a procedure for **explaining or elaborating on the coded categories**. Memos are conceptual in intent, vary in length and are primarily written to oneself. The final analysis and interpretation is based on integration and analysis of memos.

The content of memos can include:

Commentary on the meaning of a coded category; Explanation of a sense of pattern developing among categories; A description of some specific aspects of a setting or phenomenon.

Potential Organizing Units and Categorizations

Chronology	key events	various settings
People	processes	behaviors
issues	changes	groups
styles	relationships	meanings
practices	strategies	episodes
encounters	roles	feelings

6. Complete Phase 4 of the analysis [20 mins]: **Inferences**. During this phase you should do the following:
    - Generate multiple explanations for your Phase 3 observations
    - Identify any additional data that may be needed to confirm or contradict your explanations
    - Use these starters to help you think more about the observations and will assist you in making inferences:
    - I believe the data suggests...because…
    - Additional data that would help me verify/confirm is…
    - Some possible solutions that address the needs omlied in the data are…
    - Additional data that I would be interested in is…
7. Debrief with the group [15 mins]. Discuss the following, firstly in pairs and then with the whole group
    - What parts of this exercise did you find most useful?
    - What challenges did you face in completing the exercise?
    - Do you think using this approach is possible with your own inquiries?

Tips & advice

- When teachers are actually conducting a PI, it is advised to do this activity earlier in the process, before teachers start collecting data or even before they have written a detailed inquiry plan. It gives a last and final opportunity to fine-tune their inquiry plans. Analyzing different types of data can help them consider how and what data to gather for their inquiry. Reflecting on the sample data of Tom Lonergon enables teachers to reflect on their data collection.
- It is important to indicate that some parts of the data can be irrelevant to the inquiry question, e.g. the Christmas test results didn't provide any usable information that could address the question.
- Because teachers are using actual data this can stimulate discussion on the quality of the data (e.g. some of the 3DIPhE teachers felt that the field notes didn't provide enough information). Again this can be a very interesting discussion because teachers will think how to gather effective field notes and observational data for their inquiry.

Paper twitter

See Volume 3 on Building Professional Learning Communities, Part 3.

Alternative activities and protocols	
PI	• ATLAS protocol (reflect on research data) • Qualitative data analysis
PLC	• World Café • Chalk talk
IBL	Volume1: 1. IBL activity double shadow 2. IBL activity penumbra

Analyzing element

How to draw conclusions from your evidence?

Now teachers have collected data about their practice, they can now start to analyze their data and come to conclusions. The protocol data driven dialogue that participants have already used in the previous element, will be used for this.
Teachers need actual time in the workshops to engage with their inquiries because they often have limited time outside. In this element they have the opportunity to work on their own data and also be supported individually by the coach. The Data Driven Dialogue Protocol is the main guide for this element.
When organizing a 5 day-course this element cannot be done, simply because the participants will not have collected their own data. Some alternatives are field visits, more IBL activities strengthen the understanding of IBL or getting familiar with other protocols to analyze data like the ATLAS protocol.

PI	Drawing conclusions from data
PLC	Analysing conclusions of others
IBL	Strengthen IBL skills

Example structure		
3DIPhE Pillars	**Analyzing Element**	**Time**
PLC	Comfort zone (revisited)	15
PI	Report on the data driven dialogue	90

Comfort zones (revisited)

Goals
- Modify earlier responses from the previous comfort zone protocol.

Time
15 minutes

Materials-instructions
1. The result from the zones of comfort should be shown again. If you don't have it on paper, you can beam a photo on a screen and teachers can add and modify using post-its. In the previous exercise they were specifically asked to note their comfort level in relation to (a) working in a PLC; (b) carrying out a PI; (c) I'm ready to start my own PI and (d) other.
2. Now ask participants to review their answers according to the same topics.
3. If they are still notes in the 'danger zone' ask how we (coach and other participants) can help.

Report on the data driven dialogue

Goals
- Make sense of the collected data from the practitioner inquiry

Time
90 minutes

Materials-instructions
All participants are using their own data they have collected in their practice. They use the Worksheet from the data driven dialogue as the main guide for this activity and follow these instructions.

1. Presentation (5 minutes) "Owner" of the data provides overview of the context and focus
2. Clarifying Questions by others 4 minutes)
3. Phase 1: Predictions
    - Group fills out predictions sheet (3 minutes)
    - Round-robin report-out of predictions (one item each person, one round only — 3 minutes)
4. Distribution and Examination of Data (7 minutes)
5. Additional Clarifying Questions, if necessary (3 minutes)
6. Phase II: Go Visual (10-30 minutes)
   Participants mark up and re-organize the data to better understand it. May be done individually, in pairs, or in small groups depending on group size and amount of data. Highlighters, chart paper, and calculators are helpful to have on hand.
7. Phase III: Observations
    - Group fills out observations sheet (5 minutes)
    - Round-robin report-out of observations may (one item each person, continue rounds until new ideas are spent — 5 minutes)
8. Check in with Presenter (2 minutes) Do we need to refocus our attention?

9. Phase IV: Inferences
    - Group fills out inferences sheet (5 minutes)
    - Round-robin report-out of inferences. May be charted (one item each person, continue rounds until new ideas are spent — 5 minutes).
10. Response from the Presenter — What new thoughts are you having about the data now? What are your next steps? (5 minutes)
11. Implications for teaching and learning (10 minutes)
12. Debrief the protocol (3 minutes)

Tips & advice

- Support teachers in this process of making senses of their data. Some tips:
    - It is better to focus on one aspect at a time when looking at the data. For example it may be too broad to see if the students' experimental skill are improved when looking at their notes. A possible focus in 'experimental skills' can be to see whether the students have developed a good understanding of dependent and independent variables changing over time.
    - Encourage me to be more objective in stating observations. We all have a natural habit of taking inferences too soon.
    - In phase 4, when making inferences, provide enough time to think about what inferences you could make.

Alternative activities and protocols	
PI	• ATLAS protocol (reflect on research data) • Qualitative data analysis
PLC	• World Café • Chalk talk
IBL	Volume1: 1. IBL activity double shadow 2. IBL activity penumbra

Sharing element

How can you share conclusions with colleagues? What did you learn for your practice in the future?

It is very important to share results with other colleagues and peers, not only to validate and see if conclusions can be extended to others, but also to take lessons for approaching IBL in the future.
In this element teachers must be motivated and prepared to take part in a sharing event like a small poster session fair or presentations at a school.

When organizing a 5 day-course this element will be different, because the participants cannot make a poster of an inquiry they haven't done. Other possibilities are, if possible, participating in a sharing event like a poster fair or a mini conference of teachers who have participated in a PI course. Try to invite teachers who are willing to present their inquiries.

PI	Learning how to create a poster / presentation
PI	Presenting and Sharing
PI	Lessons for your practice in the future
PLC	Learning from others
IBL	Lessons for approaching IBL in future

For this element there are no specific protocols described. Tasks that need to be completed in this element are getting familiar with certain templates for sharing (e.g. poster template), making a poster or a presentation (if possible with peer feedback) and preparation for sharing moment.

Some tips and advice for this element:

> Preparing a presentation, making a poster, writing a report, … all these activities are very important for teachers to help them to clarify their thoughts and inferences about their inquiry. But teachers need support. For instance, help them in presenting their data in a poster structure.
>
> Provide examples of good practice. Teachers need examples to see possible outcomes. Here you can find some Poster examples from 3DIPhE course. A good exercise is to compare different posters, discuss them and synthesize good elements from the posters. You can also ask for tips for improvement and elements that are missing in the poster to have a better understanding of the inquiry.

Different formats are possible! Be creative. The key idea is that participants share what they have learned, but there are many ways to do this:

- Poster session in school
- Presentations during a staff meeting
- Vlog or blog link with the school website
- Interview in the school magazine.

Organize a sharing event like a mini conference with poster and presentation sessions. You can limit this event only at one school, involve teachers from different schools from different regions or even try to go international and exchange experiences from different countries. This international exchange has been done several times during the 3DIPhE project at local multiplier events. These two-day events were very inspiring and motivating for all who attended. Depending on the country, the programs of each event were a bit different but in general the planning and objectives were quite similar. It is important to have a short introduction and welcoming so that teachers feel comfortable and welcome, to have the same mindset of working in a PLC and teachers are willing to share and listen. It can be followed by a short presentation of each participant who described their inquiries. From then on, you can alternate between small group poster sessions where the teachers had an opportunity to share and learn in detail about each other's work, group discussion on doing PI as a part of a PLC and workshops about IBL. An example structure of a possible program can be found on the page 111.

Proposed agenda and specific timetable

A proposed agenda and timetable are shortly described to help scheduling the course.

1. 5-day course for 20 participants: How to conduct PI in the context of IBL

Target group: (science/STEM) teachers willing to improve their practice (on IBL/STEM) through practitioner inquiry (PI)

Take home products for participants:
- IBL inspirations and theoretical background
- Experiences and learning how to do a PI
- Possible deliverable is a personal inquiry plan for each teacher that can be conducted in the future in their own practice.
- Experiences, activities, protocols on how to work in a PLC.

Planning: see scheme below. This is based on the different elements described previous in this guide.

<table>
<tr><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr>
<td>Motivation element (1 day)

Output & content:
• IBL inspiration
• first draft question about their inquiry (PI)
• Learn how to work together in PLC</td>
<td>Insuiry element (1 day)

Output & content
• IBL inspiration and extended
• Inquiry question
• Extended PLC bonding</td>
<td>Development element: (1 day)

Output & content:
• IBL extended
• inquiry plans (with data collection tools)</td>
<td>Analyzing element (1/2 day)

Output & content:
• learnings how to analyze data
• IBL extended

Field visit (½ day)
• class visit and observations on IBL
• excursion to science centre</td>
<td>Sharing element of PI

Output:
• final inquiry plan with adaptation
• presentations of teachers</td>
</tr>
</table>

2. Professional learning community of teachers doing a PI in the context of IBL

When working in PLCT you can spread out the course so teachers can do an actual PI in their own professional practice. However, the course is pretty time consuming and it is important to be as time efficient as possible while planning a series of workshops. A workshop every two months is not so efficient. Therefore, it is better to plan the first series of workshops in a quicker succession, starting from the motivation element up to the development element. A bigger time interval after these workshops is recommended so teachers have time to conduct their inquiry and collect data. A new series of workshops can proceed afterwards, also in a quicker succession. Do not try to give them too much homework but provide time for actual work during the workshops. Organize a multiplier event of 1 day to share results with other teachers that have done a PI, with colleagues from the same school to extend and validate results within the school and list up follow-ups for the future.

An example timeline over a period September - March of a school year

September beginning	September End	October Beginning	November End	January Beginning	January End	March
1 day WS motivation element	½ day WS inquiry element	½ day WS inquiry element	1 day WS development element	½ day WS Analyzing element	½ day WS Analyzing element	1 day Sharing event

PART C: APPENDIX

Pre-course survey

Introduction to 3DIPhE (example presentation from DCU, separate PDF)

Presentation of IBL activity plants in space (separate PDF)

Passion protocol: 8 passions

Farmer versus Gardening

Passions for IBL - Fibonacci Protocol

My priority/preferred ambition in IBL (my passion in IBL)

Inquiry based learning - Questionnaire

Examples of PI questions from the 3DIPhE experience

Litmus test on the inquiry question

Litmus mindmap

Presentation ‘PI on IBL workshop on water rockets’ (separate PDF)

Exploring the problem space using 5W + 1H

Inquiry question for PI (Practitioner Inquiry)

My PI for IBL

Websites for specific based literature

Different ways of data collection

Barometer

Tom Lonergan`s Inquiry Plan

Overview of Tom`s Data Collected

- Tom`s field notes
- Sample of student work
- Pictures of in-class activities
- Student Surveys
- Christmas results

Poster examples from 3DIPhE

Example program of a local multiplier event

Pre-course survey

Date:

1. Name:

2. Country and Location:

3. Gender:

4. Years teaching experience: <3years 3-5 years 6-10 years 11-20 years >20 years

5. Please indicate the subjects you teach and the corresponding level at which you teach them:

Lower Secondary	Upper Secondary	Lower and Upper Secondary

6. Type of school you teach in: Mixed gender All boys All girls

7. Please describe your general approach when teaching physics or chosen subject. Please make reference to practical work if relevant. (Description of context can be included if helpful)

8. Please describe any challenges you may face when teaching physics or chosen subject. Please make reference to practical work if relevant.

9. Please indicate your level of agreement to the following statements regarding your teaching of physics or chosen subject. (-3 = Strongly Disagree, 3 = Strongly Agree, NA = Not Applicable)

		-3	-2	-1	1	2	3	NA
a	I think it's important for students to do practical work when learning physics or chosen subject							
b	I find it difficult to facilitate students doing practical work							
c	I am comfortable teaching practical work where the answer to an investigation is unknown to the student							
d	I am comfortable teaching practical work where the answer to an investigation is unknown to the teacher and student							
e	I am confident in my own content knowledge for teaching physics or chosen subjects' concepts effectively							
f	I am confident in my own approaches for teaching physics or chosen subjects' concepts effectively							
g	I understand what is meant by the phrase inquiry-based learning							
h	I regularly use inquiry-based learning when teaching							
i	I am confident using inquiry-based learning when teaching							
j	I am motivated to try different approaches when teaching							

10. Please indicate your level of agreement to the following statements in regard to your experiences in teaching physics or chosen subject. (-3 = Strongly Disagree, 3 = Strongly Agree, NA = Not Applicable)

		-3	-2	-1	1	2	3	NA
a	My students learn content knowledge when I use inquiry-based learning							
b	My students develop skills and competences when I use inquiry-based learning							
c	My students learn content knowledge when I use demonstrations							
d	My students develop skills and competences when I use demonstrations							
e	My students are more motivated to learn when they engage in practical work							
f	My students are more motivated to learn when they design their own investigations							
g	My students are more motivated to learn when they analyse their own data							
h	My students are more motivated to learn when they are drawing their own conclusions							
i	My students are more motivated to learn when they collaborate							
j	My students are more motivated to learn when they have opportunities to question their peers							

11. Please indicate your level of agreement to the following statements in regard to your experiences in teaching physics or chosen subject. (-3 = Strongly Disagree, 3 = Strongly Agree, NA = Not Applicable)

		-3	-2	-1	1	2	3	NA
a	I am keen to understand how to enhance my teaching							
b	I regularly self-reflect on my practice							
c	I am confident I can effectively inquire into my own teaching practice							
d	I am able to identify ineffective teaching approaches							
e	I regularly challenge my assumptions about my own teaching							
f	I am open to looking at classroom issues from different perspectives							
g	Reflection helps me keep track of my effectiveness as a teacher							
h	When reflecting on my teaching I consider all stakeholders (School management, colleagues, students, parents/guardians)							
i	I encourage peers to give feedback on my teaching							
j	There are opportunities for peers to give feedback on my teaching							
k	I provide feedback to peers on their teaching							
l	I engage in dialogue with peers about how to teach effectively							
m	I regularly ask my students for feedback on my teaching							
n	I often do not have access to knowledge that will improve my teaching							
o	I believe that my inquiries into my own practice can inform and support other teachers in their practice							
p	I believe that my inquiries into my own practice can be used to inform policy direction at school level.							
r	I believe that my inquiries into my own practice can be used to inform policy direction at national level.							

Passion protocol: 8 passions

1: the child

You became a teacher because you mainly **wanted to make a difference** in the life of a child. Perhaps you were one of those children whose lives were changed by a dedicated, caring teacher that made you decide to become a teacher so that you can do the same for other children. You are **always curious about certain special students** whose work and / or behavior simply does not seem to be in line with the rest of the students in the class. You wonder how student interactions seem to influence the chances of completing an assignment, or how it is possible that one of your students may seem to make remarkable progress from one day to the next.

Or how you can **motivate** a certain student to perform certain assignments. You believe that understanding the unique characteristics of each student is the key to unlocking their full potential as learners and learners.

2: the curriculum

You are one of those teachers who always "**tinker**" with the lessons to increase the **learning opportunities for the students**. You have a thorough knowledge of the content of your lessons. You attend conferences and you are subscribed to magazines that help you stay up to date with c**urrent trends in your subject** (s).

You sit on the cart with **educational innovations and new trends**, and would like to **try them out** in class where possible.

Although you are often dissatisfied with the curriculum itself, you are almost always sure that you are doing better than what is prescribed. You always criticize the existing curriculum and you find ways to do better for the benefit of the children's learning - especially if you have a strong feeling that this is possible.

3: knowledge of the learning areas / subjects

You are at your best in class when you teach based on **a thorough knowledge of the content** and / or subject you are teaching. Teaching about something you don't know much makes you uncomfortable and always motivates you to sharpen your knowledge about this part of your assignment. You realize that what you know about the subject will influence the way you can convey it and thus promote the development of your students. You spend a considerable amount of personal time - both during the school year and during the holidays - searching for books, materials, workshops and courses to strengthen your **substantive knowledge.**

4: educational strategies / techniques

As a teacher, you are most motivated by the desire to improve your **teaching strategies and techniques** and to experiment with them. You have experienced the value of certain strategies and understand that you can offer students **powerful learning environments** and you really want to become good at things like this.

There are also many uncertainties and difficulties with certain learning techniques, and you **really** want to **get the hang of how you apply a certain technique**. You are always working on expanding your educational repertoire.

Exercise 2: Browse (virtually) your manuals, your curricula and your old diaries. As you browse through those documents, you draw up a list of things that you taught but where you didn't feel good and what you want to optimize in the future. In addition to each topic in your list, describe in a few words why you were not satisfied with this section and how you could optimize it. Finally, choose one topic from your list that you want to focus on with future research. Brainstorm questions related to teaching on this topic.	**Exercise 1:** Make a list of all the students in your class or make a list of all the students you teach in a certain period. As you make the list, note what makes each student unique. Focus on characteristics that the student shows and that you observe. Avoid judging or criticizing students. Write one question next to each student's name. That question is about something that can give you insight into how that student learns.
Exercise 4: Brainstorm a list of educational strategies that you want to try. In addition to each item on your list, you should briefly state why you want to try this strategy. Write down a question that is related to the strategy you want to try and why you want to try it out. Brainstorm about a list of the most frequent educational strategies that you apply in your practice. Then place an asterisk next to the strategy that intrigues you the most. Write here in a few sentences why this strategy intrigues you the most. Then formulate a question that is related to the educational strategy and why it intrigues you.	**Exercise 3:** Make a list of things that you do in your practice and that you think promote the student's learning. Circle what you think can still be improved. Make an evaluation of the materials you use to teach (eg within one subject / learning area). Do these materials ensure that you pay sufficient attention to the diversity and different backgrounds of your students? For which students are these materials insufficient? What's missing? .

5: relationship between yourself and your colleagues

You are essentially **a team player** , so you do your job the way you do. You like to measure yourself with colleagues, discuss approaches with them and listen to ideas and techniques that they apply. Because you only really learn when you can discuss it with them.

Teaching is a **challenge** that you all **tackle as a group**. You only win if everyone wins.

When you try something new in class that is very successful, one of the first things you think is "I have to tell X".

6: the intersection between your personal and professional identities

You came **from a different job** in education and you often have the feeling that your previous professional identity conflicts with your new identity as an educator. You do not feel efficient and are frustrated when your students or colleagues do not tackle a certain task in the same way as you, based on an approach that is considered second nature to you, arising from your previous identity as a writer, actor, artist, researcher ... What keeps you awake at night is how you can use the knowledge, **skills and experiences that you have brought from your previous professional life** to come to powerful forms of teaching and learning in your class and / or school.

7: Challenges of the future

You became a teacher **to change** / help **the world to** create a more just, fair, democratic and peaceful world. You know that the world of the **future will be full of challenges** and move faster than the world you have always known. You constantly think of ways to integrate things like 'race, class, disability, power ...' into your practice. You wonder **what skills the students of the future need to have** to function in that world, and you want to do everything to sharpen those skills.

8: School as a quality indicator

What keeps you awake at night is how your students **can maintain a high level**, despite the many distractions they experience every day in your class / school.

It seems that the **school context** is conspiring against everything you know about effective teaching and learning.

You worry about **exam results** and things like **pisa scores**.

Is it not the task of an education to aim high and go for good evaluations? And how do you actually, **effectively and efficiently evaluate it ?**

Exercise 6:

Write your biography concisely. Discuss the development of your interests and passions. Finally, discuss why you chose to become a teacher. Draw a timeline of your career where you indicate how you grew as a teacher. Start with your date of birth and note dates and dates in which crucial issues occurred in your life and career. Make a coat of arms of yourself as a teacher. For example, you can place a mythical image in one part that describes how you want to be as a teacher. In another part you can place a symbol that indicates how you want to be as a teacher. In another part you choose the colors that best suit who you want to be as a teacher. In another part you can depict a characteristic of what you want to be as a teacher. Finally, you can choose a word or spell that matches how you want to be as a teacher.

Exercise 5:

Remember the last time you were impressed by a colleague. What did he / she do that impressed you?

Was there anything you wanted to do about it? Why did that have such an effect on you?

In what way does that colleague differ from you?

Are there things that could be beneficial if you took over something from him / her?

Exercise 7:

When you think of the world that your students end up in, what do you think of?

Which skills and characteristics are important in that world of the future?

If you think of the educational reform of 2040 or 2050, what do you think will be circled in red at the top of the agenda?

Can we already learn something from this insight? Can you make that concrete for your own lesson?

Exercise 8:

Why do you think it is important to strive for a high level and good results?

Is it more important that they reach their very highest level with the highest potential, or is it more important that the general level is as high as possible?

What exactly does a high level mean to you? How can you measure that? Can you see that?

Does the way you measure influence the way your system works? What kind of conclusion do you draw for your own lesson?

Farmer versus Gardening

Lawrence Stenhouse noted that the difference between the teacher-researcher and the large-scale education researcher is like the difference between a farmer with a huge agricultural business to maintain and the "careful gardener" tending a backyard plot:

> In agriculture the equation of invested input against gross yield is all: it does not matter if individual plants fail to thrive or die so long as the cost of saving them is greater than the cost of losing them.. . .This does not apply to the care- ful gardener whose labour is not costed, but a labour of love. He wants each of his plants to thrive, and he can treat each one individually. Indeed he can grow a hundred different plants in his garden and differentiate his treatment of each, pruning his roses, but not his sweet peas. Gardening rather than agricul- ture is the analogy for education. (Rudduck & Hopkins 1985, p. 26)

Table 1: Comparing academic research and practitioner inquiry (based on tables from Fichtman Dana & Yendol-Hoppey, 2014; Bolhuis & Kools, 2012)

	Academic research	**Practitioner inquiry**
Goal	Expand academic body of knowledge in a certain field	Provide insight into teaching in an effort to make change
Conducted by	Scientists	Practitioners
Conducted in	Controlled settings (labs) or in vivo (in schools)	A specific educational practice
Impact on the academic community	Broad on the academic community trough publications in peer-reviewed journals	Very limited
Impact on educational practice	Very limited	Profound on the practice at hand
Scope of findings	Generalizable; valid for and transferable to different contexts	Limited to specific practice at hand.
Involvement of practitioners	Source of data and/or actor in implementation of intervention	As researcher or as critical friend in practitioner inquiries of colleagues

Passions for IBL - Fibonacci Protocol

Based on the Fibonacci Self-Reflection Tool for Teachers form

Source:
Page 41 and 42 of the booklet Tools_for_enhancing_inquiry_in_science_education of the Fibonacci project

Procedure:

Introduction: Form groups of 4.

a. Individually:15 min

Read the indicators of the self-assessment tool. Assess yourself in the 4 categories. Look at possible weaknesses in your practice. Look at your list vertically, and decide which topic you are most motivated for to improve.

Ask yourself a question about this improvement.

b. In the group of 4:

b1 - each one informs the others on the indicator he is most interested in to improve: 2 min for all 4 (overview of 4 topics)

b2 - **Take turns in: (4 x 7 minutes)**

- **each one asks the relevant question (How can I improve…) and explains in 2 minutes how he is interpreting the question**
- **the group reflects on the explanation of the presenter: 4 minutes**
- **the presenter has the last word. 1 min.**

=> All together: 45 minutes

Result: the participant has found a topic which he wants to improve, and asks an inquiry question about it.

Here below screenshots of the tool

Self-Reflection Tool for Teachers – Primary and Middle School

Section A: The Teacher's Role

	Items (T = teacher; Ps = pupils)	Examples of good practise	Decision			Notes
1. Building on Ps' ideas	1a Did you ask questions to reveal and show interest in Ps ideas?	You phrased questions such as 'what do you think is happening?' 'why do you think this might be?' rather than 'what is the reason?' or 'why is this happening?'	yes	no	NA	
	1b Did you help Ps to express their ideas clearly?	You gave Ps time to think about how to express their ideas so that others could understand them; perhaps by giving a short time for discussion in pairs or small groups, or you repeated what they said and asked 'Is this what you mean?'	yes	no	NA	
	1c Did you give Ps positive feedback on how to review or take their ideas further?	You may have suggested how Ps' ideas could be investigated at some stage in the current activity or later; you may have referred to their ideas in later discussion asking ' do you still think that....?'	yes	no	NA	
2. Supporting pupils' own investigations	2a Did you encourage Ps to ask questions?	You asked them, for instance, 'What would you like to know about....?' Or provided a 'question box' or board where Ps could post their questions.	yes	no	NA	
	2b Did you help them formulate productive (investigable) questions?	This might be through discussing the kinds of questions that can lead to investigation and which include an indication of what to do and what to look for in order to answer it (i.e.: clarify the meaning of words such as 'best' in a question such as 'which is the best shape for a paper aeroplane?')	yes	no	NA	
	2c Did you ask them to make predictions?	At some stage of discussing an investigation you asked Ps 'What do you think will happen if ... or when....? Why do you think that?"	yes	no	NA	
	2d Did you involve them in planning investigations?	Perhaps you provided a planning framework, or discussed with Ps the possible steps in the investigation, asking for their ideas in relation to parts of the plan so that they regarded it as their own and not planned entirely by you.	yes	no	NA	
	2e Did you encourage them to include fair testing where appropriate?	In investigations where comparisons were being made you prompted them to think about what has to be kept the same and what had to be changed so that only the variable under investigation was changed.	yes	no	NA	
	2f Did you ask them to check their results or observations?	You asked Ps to check their results by repeating their observation or measurements where possible and ensuring accuracy, for instance in reading measurement scales carefully.	yes	no	NA	
	2g Did you help them to keep notes and record results systematically?	This might be through showing Ps how to organise data in a table or suggesting a list of headings or a checklist of items to be included in their report.	yes	no	NA	
3. Guiding analysis and conclusions	3a Did you ask Ps to provide some conclusions from their work?	This might be by helping Ps to make some general statement about what they found rather than only listing individual findings; for instance about the factors that were found to make a difference, not just the difference between one condition and another.	yes	no	NA	
	3b Did you ask Ps to check that their conclusions were consistent with their results?	Where Ps gave a conclusion, you asked them to be sure that it fitted all their observations or results.	yes	no	NA	
	3c Did you ask Ps to compare their conclusions with their predictions?	You asked Ps to recall what they predicted and to compare this with their conclusions.	yes	no	NA	
	3d Did you ask Ps to think of reasons or explanations for what they found?	Whether or not there was agreement with predictions, you encouraged Ps to try to explain what was found and develop their understanding of the events or phenomena investigated (i.e., by helping them to use an idea that could also explain other situations).	yes	no	NA	
	3e Did you ask Ps to identify possible sources of error?	You discussed with Ps whether some aspects of the way the investigation was carried out could have affected the result, perhaps by asking if they would get exactly the same result if repeated.	yes	no	NA	
	3f Did you ask Ps to identify further questions?	You encouraged Ps to continue to inquire, perhaps by discussing other questions that arose or asking 'what else would you like to find out about ...?'	yes	no	NA	
	3g Did you encourage Ps to reflect on what they found and how they found it?	You spent some time after the investigation helping Ps to recall what they had done, discuss what they had learned, how they could improve their investigation and apply this in future work.	yes	no	NA	

PLEASE READ THE INSTRUCTIONS CAREFULLY BEFORE USING THIS TOOL

Self-Reflection Tool for Teachers – Primary and Middle School

Section B: Pupils' Activities

	Items (T = teacher; Ps = pupils)	Examples of good practise	Decision			Notes
4. Carrying out investigations	4a Did Ps work on questions which they identified as their own, even though introduced by you?	Indicated by being able to explain in their own words what they were trying to do or find out.	yes	no	NA	
	4b Did Ps make predictions based on their ideas?	Ps could give a reason for what they predict, even if it was inaccurate, showing that it was not just a guess.	yes	no	NA	
	4c Did Ps take part in planning an investigation?	Ps suggested in general terms what to do to solve a problem or answer a question even if they needed help with details.	yes	no	NA	
	4d Did Ps include 'fair testing' in their plan if appropriate?	Ps suggested what things to change, what to keep the same for a fair test.	yes	no	NA	
	4e Did Ps carry out an investigation themselves?	Ps were actively involved in collecting information (either from real objects or from secondary sources such as books, posters, websites), not watching others do this.	yes	no	NA	
	4f Did Ps gather data using methods and sources appropriate to the inquiry question?	Ps were making observations, measurements, using appropriate equipment, or gathering evidence in other ways (including secondary sources) that were relevant to the question or problem.	yes	no	NA	
	4g Did the data gathered enable Ps to test their predictions?	The nature of the data collected by observations, measurement, or from secondary sources enabled them to test their predictions and answer their inquiry questions.	yes	no	NA	
	4h Did Ps consider their results in relation to the inquiry question?	In a group or whole class discussion, Ps discussed whether what they found answered the inquiry question.	yes	no	NA	
	4i Did Ps propose explanations for their results?	In a group or whole class discussion, Ps gave possible reasons for what they found even if it did not answer the question being investigated.	yes	no	NA	
5. Working with others	5a Did Ps collaborate with others during group work?	Ps discussed and worked together to agree what to do, not simply working individually although seated in groups.	yes	no	NA	
	5b Did Ps engage in class or group discussions of their investigations and explanations?	For instance, after completing their investigation Ps took part in discussions in groups or as a whole class of what they did and found and how they explained their results.	yes	no	NA	
	5c Did Ps report their work in some form to the whole class?	There was some way in which Ps shared their work with others, either by reporting to a group or the whole class or displaying their records as a poster or artefact.	yes	no	NA	
	5d Did Ps listen to each other during reporting?	Indicated by looking at another who was presenting their work, not speaking themselves, and responding if asked.	yes	no	NA	
	5e Did Ps respond to each other during reporting?	Responding may imply asking questions to better understand their classmates' presentation or agreeing or disagreeing with what is being reported.	yes	no	NA	

PLEASE READ THE INSTRUCTIONS CAREFULLY BEFORE USING THIS TOOL

Self-Reflection Tool for Teachers – Primary and Middle School

Section C: Pupils' Records

	Items (T = teacher; Ps = pupils)	Examples of good practise	Decision			Notes
6. Records Ps make of their work	6a Did Ps make some record of what they did and found?	Ps made some collective or individual record of what they did in the form of a drawing or writing or artefact as appropriate to the age group. (Note that if the answer to this questions is No, then it will also be No for the following five questions.)	yes	no	NA	
7. Ps' written records	7a Did Ps include in their record a clear statement of the inquiry question or problem?	Any written group or individual records includes a title or statement that indicates the inquiry question or problem.	yes	no	NA	
	7b Did Ps' records indicate what data were collected and how they were collected?	Any records, either collective or individual, indicate in words or drawings what was observed or measured and how this was done.	yes	no	NA	
	7c Did Ps record observations and data collected in a systematic way?	Any record, either collective or individual, presents data in a table or organised list or show results in the form of a diagram.	yes	no	NA	
	7d Did Ps indicate in their records whether results agreed with their predictions?	Any records, either collective or individual, include a reflection on whether what was found agreed with what they predicted.	yes	no	NA	
	7e Did Ps state their conclusions in their record?	Any records, either collective or individual, include a statement of what was concluded from the investigation, that is, not just the results but what they mean in more general terms.	yes	no	NA	
	7f Did Ps make personal notes during their work?	Indicated by Ps jotting down some personal notes of ideas or data during the investigation, not the formal record made afterwards.	yes	no	NA	

PLEASE READ THE INSTRUCTIONS CAREFULLY BEFORE USING THIS TOOL

My priority/preferred ambition in IBL (my passion in IBL)

Source: Tool 016 – The 8 passions, LINPILCARE

Process:

- The tool is appropriate for teams with 10 to 15 participants
- Each participant receives and reads the text "Seven different ambitions" individually.
- Each participant decides on his/her priority among ambitions.
- Participants, who have decided on the same ambition, form subgroups; all participants, who selected an ambition different than any of the others, form one subgroup. I only one participant selects an "isolated" ambition, he/she decides for an alternative from already chosen ambitions and joins the corresponding subgroup.
- Participants explain to each other the reasons for their selection.
- Sub groups share their findings related to the reasons for choosing specific ambition with the whole group.

Teacher's ambitions

Teachers regularly meet various problems during their work, starting from the attitude of students to the subject itself, methods of teaching, and a feedback on students' knowledge, to their own interests and interests, which the teacher develops in during the work over the years.
You joined the project precisely because you valued your professional development and improvement of your work. As the project focuses on inquiry based learning (IBL), there are seven generic ambitions quoted below. Each of them is described in more details. In a real life, many of them overlap, but here they are written separately to help you define the area you would prefer to focus on.

Seven IBL related ambitions

1. Effective learning

Students often face problems when acquiring new physics/science contents or learning physics/science in general. They can lose attention, due to new and not yet acquired vocabulary of the subject the lack understanding of the content.... I am convinced that experience during experimental work helps many students to comprehend teacher's information easier and include it better to their personal knowledge network. In addition, personal experience, observations, testing by observation or conducting experiments is often an effective support for developing an understanding of concepts.

2. Effective teaching

I often blame myself and my methodology of teaching for unsatisfactory results. I could be able to change the effectiveness of teaching by monitoring and observing my own dynamics and teaching methods, various methods of testing and assessing acquired students' knowledge, and other classroom work. I am convinced that an introduction of methodological changes is a demanding work, but it can lead to valuable results, especially when the changes are driven by personal ambitions to achieve better learning outcomes of students.

3. Monitoring own practice

Decisions to introduce changes to my teaching are often based on my feelings and opinions regarding various approaches and their success. To substantiate such feelings, a documented follow-up of own work in the classroom is welcome. In my opinion, if introduction of changes is planned based on documented findings, and accompanied by documented evaluation of its effects, it is easier to distinguish between personal beliefs and actual practice.

4. Experimental work in the classroom

I believe that experiments during lessons have different roles, from demonstrating phenomena the learners only observe, to practical experiments where learners also plan their execution. By experimenting independently, students develop their experimental skills, improve motor skills, and at the same time participate in the acquisition of new knowledge not only as observers but also as active participants. I am sure that they remember more and better, which often results also in a change of their attitude to the subject.

5. Research approach

I believe that experimental work in a classroom can be different, but if one wants to promote an inquiry approach to the unknown, it is important to ask questions, form predictions, design experiments, control variables, measure properties, manipulate data, formulate conclusions, and present new findings. Moreover, it should not be overlooked that new knowledge can often be used in different circumstances in everyday life. I believe that active students' involvement in experimental work is not just a work in itself; good results are often driven by a team work and effective communication between team members.

6. Attitude to the subject

I often find that students are less interested in science and maths, which results in their low motivation to learn. Although the contents of the courses often seem distant from everyday life, I think that it is usually possible to find their relevance to everyday experience or examples from everyday life where new knowledge can be used. This often leads to a positive attitude of the students towards the subject, an interest in the content and motivation for learning. I am convinced that students and teachers are allies in achieving this goal, although quite often students do not value this link as such.

7. Developing critical thinking

I believe that science and mathematics are fundamental subjects where it is possible to teach and and train drawing conclusions from data, measurements or documented evidence. In modern language, this is called critical thinking. I am convinced that it is developed by stimulation of curiosity through asking questions, finding answers and their testing and verification. Responsible citizenship, in my opinion, begins with a critical consideration of "quasi news", populists' statements and unverified bombastic reports.

Inquiry based learning - Questionnaire

Inquiry based learning is a teaching approach, where students also perform experiments.

1. According to your opinion, describe an activity that would you consider as an »inquiry based learning«. Illustrate with an example.

2. How often do you use the approach described above during the school year?

a) For each topic at least once;

b) For selected topics (a few times per year);

c) For one (two) particular topic(s);

d) Actually never.

3. Do you succeed to implement this approach every time you consider it relevant?

YES NO CANNOT SAY

4. If not, what are the obstacles?

Examples of PI questions from the 3DIPhE experience

Inquiry Question	Age	Topic/subject
How the group size (of 3 or 4) influences the group work?	17-19	Electricity (circuits)
How to increase understanding of energy transformations?	14-15	physics/energy in topic "To jump or not to jump"
How well students transfer the theoretical knowledge to examples? Are students able to find everyday examples and explain them?	14-15	several topics
Which learning method improves an understanding of "distance"?	11-12	math; The shortest route to understanding a "distance"
How to motivate students of vocational programs for science?	16-17	Applied science
Does an experimental activity that gives meaning to the centre of gravity in a triangle, improve memorization of rules for its construction	12-13	math;
How students form predictions?	18-19	physics
Which misconceptions regarding the circuits exist before and after the activity?	15-16	electrotechnics/ simulation of circuits using edison; Title: Simulation of circuits
What are the main obstacles for our students solving problems in regard to balance of forces?	16-17	physics; Title: Strike a balance
How students become more independent during the inquiry?	9-10	measuring a cooling water
How the best students deal with open inquiry?	14-15	Conservation of kinetic and potential energy
How much content knowledge students learn while using "IBL" versus the "reading the text"?	9-10	Heat, insulators
How do writing your own notes and asking questions contribute to a better understanding of what STEM is?	13	Integrated STEM course;
How can I involve students more in the design of a research plan in a scientific study?	14	Biology
How can we improve the ability of students to formulate hypotheses?	13	looping, speed, soap bubble
How can students investigate speed independently?	14	speed of cars

How can students write down more personal feedback during a lab work and take it with them to the next lab?	15	Power of a person
How can inquiry based learning (iMuScica) affect 'active citizenship'?	17-18	standing waves and eigenfrequencies
Does adding music to science result in extra motivation for the learners?	15-16	sound and tone, eigenfrequencies
How do I give feedback during lab work in a more efficient way?	16-17	Biotechnical sciences
In what way can I increase the motivation for the lessons on chemical arithmetic among less mathematical students and thus achieve deeper learning?	15-16	Chemistry
How can I develop co-operative learning in my 5th Year Ordinary Level Class?	16-18	Maths
What is the most effective type of homework s to consolidate learning and what frequency is best for maintaining standards?	16-18	Physics
What is the influence of simple inquiry activities and prompt questions at student understanding of electrical flow?	12-15	Physics - electricity
What is Pre-Service Teachers prior knowledge and understanding of the role of mandatory physics experiments?	Student Teachers	Physics - Refractive Index and Electrical Circuits (IV Curves)
How can IBL be used to derive formulas to develop student learning and understanding?	16-18	Maths - Area of Circle

Litmus test on the inquiry question

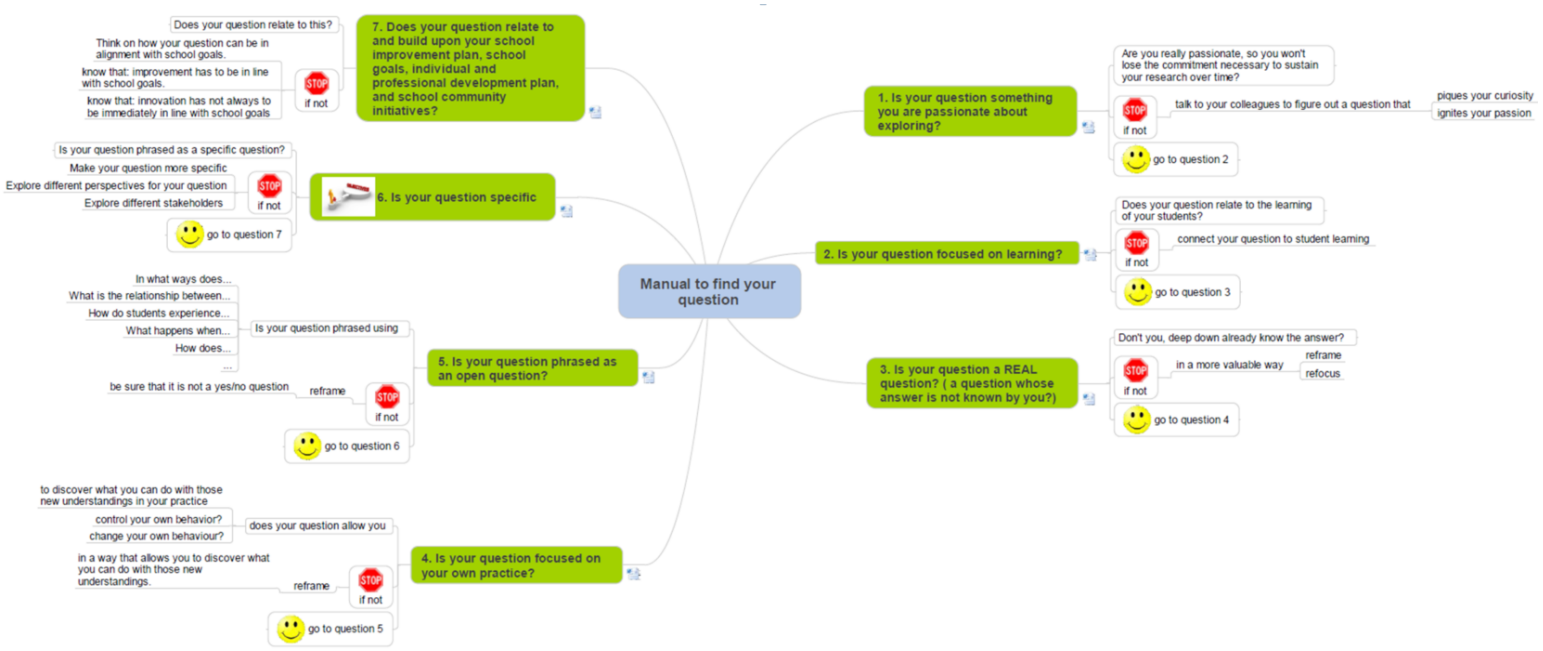
Use the litmus test mind map along with this tool to refine your inquiry question.

My Passion is		
What is your question about?		
My personal first version of my inquiry question is		
Phase	Theme	Indicate thoughts, questions and changes as necessary
1.	Passion	
2.	Focus on learning?	
3.	A real question?	
4.	Own practice?	
5.	Is your question an open question?	
6.	Specific?	
7.	Related to context?	
Conclusion	Write the updated version of your inquiry question here:	

Litmus mindmap

Adapted from LINPILCARE 2014-1-BE02-KA201-00432

Please copy the picture below to another document and print it in A3 format for the user's convenience. The original pdf version is also available on the Linpilcare website.



Exploring the problem space using 5W + 1H

Name: ……..

Problem space Describe your problem as thoroughly as possible with the method 5xW + 1H (what, who, when, why, where & how).
<u>What</u> is the problem? *Give a clear description of the problem:* - *Is something going wrong?* - *Is there something undesirable or unacceptable?* - *Is something missing?* - *Could anything be improved?* - *Is there anything very successful and should be more widely implemented?*
<u>Who</u> is facing the problem? *Try to identify who is involved in the problem:* - *Who are the stakeholders, the 'users'?* - *How these stakeholders are related to the problem?* - *How do these stakeholders experience the problem? What differences do they have?*
<u>When</u> does the problem occur? *Clearly indicate when the problem occurs.* - *How often does the problem occurs?* - *At what time does this problem arise?*

Why is it a problem?

Make it clear why this problem should be solved.

- *Are there certain standards or priorities that must be met?*
- *Why is the problem perceived as a problem?*
- *What is the use of solving the problem?*

Where does the problem occur?

With this question you provide insight into the locations and situations where the problem occurs.

- *In which rooms does the problem occur?*
- *In what situations does the problem occur?*

How did the problem arise?

Indicate how the problem arose over time.

- *What was the cause of the problem?*
- *What preceded the problem?*

Capture benefits

What do you hope the inquiry will deliver? When will you be happy/satisfied?

Notes from discussion with your critical friends (group of peers in your PLC)

Now try to synthetize your problem in one question:

Inquiry question for PI (Practitioner Inquiry)

Name and surname:

_____

1. Part Examples of inquiry questions:		
1. What did the students notice during the experiment?		2. How long did they need to complete the experiment...?
3. How many different explanations did the students propose?		4. What were characteristics of groups in which the students participated equivalently?
5. How long did students need to draw conclusions?		6. How many students suggested a different solution from the expected?
7. What misconceptions remained after the activity?		8. Your suggestions...

From examples above, select and inquiry research question you would like to try to answer by your inquiry and encircle it with a red pen. Mark your second choice with blue.

2. Part The reason for your choice:

Why did you decide for those two questions?

My PI (practitioner inquiry) question:

Compare both inquiry questions (first part of the tool) and the reasons for choosing (second part of the tool). You can either keep one of the chosen questions or form a new one that is closer to your interests with respect to reasons listed in the second part.
Write your inquiry question:

Check your inquiry question:
- Is the answer to YES or NO? Such questions are not recommended.
- Do you already know the answer to the question? In this case, we suggest its replacement.
- Is the question specific or precise enough?
- Do you know which data you will need to answer the inquiry question and how will you collect it?
- Can the question be clearly answered?
- Is the question relevant to your practice?

MY INQUIRY FOR
»INQUIRY BASED LEARNING«

STEP 1:
For the IBL activity you prepared for the next month in the first part of the meeting, consider a potential inquiry question for its implementation.

For inquiry question(s) and write it(them) in the frame below.
If you have written more than one question, decide for one and quote also the evidence you are going to collect to support conclusions.

(8 minutes)

Inquiry question(s):

THE question:

Evidence:

STEP 2:
Divide into groups of 3 persons. Follow the protocol in continuation, to receive a reflection of your colleagues regarding your inquiry question and the planned evidence.
(3×6 min = 18 min)

1. One member of the group presents his inquiry question and the planned evidence. (1 min)
2. Other members of the group pose clarifying questions, the author clarifies and explains. (2 min)
3. Members discuss the question and the evidence, the author listens and takes notes. (2 min)
4. Author reflect the debate and reports on changes he is going to adopt. (1 min)
5. The process is repeated for each member.

Presentation of the inquiry question (1 min)

Clarifying (2 min):
Colleagues ask questions that help clearing ambiguities. Note questions that you find helpful and/or important.

Gossiping (2 min):
Members of the group discuss presented inquiry. You remain silent and listen to your colleagues' discussion. Write helpful and/or relevant information and comments.

Reflection (1 min)
Present the new form of the inquiry question and/or new plan for evidence, if you have changed anything. Discuss also, which questions or discussed ideas influenced your decision to change anything in your plan.

STEP 3:
Write the final version of your inquiry question, the planned evidence and the plan for collecting evidence. Prepare for presentation of your inquiry question to the whole group.
(4 min)

Websites for specific based literature

Scientific digital databases:

- Teaching Council Digital Library
- What works clearinghouse
- ERIC
- Google Scholar
- Directory of Open Access Journals

Databases on science education, IBL and other interesting teaching materials:

- Fibonacci,
- Sails,
- Scientix,
- Establish,
- Open schools;
- PHET;
- Ambitious Science Teaching;
- Advancing Science & Engineering through Laboratory Learning.
- Institute of Physics,
- Assessment of transversal skills in STEM;
- Scientific abilities and rubrics to assess them.

Different ways of data collection

Data collection 1: Field notes

To capture action in the classroom, many teacher researchers take field notes as they observe. Field notes can come in many shapes, forms, and varieties. Some of these include scripting dialog and conversation, diagramming the classroom or a particular part of the classroom, noting what a student or group of students are doing at particular time intervals '(e.g. every two minutes), and recording every question that a teacher asks. Field notes are not interpretations but rather focus on capturing what is occurring without commenting as to why the action might be occurring or how one judges a particular act.
The forms that your field notes take depend on your wondering.

Data collection 2: Documents/artifacts/student work

Field notes capture actions as data on paper. However even without field notes, schools and classrooms naturally generate a tremendous paper trail that captures much of the daily classroom activity. The paper trail includes student work, curriculum guides, textbooks, teacher manuals, children's literature, individualized education plans, community memos, parent newsletters, progress reports, teacher plan books, written lesson plans, and correspondence to and from parents, the principal, and specialists. The amount of paperwork that crosses a teacher's desk can make any teacher bleary eyed. Often the papers teachers view do not hold significant meaning when read in isolation or when quickly in order to be able to hand them back in the morning. Teachers need to 'get through' paperwork in order to keep up with their work.
Yet, when teaching and inquiry are intertwined with one another, the papers become data and take on new meaning. When teacher-inquirers select and collect the papers that are related to their research wonderings, we call these papers documents and artifacts. Systematically collecting papers provides you with the opportunity to look within and across these documents to analyze them in new and different ways.

Data collection 3: Interviews

Teacher talk is important! As talk is crucial to the life of a teacher, capturing talk can be an important form of data collection. Field notes are one way to capture talk that occurs naturally in the classroom. Some teachers-inquirers go a step further than naturally occurring classroom talk by interviewing as well. Interviewing can be informal and spontaneous or more thoughtfully and planned.

Data collection 4: Focus groups

Focus groups offer teachers another vehicle for collecting the talk and thoughts of children in the classroom. In many ways, focus groups occur daily in the form of whole-class or small-group discussion. The focus-group discussion can serve as a tool for understanding students' perceptions. For example, a focus group can provide insight into how students experience a new instructional strategy.

Data collection 5: Digital pictures

Interviews and focus groups can capture words as data. A very old proverb you are likely familiar with is 'a picture is worth a thousand words.' Another wonderful way to capture action that occurs in the classroom as data is through digital photography

Data collection 6: Video as data

Digital pictures capture a single snippet of action in the classroom at one point in time. Video as a form of data collection takes digital pictures one step further by capturing an entire segment of action in the classroom over a set time period. Given that teachers often collect their best data by seeing and listening to the activities within their classroom, video becomes a powerful form of data collection for the teacher researcher. Teacher researchers have found that using video can help them collect descriptive information, better understand an unfolding behavior, capture the process used, study the learning situation, and make visible products or outcomes. More specifically, through observing video of one's own teaching, teachers can observe attitudes, skill and knowledge levels, nature of interactions, nonverbal behavior, instructional clarity, and the influence of physical surroundings.

Data collection 7: Reflective journals

Strategy 1 to 6 are ways to make data collection a part of your teaching by capturing what naturally occurs in your teaching day – action in the classroom through field notes, digital pictures, and video; student progress in your classroom through document analysis; and talk in the classroom through interviews and focus groups. One of the ways that interviewing and focus groups serve as powerful data collection strategies is through the talk of interviewing, because a teacher-inquirer gains access into the thinking of the child or adult being interviewed.

Capturing "thinking" is a challenge for any researcher. One way a teacher researcher captures the thinking that occurs in the school and classroom within his or her own mind is through journaling. Journals provide teachers a tool for reflecting on their own thought processes and can also serve as a tool for students to record their thinking related to the project at hand.

Data collection 8: Weblogs

Similar to a journal, weblogs are another excellent way teacher researchers can capture their thinking as an inquiry unfolds. Weblogs are easily created, easily updateable web sites that allows an author (or authors) to publish instantly to the Internet from any Internet connection. As blogs consist of a series of entries arranged in reverse chronological order, they can serve as a sort of "online diary" where teacher researchers can post commentary or news about the research they are currently engaged in. Unlike the journal as a form of data collection, the teacher researcher who blogs can combine text, images, and links to other blogs as well as post comments in an interactive format. The comment feature of blogs provides the opportunity for teacher researchers to receive feedback from anyone in the world (in an open blog community) or teacher researchers (in a closed community).

Data collection 9: Surveys

Some teacher-inquirers employ more formal mechanisms (such as sociograms and surveys) to capture the action, talk, thinking, and productivity that are a part of each and every school day. The most common formal mechanism we have observed in our work with teacher-inquirers is surveys. Surveys can give students a space to share their thoughts and opinions about a teaching technique or strategy, a unit, or their knowledge about particular subject matter;

Data collection 10:
Quantitative measures of student achievement

In this area of high-stakes testing and accountability, numerous quantitative measure of student performance abound, and these measures can be valuable sources of data for the teacher-researcher.

Data collection 11: Critical friend group feedback

Using multiple sources of data is important. An additional way of data collecting is through critical friend group feedback. Critical friend groups are one version of professional learning communities. A professional learning community is consisting of educators who come together voluntarily at least once a month for some hours. Group members are committed to improving their practice through collaborative learning.

Data collection 12: Literature as data

Although we often do not think of literature as data, literature offers an opportunity to think about how your work as a teacher-inquirer is informed by, and connect to the work of others. No one teaches or inquires in a vacuum. When we engage in the act of teaching, we are situated within a context (our particular classroom, grade level, school, …), and our context mediates much of what we do and understand as teachers. Similarly, when teachers inquire, their work is situated within a large , rich, preexisting knowledge base that is captured in such things as books, journal articles, newspaper articles, conference papers and Web sites. Looking at this preexisting knowledge base on teaching informs your study. All you need to figure out is which pieces of literature connect to your wonderings and will give you insights as your study is unfolding. Teacher-inquirers generally collect literature at two different times.

- When they define or are in the process of defining a wondering and
- As their studies lead them to new findings and new wonderings.

In these cases, teachers use the literature to become well informed on what current knowledge exists in the field on their topic. Literature is an essential form of data that every teacher-inquirer should use so as to be connected to, informed by, and a contributor to the larger conversation about educational practice.

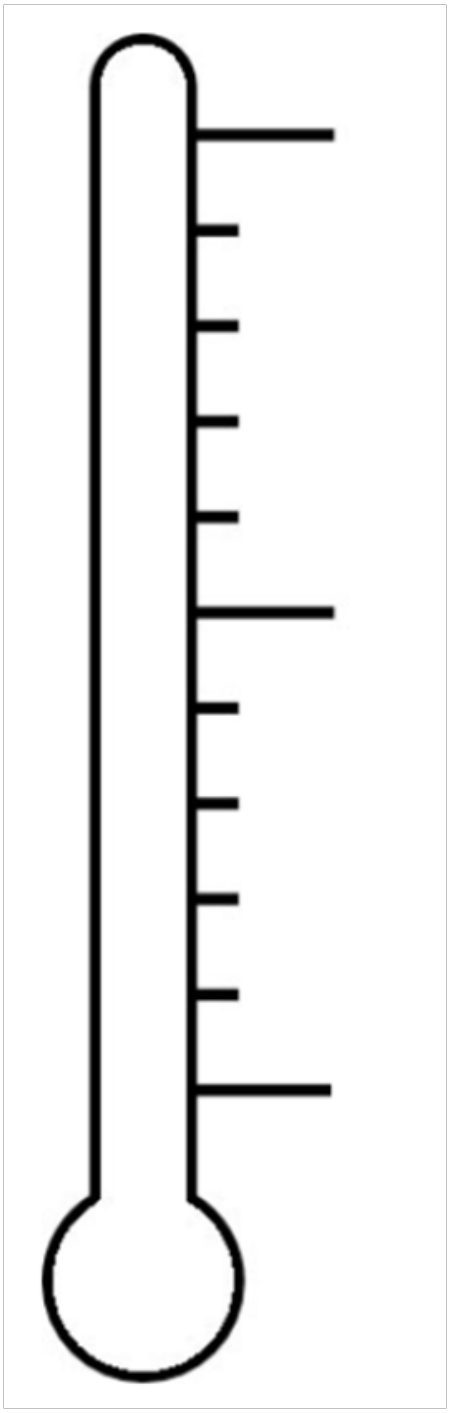
Barometer

Questions:

A. How do you value today's session?

B. Scale what impact this session will have on your work?

C. Scale you participation in today's session?



Tom Lonergan`s Inquiry Plan

Outline the background and motivation for your inquiry (this should link to your passion)

The purpose of my inquiry is to improve my practice and my student's learning. I want to adopt good teaching strategies when teaching students how to design experiments. I want to use more inquiry based approaches as I've read and learned that taking this approach helps to develop students skills as well as content and conceptual knowledge. I've limited experience using inquiry approaches so I want to enhance my practice in this regard too. Finally, I want to increase students interest and motivation when learning science.

My Inquiry Question

My inquiry question is:
How can I develop my students confidence and experimental design skills in an inquiry science classroom at Junior Certificate Level?

What data will I collect?

Literature
My Field Notes
Examples of Student Work
Pictures
Student Survey
Student Christmas Exam Results

What is my implementation plan (include timeline etc.)

My approach will be to give students a challenge question in which they have to plan an experiment that deals with reaction rates. I'm adapting this from the SAILS EU project. For the task I will give my students the following challenge:

> *I'm usually in a rush in the morning and I want my vitamin drink to be ready as quickly as possible.*
> *Carry out investigations using one vitamin C table per experiment with 100 mL of water to make the reaction go to completion as fast as possible.*
> *Keep notes on the factors that make the reaction go more quickly*

I'm interested in students understanding, planning skills, engagement and confidence. I will deliver the session in one double class. I will get students to complete a survey after the class as well.

This inquiry will take place in one double class period and students will also complete a survey. It will take place in the term after Christmas.

Overview of Tom`s Data Collected

See Tom's data folder:
https://drive.google.com/drive/folders/1rxw2BsaiGfh4uPGe7zvhvWdHEv9tdQ9N

1. **Literature**
   a. 3 Papers
      i. THE BSCS 5E INSTRUCTIONAL MODEL AND 21ST CENTURY SKILLS
      ii. Inquiry Based Science Instruction - What is it & Does it matter?
      iii. Mentoring students towards Inquiry
   b. SAILS EU Project

2. **My Field Notes**
   a. I decided to focus on three aspects linked to my wondering so took notes on students understanding, students' planning skills and their engagement and confidence.

3. **Examples of Student Work**
   a. Samples of three groups which represents 9 students

4. **Pictures**
   a. Some pictures of students working on the task

5. **Student Survey**
   a. This was a survey with 8 questions

6. **Student Christmas Exam Results**

Tom`s field notes

My field notes on the inquiry Reaction Rates Experiment

Students Planning Skills

- Some groups are just sitting there not sure where to start.
- Some groups have started without making a plan.
- They're looking at the equipment and using that to decide what to do.
- Some groups are making detailed plans and talking though them.
- Only a few are using tables – Mass of tablet not considered.
- Write ups are messy.
- not all using fair tests.
- UNITS!!!
-

Student Engagement and confidence

- Most really engaged!!! Good Energy in the room.
- Some sitting back and letting others do the experiment.
- I'm not sure if all did the planning???
- Are some overwhelmed?

Student Understanding

- Some are getting the concept of surface area after probing.
- They realise heat has an influence but I need to probe more to see if they understand why it influences rate.
- little use of scientific language.

Sample of student work

GROUP NAMES: A, B, C .

CHALLENGE

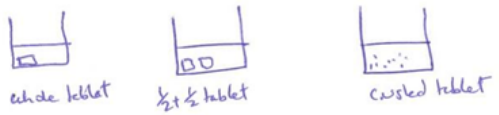
I'm usually in a rush in the morning and I want my vitamin drink to be ready as quickly as possible.

Carry out investigations using one vitamin C table per experiment with 100 mL of water to make the reaction go to completion as fast as possible.

Keep notes on the factors that make the reaction go more quickly

---

Exp 1



Exp 2.

	Tablet	Time	Temp	Water
Exp1	whole	2.37	cold	100mL
	½+½	2.15	Cold	100 mL
	crushed	1.35	Cold	100 mL
Exp2	whole	2.37	Cold	100 mL
	whole	2.05	medium	100 mL
	whole	1.48	Hot.	100 mL

We found that how hot the water is and the size of the tablet changes how fast you can make your drink

GROUP NAMES: D, E, F

CHALLENGE

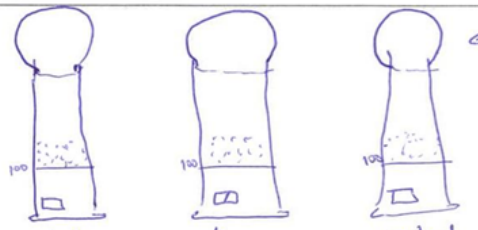
I'm usually in a rush in the morning and I want my vitamin drink to be ready as quickly as possible.

Carry out investigations using one vitamin C table per experiment with 100 mL of water to make the reaction go to completion as fast as possible.

Keep notes on the factors that make the reaction go more quickly

---

Exp 1



← balloon (gas)

100cm³ in all cylinders

Whole
2.70s

½
2.10s

crushed.
1.50s.

Exp 2. We will do same as above but change water temp.

① 2.20s
② 2.01s
③ 1.45s.

GROUP NAMES: G, H, I.

CHALLENGE

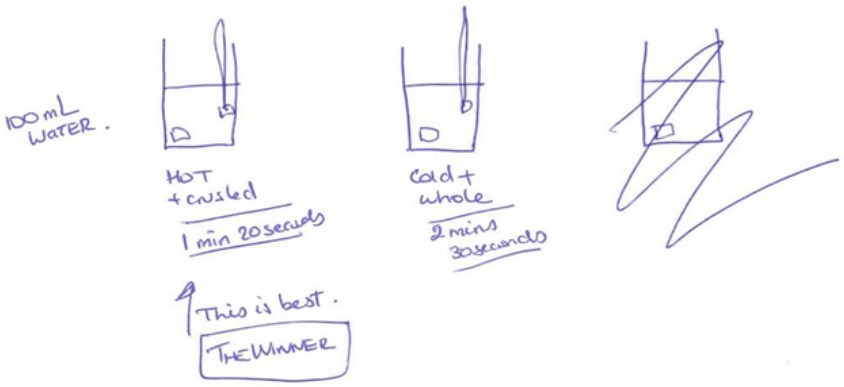
I'm usually in a rush in the morning and I want my vitamin drink to be ready as quickly as possible.

Carry out investigations using one vitamin C table per experiment with 100 mL of water to make the reaction go to completion as fast as possible.

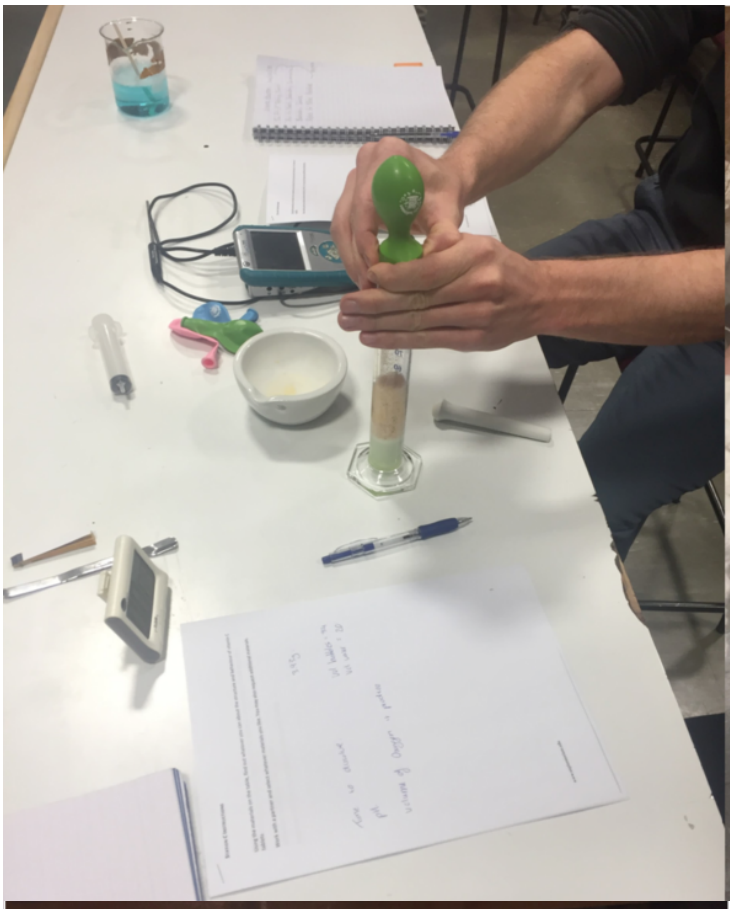
Keep notes on the factors that make the reaction go more quickly

---

Experiments 1 + 2 change tablet size and water temp.



Pictures of in-class activities



Reaction Rates Student Survey

Name: A **Date:** Sep 2017.

1. What did you do to try to solve the challenge? Explain what you and the group did first.

We talked about how a vit c. tablet works and made a plan to do two experiments. I suggested changing the water temp. We didn't start until the plan was complete.

2. What was the most challenging aspect of this task?

Planning and doing everything on time

3. How many variables did you test?

2. temperature & surface area.

4. How many variables did you test at a time?

1

5. How did you ensure that your tests were fair?

Yes, we talked about this and made sure we used 1 tablet for all, the same water, and the same end point.

6. Did you like having to design the experiment yourself? (YES) NO
Please explain your answer.

I liked having responsibility and others listening to my ideas.

7. What science did you learn by completing the task?

the speed of the exp is changed by temp and surface area.

8. Would you like to do more experiments where you are given a challenge? (YES) NO
Please explain your answer.

I liked having to do this.!

Reaction Rates Student Survey

Name: D **Date:** September 2017

1. What did you do to try to solve the challenge? Explain what you and the group did first.

We planned our experiment together. We changed the heat and particles of the tablet.

2. What was the most challenging aspect of this task?

Trying to see when the tablet had dissolved. Trying to decide how much the balloon expanded.

3. How many variables did you test?

2 or 3 ? Is gas a variable?

4. How many variables did you test at a time?

One.

5. How did you ensure that your tests were fair?

We set up everything the same.

6. Did you like having to design the experiment yourself? YES (NO)
Please explain your answer.

I was a bit unsure if I was doing it correctly and the teacher wouldn't tell me.

7. What science did you learn by completing the task?

temperature + heat changes reaction speed.

8. Would you like to do more experiments where you are given a challenge? YES NO
Please explain your answer.

maybe, but with a little more help.

Reaction Rates Student Survey

Name: G. **Date:** 2/4/2017

1. What did you do to try to solve the challenge? Explain what you and the group did first.

We started playing with the equipment and tablets and discovered it dissolved quicker when broken up so did an exp. with that and heat.

2. What was the most challenging aspect of this task?

It was easy enough.

3. How many variables did you test?

2

4. How many variables did you test at a time?

2

5. How did you ensure that your tests were fair?

Same set up

6. Did you like having to design the experiment yourself? (YES) NO
Please explain your answer.

It's grand, I liked trying things.

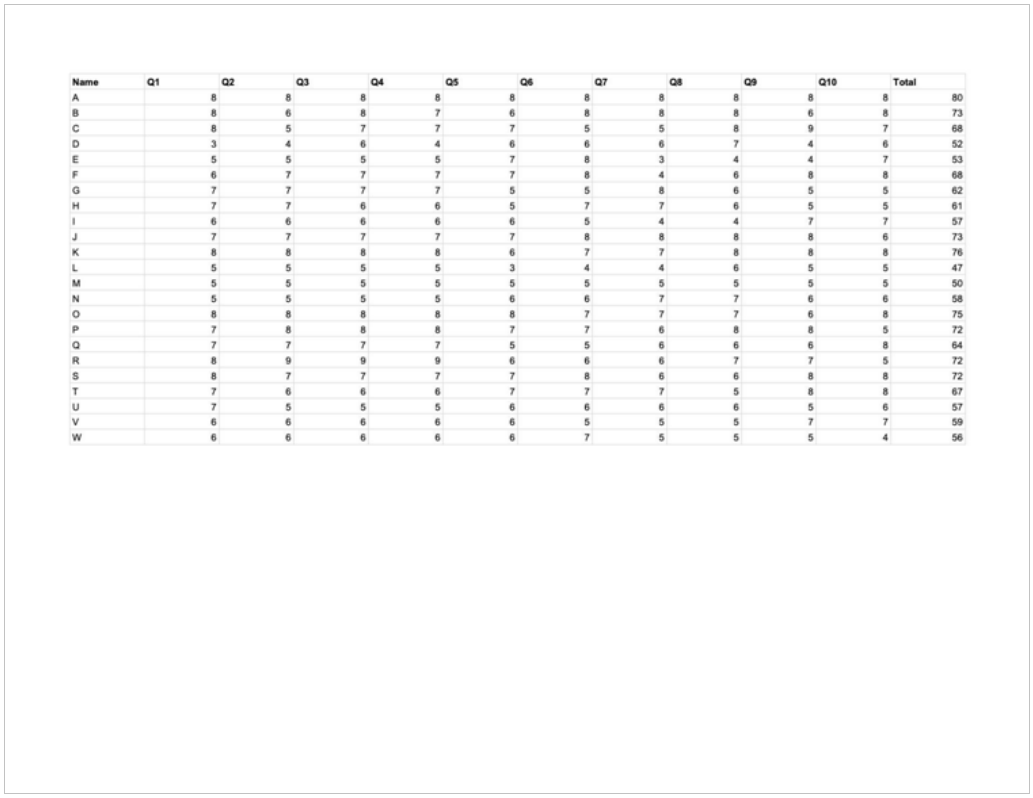
7. What science did you learn by completing the task?

A crushed tablet in hot water makes the fastest drink.

8. Would you like to do more experiments where you are given a challenge? (YES) NO
Please explain your answer.

It's fun trying to beat the other groups.

Christmas results



Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
A	8	8	8	8	8	8	8	8	8	8	80
B	8	6	8	7	6	8	8	8	6	8	73
C	8	5	7	7	7	5	5	8	9	7	68
D	3	4	6	4	6	6	6	7	4	6	52
E	5	5	5	5	7	8	3	4	4	7	53
F	6	7	7	7	7	8	4	6	8	8	68
G	7	7	7	7	5	5	8	6	5	5	62
H	7	7	6	6	5	7	7	6	5	5	61
I	6	6	6	6	6	5	4	4	7	7	57
J	7	7	7	7	7	8	8	8	8	6	73
K	8	8	8	8	6	7	7	8	8	8	76
L	5	5	5	5	3	4	4	6	5	5	47
M	5	5	5	5	5	5	5	5	5	5	50
N	5	5	5	5	6	6	7	7	6	6	58
O	8	8	8	8	8	7	7	7	6	8	75
P	7	8	8	8	7	7	6	8	8	5	72
Q	7	7	7	7	5	5	6	6	6	8	64
R	8	9	9	9	6	6	6	7	7	5	72
S	8	7	7	7	7	8	6	6	8	8	72
T	7	6	6	6	7	7	7	5	8	8	67
U	7	5	5	5	6	6	6	6	5	6	57
V	6	6	6	6	6	5	5	5	7	7	59
W	6	6	6	6	6	7	5	5	5	4	56

Poster examples from 3DIPhE

Beata Swider (PL)
Malgorzata Szymura (PL)
Špela Gec Rozman and Špela Povše Pistotnik (SLO)
Natasa Jelen (SLO)
Uros Medar (SLO)
Peter Bosman (BE)
Rita Deraedt (BE)
Guy Meldert (BE)
Deirdre O'Neill (IRL)
Michael Doran (IRL)

Example program of a local multiplier event

Day 1 (evening 17:30-20:00)

	Activity	Time
1	Coffee and registration	10
2	Introduction to project and coming event	20
3	Plenary of posters 2 mins each from each PLCT teacher (no questions)	30
4	Posters Round 1 (Group Tour) (3 posters per station max)	45
5	Group round table discussion, facilitated by coaches, on doing PI as part of a PLC (Flip charts for each question , 1-5) 1. What is the impact of doing a PI for a teacher? 2. What is the impact of doing a PI for student learning? 3. How does a PLC support a teacher doing a PI? 4. What advice would you give to a teacher starting a PI for the first time? 5. Open questions/advice from the group	20
6	Reporting back from round table discussion (combined flip charts on the wall)	10
7	Certifications and Photographs	10

Day 2 (10:00-16:30)

	Activity	Time
1	Introduction to day	10
2	10.10 Posters Round 2 (Group Tour) (3 posters per station max)	30+15
3a	10.55 Inquiry Based Learning and its use in the second level science and mathematics classroom (Parallel Session)	45
	11.40 Coffee	15
3b	11.55 Inquiry Based Learning and its use in the second level science and mathematics classroom (Parallel Session)	45
	12:40 Lunch and Posters Round 3	40+20
4a	13.40 Practitioner Inquiry and how it enables teachers to examine their own practice in the context of a professional learning community	45
	14.25 Coffee	15
4b	14.40 Practitioner Inquiry and how it enables teachers to examine their own practice in the context of a professional learning community	45
5	15.25 Overview of 3DIPhE project outcomes - Education Design Research as a framework for design and evaluation of professional learning	30
6	15.55 Post-Survey and advertise final courses and conference	20

Focus Group Discussions with PLCTn and PLCTe (directly after lunch)

4a	**13.40 PLCTn + Post Survey + Cleanup of posters**	60
4b	13.40 PLCTe + Post Survey + Cleanup of posters	60

PARTNERS IN THE PROJECT:

KATHOLIEK ONDERWIJS .VLAANDEREN

DCU Dublin City University

artevelde university college ghent
MEMBER OF GHENT UNIVERSITY ASSOCIATION

University of Ljubljana
Faculty of Education

JAGIELLONIAN UNIVERSITY IN KRAKÓW

UC Leuven Limburg
MOVING MINDS

National Education Institute Slovenia