



Jagiellonian University Poland Case Study

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Introduction

This case study reports on the implementation of a professional development course for second level science teachers facilitated by partners from Jagiellonian University (UJ) Poland. The course, which is part of the second iteration of the Three Dimensions of Inquiry in Physics Education (3DIPhE) Erasmus+ programme was designed to develop teacher's competencies and understanding of Practitioner Inquiry (PI) and Inquiry Based Learning (IBL) through engagement in a Professional Learning Community (PLC) of teachers.

Context and background

Two groups of teachers participated during the second iteration of PLCTs at UJ - a group of novice teachers (PLCTI2n) and a group of experienced teachers (PLCTI2e) that had participated in the first interaction. The PLCTI2n course began in April 2019 and consisted of 36 workshop hours delivered over six workshops held on Saturdays. All of the PLCTI2n teachers came from different schools. Half of the PLCTI2n teachers lived in Krakow city and the other half of the teachers lived and worked in small towns or villages outside of the city and travelled for the course workshops, with travelling times between 1.5 - 9 hours each way.

The UJ PLCTI2n group of teachers began with eight participants (seven females and one male), four of the teachers were teaching physics, one was teaching physics and informatics, one was teaching physics and chemistry, one was teaching biology, and one (the male teacher) was a pedagogical advisor. During the course three female teachers of physics resigned at different stages and for different reasons, and after the second PLCTI2n meeting one more physics teacher working with learners with special needs joined the group. So at the end of the second iteration, the group of novices consisted of six teachers. Three teachers from the final group of six teachers had already been involved in the European SAILS project and one had participated in national Akademickie Centrum Kreatywności (ACK) project, so all four of them had been familiar with Inquiry-based Learning (IBL) method prior the beginning of 3DIPhE course. The other teachers had never heard of IBL. These teachers had heard about PI for the first and only time during the 3DIPhE Multiplier Event in March 2019 (eight participants) and the First Congress of Physics Teachers (two participants). So all of these teachers were motivated to join the project by the presentations from coaches and teachers from PLCTI1.

In April 2019, when the PLCTI2n course started, the educational system in Poland comprised of schools at three educational levels: primary school (six grades, ages 7-13, compulsory), lower secondary school (three grades, ages 13-16, compulsory) and upper secondary school (three grades, ages 16-19, not obligatory). However, during the 2018/2019 school year, the Educational System in Poland underwent reform to include a new grade, 7th grade, in the primary schooling system. When the PLCTI2n continued in the school year 2019/2020, the lower secondary schooling level ceased and since this school year the Educational System in Poland comprises of only two levels - primary school (eight grades, ages 7-15, compulsory) and secondary school (four grades, ages 15-19, not obligatory). As a consequence, many teachers in Poland, including the novice teachers in PLCTI2n, had to change schools or to prepare their teaching for extended grades in their school over Summer 2019. Thus the same teacher might report working in A type of school in the Baseline Pre-survey, but work in a B type of school in the subsequent school year.

Nine participants were involved in the second iteration, one teacher was employed in a primary school, three teachers were employed in lower secondary schools, two others at upper secondary schools and two others were employed in both types of schools. All of the teachers worked in mixed-gender schools. One participant was a former physics teacher currently employed as pedagogical advisor. Two of the teachers taught just physics, while the others all taught physics along with other subjects, e.g. computer science and mathematics, computer science and technology, chemistry and science or computer science. One of the teachers did not teach physics at all and was a biology, chemistry and computer science teacher.

The teaching experience of five of the teachers was longer than over 20 years, for two others it ranged from 11 to 20 years and one of them had less than 10 years of school work experience. The final group consisted of five women and one man. One teacher worked in primary school, two of them in lower secondary school, one in both, the lower secondary and high school and two others only in the high school. It is worth mentioning that this description was valid only at the time of filling out the baseline questionnaire, since two months later the lower secondary schools stopped due to the educational reform in Poland as noted previously.

The participants reported that during the lessons they tried to show the context of phenomena they talked about. In their work, the teachers used experiments, demonstrations, group work, lecture, brainstorming, computational tasks, individual work and multimedia materials. The challenges indicated by the teachers when teaching physics included:

- not enough equipment for doing experiments in the school
- no time to prepare experiments before the lesson (a demand for taking break-duties between lessons)
- overloaded curriculum, too few physics hours per week
- lack of students' motivation
- lack of adequate equipment to conduct high-level experiments

All teachers agreed that it is important to use practical activities during lessons, however one of them expressed that they did not feel comfortable implementing practical activities. Most of the teachers understood what was meant by Inquiry-based Learning (IBL) but reported that they did not use IBL method regularly. Only two of them answered that they were confident using IBL during lessons. All respondents were strongly motivated to try different or new approaches to teaching. Only two teachers agreed that students learn content knowledge when they take part in IBL activities, all other teachers were not sure about it. Six teachers were sure that their students develop skills and competences during IBL lessons. All teachers strongly agreed that students are very much motivated to learn when they design their own experiments, draw their own conclusions and collaborate. Only one teacher disagreed that students were more motivated to learn when they analysed their own data.

The teachers indicated that they regularly self-reflected on their practice but they were not sure if they were able to identify effective teaching approaches. Only three of them admitted that they encouraged peers to give feedback on their teaching. In general they did not ask students for feedback on their teaching. Five teachers believed that their inquiries into their own practice could inform and support other teachers in their practice and be helpful at school level.

In this case study a detailed overview of the course and facilitator reflections will be presented. It will also provide a rationale for some of the course activities which will be supported by learnings from the first iteration of the 3DIPhE project.

Overview of Course

The PLCTI2n course was led by two coaches from 3DIPhE project, one employed at the faculty and one being a PhD student. PLCTI2n was the second group of teachers that these coaches facilitated in PI and development of a PLCs. One coach had a 13y experience in carrying workshops on IBL with teachers and pupils at all levels of schooling, including training in three European projects: Fibonacci, SAILS and Akademickie Centrum Kreatywności (ACK). Both coaches participated in C1 course in PI for coaches provided within the 3DIPhE project and one of them additionally participated in two other courses on PI carried out in Linpilcare ERASMUS+ KA2 project. All teachers participated in the meetings voluntarily, during their free time on Saturdays. In fact they preferred workshops on Saturday to workshops on other days, because most of them had to travel a long distance to participate in the project.

Workshop Details	IBL	PI	PLC
WS1: Duration 6 hours (7 participants) 1. Introduction to 3DIPhE (project process, aims and objectives) 2. Quick presentation of yourself - teachers and coaches 3. Presentation: <i>Farming vs Gardening</i> 4. Protocol: <i>Farming vs Gardening</i> 5. Protocol: <i>Passions protocol</i> (development of PI) 6. Wonderings ripped by passions- list of 8 7. Presentation: <i>Introduction to IBL</i> 8. Physlets and Tracker Workshop	 ● ●	 ● ● ● ●	 ● ●
WS2: Duration 6 hours (7 participants) 1. Baseline Questionnaire 2. Protocol: <i>Compass Points</i> 3. Presentation: <i>Research in PI</i> 4. Protocol: <i>Choosing the right question</i> 5. Peer review of research questions 6. Survey on Tracker Workshop 7. Inquiry - in short 8. IBL module - Spectroscope - presentation 9. IBL module - Spectroscope - unit	 ● ● ● ●	 ● ● ● 	 ● ●
WS3: Duration 6 hours (8 participants) 1. Professional Learning Community - survey 2. Protocol: <i>Consensogram</i> 3. Two dimensions of Inquiry - presentation 4. Protocol: <i>Litmus Test</i> 5. Mind map 6. IBL module - Friction 7. Developing IBL skills - part 1: Brainstorming presentation 8. Protocol: <i>Developing IBL skills - part 1 : Brainstorming</i>	 ● ● ●	 ● ● 	 ● ●
WS4: Duration 6 hours (6 participants) 1. Quick presentation of your professional activities 2. Data collection in PI - presentation 3. Protocol: <i>Easy ways to collect data</i> 4. Analysing Data of IBL Class observation - activity 5. Protocol: <i>What? So what? Now what?</i> 6. Designing your PI plan 7. Peer review of PI plans - 1 8. Development of IBL unit - presentation 9. Developing IBL skills - part 2&3: Formulating a research question & designing an IBL experiment - presentation 10. Protocol: <i>Developing IBL skills - part 2: Formulating a research question</i> 11. Protocol: <i>Developing IBL skills - part 3: Designing an IBL experiment</i>	 ● ● ● ● ● ●	 ● ● ● ● ●	 ●

<p>WS5: Duration 6 hours (6 participants)</p> <ol style="list-style-type: none"> 1. Protocol: <i>Data Driven Dialogue</i> 2. Qualitative Data Analysis 3. Fine-tuning your PI plan 4. Peer review of PI plans - 2 5. Practicing IBL - inspirations for IBL units 6. IBL assessment tools - presentation 7. Protocol: <i>Developing IBL skills - part 4: Evaluation at the IBL</i> 		<p>●</p> <p>●</p> <p>●</p>	<p>●</p>
<p>WS6: Duration 6 hours (5 participants)</p> <ol style="list-style-type: none"> 1. Teacher presentations. Critical friends' remarks during and after each presentation. 2. Teacher posters. Critical friends' remarks during and after each poster presentation. 3. Self-reflection Tool for Professional Development in IBL Teaching 	<p>●</p>	<p>●</p>	<p>●</p>

For further details on the protocols referred to in the workshops please refer to Appendix B.

Analysis and Reflections on Training Delivery

Workshop 1

Which elements of the workshop do you believe contributed most effectively to the purpose of the workshop?

After a short introduction to the 3DIPhE project teachers briefly presented themselves to each other. Then in order to give the initial feeling about the PI, the *Farming vs Gardening* protocol was implemented. Teachers did not appear to have any difficulties in collaborating in groups. They discussed the issue promptly and together agreed on features of different kinds of crops. This simple protocol, depicting one of the goals of the project, helped to launch a PLCTI2 of novices and gave a boost to collaboration that would be very important in the next stages of the project. Subsequently the Passion protocol was provided to the participants. Although having some doubts about just one right choice, teachers quite quickly came to the conclusions of what would be the driving ideas of their inquiries in the 3DIPhE project.

Almost half of the teachers had previous contact with the IBL method, e.g. in the SAILS project, so only a short presentation on IBL cycle and levels was given during the first workshop. Subsequent *Physlet* and *Tracker* activities were organized. Tracker allows the use of ICT in teaching physics, which can be helpful even in classes that are not focused on science. It can also be used practically at any level of education. The workshop was delivered by a guest from the USA, co-author of Tracker and Physlets. It turned out to be surprising and very interesting for every participant, although some teachers struggled at the beginning with lack of their ICT competences and English (the report on delivery of the Physlet workshop was published in the article, Teaching with Physlets (Christian et al., 2020).

Which elements of the workshop would you change if you were to repeat the workshop?

We would prepare teachers in advance for the ICT workshop with a foreigner tutor. Most of them enjoyed and appreciated the workshop, but some of them struggled with English and/or lack of their own ICT skills.

What design principles for future workshops would you recommend based on your experience.

During the implementation of the *Passions* Protocol, teachers need more time than planned. It should be noted that this is a new perspective and method for them and, especially teachers with many years of teaching experience may have a problem defining their passions.

We would recommend to devote time to all three parts: building PLC, designing PI and developing IBL teaching competences in every workshop. That approach was already proposed in the Case Study on PLCTI1, as a result of our experience during the first iteration, however in PLCTI2 group of novices it could be fully implemented over all workshops.

Overall reflections

For the group of teachers participating in PLCTI2n, the purpose of the 3DIPhE project, its purposes and requirements were slightly more clear than for the PLCTI1 group. The reason might be that they had a chance to attend a conference summarizing the first iteration of the project. They saw examples of teachers' research projects that could be conducted in a Polish classroom. Still, many teachers were not aware of the huge number of small tasks they would have to go through during the course. They probably did not expect that during the course they would have to look at their work from many different perspectives. We observed that the group was well established from the very beginning. No one was left alone or showed up as a leader. The group started as a community of equal colleagues, willing to learn from each other.

Workshop 2

Which elements of the workshop do you believe contributed most effectively to the purpose of the workshop?

The meeting started with the baseline questionnaire session. Afterwards the compass points protocol was proposed as one of the steps for building the PLCT. Subsequently the coach presented an overview of the research in PI and the *Choosing the right question* protocol was implemented. After a break teachers peer reviewed their research questions, giving critical but friendly remarks and advice. The part on IBL started with the survey on Physlets and Tracker activities held in the previous meeting. Subsequently a short presentation on IBL was given and the teachers went through the IBL module on spectroscopy.

Which elements of the workshop would you change if you were to repeat the workshop?

We would provide the baseline questionnaire during the first meeting. Similarly to the course in iteration 1, we did not manage to administer this survey, however due to a different reason. It was not possible in this course, since during the first meeting the *Physlet* and *Tracker* session took quite a long time, but, definitely, it is better if the baseline survey is administered as soon as possible.

What design principles for future workshops would you recommend based on your experience.

Choosing the right question is a process, and not the result of a one-time protocol. Teachers need to get the message that this first approach does not bring them the final PI research question and that it does not even have to. Teachers should take this first research question with them and should be given time of a month or two to think it over and adjust it to their own practice after a few steps of reconsideration. They need to be reminded that the research question should relate to the implementation of IBL. This approach had already implemented the course in iteration 1, and since it had worked, it was repeated in iteration 2.

Overall reflections

The group started to build up very quickly. It was obvious that teachers wanted to collaborate and help each other. Teachers did not oppose any of the activities. One could feel the atmosphere of pursuing a common goal. An exemplary IBL unit was implemented as a starting activity for the part of the course about developing skills in teaching IBL, upcoming during the next meeting.

Workshop 3

Which elements of the workshop do you believe contributed most effectively to the purpose of the workshop?

As the warming up activity a *Professional Learning Community* survey was implemented, followed by the *Consensogram* protocol related to this survey. The use of the Consensogram protocol allowed us to better understand the entire group and identify the problems teachers are confronted with in their schools. It is also a great tool for headmasters, who would like to know some details about the functioning of their schools. Teachers indicated that there was a lot of discussion in schools, but unfortunately not much about teaching itself, and not about problems or doubts related to it, but almost all is devoted to behaviour and pedagogical topics related to students. The problem is also that in schools it happens quite often that only one person teaches physics. Teachers do not really have time to talk to each other. The participants took up a long discussion about what it meant "high level" in relation to students. All agreed that it was very important to focus on particular students and their abilities. Teachers realized that one of many ways of carrying out a PI was to focus and do research concerning just one student. Teachers agreed that yet another problem was quite common - there was no time for an individual approach with a student. Teachers in Polish schools unfortunately do not make joint plans, e.g. in the field of STEM subjects. They do not have common materials. Common or related topics (e.g. in mathematics vs. physics) are not discussed interdisciplinary. Participants also raised a problem of teachers not interested (in general) to take part in workshops and conferences outside the school, and that individuals who decided to do so (like 3DIPhE participants), were often treated with a reserve in their schools. Teachers also noticed that it was very difficult to admit in front of other teachers that you had a problem or you did not have the idea how to deliver a topic. This long discussion helped to consolidate the PLCTI2 a lot.

After a short break a presentation *Two dimensions of inquiry* was given by one of the coaches to show similarities and differences between PI and IBL cycles. Subsequently the *Litmus Test* protocol was implemented. It occurred that many of the teachers adjusted or changed their PI research questions afterwards.

As an example of an IBL unit, the Friction module was implemented. At the end of the meeting the first part of *Developing the skills in teaching IBL* sequence of activities, namely the *Brainstorming* protocol, was implemented.

Which elements of the workshop would you change if you were to repeat the workshop?

During implementation of the *Consensogram* protocol based on the *Professional Learning Community* survey, the facilitator needs to be particularly restrictive about keeping the time. It turns out that analyzing the results in this protocol is quite exciting and engaging for teachers. They willingly share their experiences and describe different situations from their schools, which can easily turn out into a never-ending sequence of life examples. However these particular activities contribute enormously to the building of PLCT, so the time devoted for the discussion cannot be too short either.

What design principles for future workshops would you recommend based on your experience.

It occurs that development of skills for teaching in IBL may not be based only on examples, even if these exemplary units are implemented in practice during the workshop and teachers engage in them playing the role of students. Coaches realized that at the end of the course in iteration 1, coming to the conclusion that it was also necessary to go with teachers through different elements of the IBL cycle, by making them take the role of IBL teachers and unit designers. It should be done in 4-5 steps. This way teachers have a chance to understand and “sense” the IBL method in portions.

The first step in such an approach is to ask the teachers to lead the brainstorming around a certain topic. It turned out that even those who declared in the survey that they conducted lessons in the IBL method, might have problems with the proper start of the IBL cycle. Asking students the right question and being a good leader during brainstorming could be a crucial step influencing the process of the next steps in the IBL cycle.

Overall reflections

By conducting the *Consensogram* protocol which related to the questions about mutual support at the school level, teachers better understood the need to belong to a PLC group and why PLC is so important in the teaching profession. That is why during training it is extremely important to create good relations in a group in which everyone can feel safe and is not afraid to ask or say what they really think.

Implementation of the *Litmus test* protocol on teachers’ PI research questions gave them a new perspective and reassured them in their research question choices.

By playing the role of a teacher and a student alternately, when taking part in the IBL protocol No. 1, teachers not only gained a lot of inspiration and shared their experiences from schools at various levels, but also had a great time. They experienced how hard it was to lead a vivid discussion, but at the same time they admitted that going through it together encouraged them to try to implement the IBL initial brainstorming in their classes.

Workshop 4

Which elements of the workshop do you believe contributed most effectively to the purpose of the workshop?

In this workshop we planned a lot of activities on PI and IBL, so the building PLCTI2 part was quite short and scheduled at the beginning of the session as a warming-up activity. Subsequently a [presentation](#) on data collection in PI was given by one of the coaches. Afterwards a protocol *Easy ways to collect data* was introduced. Two remarks were given by the teachers. For most of the proposed data collection tools teachers pointed out one problem - time allocation.

Some of the teachers, as a part of a research plan in 3DIPhE, took photos during lessons in the trial classes, which turned out to be helpful in creating notes, but also in analyzing the situation in groups. Thanks to the pictures, they could also see the details they were not aware of during the lesson. So they all agreed that taking photos or recording the videos was supportive evidence for their PI, not too much time-consuming.

Since in many PIs the teachers deal with loose comments, observation notes or student responses in open-ended survey questions, we wanted to help teachers get experienced in handling such a sort of data. An activity related to the analysis and categorization was offered to them. The data was a collection of notes taken by the observers of

the lesson conducted in the IBL methodology during some other training prepared by the coaches. It was a very good exercise, showing that the same data could be analyzed from different perspectives, depending on what the teacher wanted to examine. The greatest discussion was carried out by the teachers inventing the names of the main categories for observation instances given to them.

Subsequently the protocol *What? So what? Now what?* was implemented. After a very short round on clarification of the research questions, all participants had ready-to-implement research questions in their hands. We asked them to write down on large sheets of paper their research questions and a general outline of what they would like to investigate and how they want to do research. Each teacher had an idea on how to collect their data, but a short session of critical friends' remarks enabled clarification of the details and resolved the doubts teachers had about their PIs. As data collection tools teachers planned in their projects: observations, photos, surveys, reflection diaries, interviews and tests.

The next stage was a further development of skills in teaching IBL. A short presentation on development of an IBL unit was given and followed by two protocols: 1) on formulating a research question and 2) on designing an IBL unit plan. Teachers worked in two groups. It was observed that teachers had problems with considering students' independence when designing the part in which students were supposed to plan and perform the experiments. Teachers had a lot of doubts about experiments done solely by students, and were concerned about the content knowledge acquired during IBL lessons. An additional problem pointed out was, again, time allocation and curriculum demands. Teachers said that they did not have the suitable equipment at school. While discussing the design of IBL experiments, the coaches tried to propose simple solutions that did not require specialized equipment.

Which elements of the workshop would you change if you were to repeat the workshop?

In this meeting we were a bit too much in a hurry. So the next time we would probably move the protocol on formulating a research question in IBL unit to the previous session.

What design principles for future workshops would you recommend based on your experience.

Delivery of development of all three parts of 3DIPhE teacher training in each training session worked for the teachers, coaches and the purpose of the course.

Even teachers a bit experienced in IBL implementation in their own classes, really appreciated the idea of going step by step throughout the entire IBL cycle with use of a series of protocols developing skills in teaching by inquiry. After this session they admitted that usually they had taken ready-to-use IBL modules and implemented them in their classes, however mastering in IBL teaching should go through a procedure of the design of each part of the IBL module, preferably in collaboration with other teachers. This way teachers shifted from a copy/paste mode to the authorship and thus to the learning ownership mode.

Overall reflections

The PLCTI2 group of novices had greater ease in preparing research questions and research plans compared to PLCTI1. We believe that was so, because this group had seen during the SME several vivid examples of PI research questions and studies implemented by other teachers in Polish school settings.

A lot of data collection methods were elaborated during this workshop. Some teachers might feel overwhelmed with them. We need to remember to remind them all the time that PI is a small-scale study, for which not too many methods of collecting data at the same time are needed. This enables us to get rid of the arguments related to the lack of time.

Teachers need to remember that when they plan experiments with students the care of a fair test should be taken. Learners usually know it, but sometimes it is inevitable that they would like to change different parameters at the same time. Planning an investigation in the IBL process is often the most difficult part for students. And an ill-considered experiment can lead to chaos and discouragement.

Workshop 5

Which elements of the workshop do you believe contributed most effectively to the purpose of the workshop?

This workshop was mostly devoted to presentation and experience of qualitative data analysis and fine-tuning of the PI plans. We started with the data-Driven Dialogue protocol and qualitative data analysis protocol. Subsequently teachers did some last changes to their PI plans on the sheets of paper showing the plans, prepared in the previous workshop.

Some teachers were ready to outline the tools for data collection in their PIs. All of them had already fully or partially implemented these tools and finished collection of data.

UJ-T18 was the only one that came to the meeting with a completed PI and presentation. However she failed a bit with data analysis, most probably because she did it on her own and before it was elaborated during the fifth 3DIPhE workshop. Nevertheless an activity of the feedback given by critical friends allowed her to look at her PI from a different angle and come back on the track. UJ-T11 was already halfway in her PI. UJ-T16 had two PI questions, collected evidence to support both of them, but did not decide which one would be chosen for her final presentation. Since UJ-T15 was not employed at school anymore, he conducted his PI in a class taught by one of the teachers from PLCT1. This situation forced him to change his initial research question. UJ-T17 slightly modified her research question, taking into account remarks from other participants received during the preceding workshop. However she did not start any data analysis yet. UJ-T13 was absent due to private reasons.

During this workshop some of the teachers made substantial changes, some others alternated their plans only slightly. The updated plans were exhibited on the walls for peer review on a forum, which was a very important part of the workshop. Instead of any protocol for building the PLCT we proposed a longer than usual coffee break in a non-formalized format. The IBL part started with a few exemplary investigations provided in a structured IBL as a kind of inspiration, easy to adapt to guided or even open inquiry. Subsequently a presentation on IBL assessment tools was given by one of the coaches. And finally the fourth protocol on developing the skills in teaching with use of IBL was implemented in two groups.

Which elements of the workshop would you change if you were to repeat the workshop?

The idea of prolonged coffee break was good, since the teachers had already established a good, consolidated PLCT. However next time we would like to change this particular activity into a more formalized one, e.g. World Cafe protocol.

What design principles for future workshops would you recommend based on your experience.

It is very much important that care should be taken of the PI of every participant. Each teacher works at his/her own pace and sometimes they get lost at the point where PI seems to be well set. This happened twice per iteration of 3DIPhE courses, so in fact for $\frac{1}{3}$ of teachers in Poland. However if the PLCT is well consolidated by the moment the teachers should have their plans almost ready, the rest of the group willingly helps those lagging behind in a

constructive manner and a friendly atmosphere. Indeed, in both PLCTI1 and PLCTI2 groups of novices, after the fifth workshop all teachers felt secured and ready to complete their PIs, also those lagging behind just a few hours before. That is why it is so very important that during the four preceding workshops enough time is devoted for building PLCT.

Overall reflections

The activity of peer-review of PI plans turned out to be the most important element of the whole workshop, because, for example, UJ-T18 came to the meeting with an idea that she was completely unsuccessful with her PI already implemented and only during the discussion with peers she realized that actually her PI was very good and the only problem was her misinterpretation of the results. Some teachers during their PI stuck to their own (sometimes very much fixed) expectations and cannot pass the threshold of relying on evidence. Coaches should be aware of that and sensitive to this problem.

The peer-review halfway of PI implementation assured that teachers will meet the goals. Some of them were lost with data interpretation, some others with a choice of the final research topic, yet others - a bit stacked with too much data and constrained by their own expectations. All these issues were solved in a friendly, but still constructive discussion in the forum.

It turned out that PLCTI2 group of novices was more advanced in technical aspects of PI presentations than PLCTI1 group a year before. This was due to the fact that most of PLCTI2 participants taught not only physics but also computer science.

During the activity on IBL assessment strategies teachers pointed out that Polish schools treat formative assessment with a serious self-constraint. Initially in participants' opinion the formative assessment was impossible during the regular classes. Only after explanation that formative assessment needs to be implemented to each student many times over the school year and thus during one lesson only a few students should be assessed this way, most of the teachers agreed that in fact they did it already in their classes, but in a less formal way without use of any specific tools (e.g. rubrics).

Workshop 6

Which elements of the workshop do you believe contributed most effectively to the purpose of the workshop?

That last workshop in the course was almost completely devoted to the PI poster and slide presentations given by the teachers as a rehearsal for their participation in ME6. At this moment the PLCTI2 (novice teachers) were already strong enough to engage in the open discussion on each presentation, giving friendly and constructive advice. So both pillars: PI and PLCT were strengthened in one long activity. We also talked a bit about teachers' participation in ME6 in Poland and participation of the selected teachers in ME4, ME5 and ME7, as well as in the final project conference.

To wrap up the IBL activities, we proposed a self-reflection tool on teaching in IBL adapted from Casulla et al 2012 (Tools for [Enhancing Inquiry in Science Education](#), S.B. Carulla (ed.), pp. 40-43).

Which elements of the workshop would you change if you were to repeat the workshop?

This approach was already repeated twice and it worked for teachers who got more confident in their research results and the format of their presentations, rehearsing in a friendly environment. It also worked for coaches, since watching presentations and having the chance to ask additional questions, they learned in detail about the final results of the PIs.

What design principles for future workshops would you recommend based on your experience.

Presentation of the PI outcomes followed by discussions within the group and with the presenter form together an indispensable part of the course. Teachers learn from each other how to improve the content and the format of their presentation and how to behave like a critical friend. They also get feedback on advancement of their IBL approach in the classroom. Such an approach is a capstone of the entire course based on three core parts - PLCT group building, development of PI competences and development of IBL skills. Being unavoidable, the session encourages teachers to fulfil the project tasks and prepare reports on their PI on time. Inclusion of this presentation session develops also teachers' IT skills.

Overall reflections

After this session some of the issues still remained to be solved, but we got the confidence that teachers understood the PI cycle, fulfilled their PIs in IBL lessons and got interesting results, relevant to other teachers. Participants appeared to the coaches to be ready for giving presentations to the broader audience from the outside of the project.

Participant Reflections on Course

Only six teachers took part in the final survey. All of them agreed that practical work during learning is important and they don't find it difficult for students and their own as facilitators. In their opinion IBL is an effective strategy to motivate students to become interested in physics. All respondents said that they are motivated to try different approaches when teaching and after course they have used IBL more frequently. Teachers, however, are still not fully convinced whether students learn content knowledge when using the IBL method. But they strongly agreed that big impacts on students' motivation to learn physics have: practical work, designing their own investigations, analysing their own data, drawing their own conclusions and during collaboration with others. All teachers understand what is meant by PI, they know how to use it and they plan to do PI in the future. All of them also say that they would recommend PI to other teachers. In the context of group PLC teachers answered that they are open to collaboration in future. All of them felt comfortable working in PLC but one of them said that she wasn't confident in sharing her practice with others. They also said that working with this group helped them to learn about their practice. All teachers would like to lead a PLC in their schools, but they wouldn't like to do that outside of their schools environment. In the open part of questionnaires we asked about activities in the course which were most beneficial in preparing them for PI.

Teachers pointed out, among others:

- practical classes when we discussed and projected PI research questions, methods and analysis;
- presentation plans of research by other teachers was very interesting
- analysis of preliminary PI results with others participants and coaches

Regarding the changes in the general approach to teaching after the course, they have indicated:

- acquiring the ability to construct lessons using the IBL method
- permanent inclusion of IBL lessons in their timetable
- self-realization as a physics teacher
- continuing a self-study
- asking oneself questions like "why" in order to build the basis for teaching
- more independent work of students during lessons
- agreement for allowing mistakes during putting the hypothesis and not correcting them ex cathedra
- giving the students less detailed instructions
- more students' involvement and independence in: brainstorming, discussions, data analysis, design of investigations

Five teachers (UJ-T11, UJ-T15, UJ-T18, UJ-T13, UJ-T17) took part in the Focus Group. Teachers said that above all during the course they learned that they could approach their work in a completely different way than before. The research approach gave them the opportunity not only to verify their work, but also to see the results of other participants. They also learned that one cannot ask himself/herself too many questions at once, and that the question could not be too general. An additional aspect for teachers was learning to cooperate in a PLC and learning interesting ways to integrate the learning community.

When asked about expectations for the course and why they decided to join the PLCTI2 of novices, UJ-T11 replied: *I didn't really know anything because I only got a leaflet during the First Congress of Physics Teachers in Łódź and I just wanted to know more.* Other teachers decided to join the second iteration after the final conference, at which teachers from PLCTI1 presented their research. UJ-T13 added that despite the fact that she had already experienced IBL beforehand, it was important for her to motivate herself from time to time by participating in IBL workshops again. And *meetings with creative people are very helpful.*

Regarding the format and the method of conducting the course, as well as changes proposed to the course delivery, the teachers replied that both the format of the course and the way of delivery was appropriate for them. The positive aspects also included: the atmosphere and meeting dates tailored with care of each participant (via Doodle).

Everyone admitted they felt good in the group. They were pleased that everyone was given enough time to speak, express themselves and receive merit comments about their questions or doubts. It was important that the UJ-T18 joined the group (although a bit later) and yet, as she said, she was very well received. One teacher added: *Thanks to the use of protocols, it was easy to make contact among participants after the workshops.*

In the subsequent part of the conversation, teachers were asked how they understood the approach based on PI and what pros of conducting such a research they could indicate. UJ-T11 said that such an approach was missing in their work earlier. However, the teachers also noticed that it was an additional difficulty to work on soft skills to which they were not accustomed. The teachers also agreed that thanks to the project they changed not only the way of conducting lessons, but also their attitude to teaching. Everyone thought PI could have a good effect on their teaching practice at school. They admitted they could explore some problems globally and find common answers to questions not only related to a specific subject.

Unfortunately, UJ was unable to organize the ME at the end of the PLCTI2 course, but some teachers had the opportunity to attend conferences at other partners' institutions. When asked about their experiences and perception, they answered:

UJ-T11: *It was fantastic, I only regret that this trip was so short that there wasn't much time to talk to everyone about the presented PI research. I learned a lot, I had many questions for each presentation, the conference in Dublin had a chastening effect on me. I am thankful that I could go there.*

UJ_T17: *It was great. The people I met were open and willing to discuss experiences. During the conference, it turned out that in other educational systems the collaboration between subject teachers is a standard and any teacher can consult an expert in their field.*

Among the difficulties encountered during the course, the teachers mentioned: changing the approach to teaching physics, fitting in the 45-minute lesson with IBL approach and PI, asking the right PI question.

Teachers said they would gladly see an IBL lesson in school practice as a part of the course. UJ-T18 added that she would gladly organize one meeting in her school - that the whole group of teachers could go through such a path.

All participants are planning to use PI in their practice. They are also willing to cooperate further not only as part of PLCT but also as coaches. Everyone would recommend the course to other teachers.

Reflections on Multiplier Event

Due to the pandemic of COVID-19 UJ could not organize the Multiplier Event (ME6), since the university was closed a few days before the event was scheduled. All six teachers prepared well in advance for the ME6 in Krakow by preparing posters and short presentations, so all of the participants regretted not being able to present their work to the external audience.

However three teachers from PLCTI2 took part in one of each partner MEs. Two of them presented a poster (UJ-T11 in ME4 and UJ-T5 in ME5) and one of them presented a poster and gave a short presentation (UJ-T17 during ME7).

Teachers willingly participated in workshops and discussions, expressing their opinions and sharing their experiences. For them it was a great opportunity to meet teachers from other countries and learn about their implementation of PI as well as country-specific school settings. One of the teachers (UJ-T11) hooked up with a teacher from Slovenia during ME4 organized in Ireland; they started to plan common activities in the future.

Key Learning and Recommendations for Design Principles:

1. We suggest that all workshops in the course should be devoted to 3 course elements, constituting the 3DIPhE pillars: 1) building the PLCT group, 2) development of PI competences, and 3) development of the competences of teaching with use of IBL.
2. The 3DIPhE course should be dynamic. Time devoted to different 3DIPhE 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, IBL should be addressed not through examples, but in a systematic approach of development of skills in teaching IBL, and for maintaining building the PLCT only short activities may be proposed. At the last stage of the course, activities based on trust and openness built so far in PLCT are proposed (critical friends discussions). At this moment more time is devoted to wrapping up the PI cycle.
3. Care should be taken to a systematic approach to developing skills of teaching in IBL. The method is so demanding that even teachers experienced in IBL should take part in a new activity, serving as a reminder ordering element. In the first iteration of working with the group this part of the workshop can be delivered more in the manner of experiencing different IBL units, taking the role of students. In the second iteration (or in the second part of the first iteration of the course) a systematic approach to develop teaching skills in IBL method should be implemented in a series of protocols.
4. The protocols proved to be useful and effective tools for PLCT group building and development of PI skills in teachers. We suggest that the time anticipated in protocols as well as training schedules to be a bit flexible. 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 and PLCT group building, not rigour of the protocols and time.
5. We suggest keeping an eye on the engagement of all teachers. If somebody lags behind, a Skype meeting or phone call to talk one-to-one can be proposed to the teacher. Some teachers need personal refinement of the goals or rules, some others - encouragement. It is better to learn in advance if teachers have enough IT skills to design and prepare the posters and the presentations on their PI.

6. An overall approach from workshop to workshop: "a big steps forward, one small step back to refine the research plan" seems to work the best for the PI development process.
7. Circulation of the materials used in workshops 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.
8. The last workshop devoted to the presentations of the PIs outcomes followed by discussions within the group and with the presenter is an indispensable part of the course. Teachers learn from each other how to improve the content and the format of their presentation and how to behave like a critical friend. They also get feedback on advancement of their IBL approach in the classroom. Such an approach is a capstone of the entire course based on three core parts - PLCT group building, development of PI competences and development of IBL skills. Being unavoidable, the session encourages teachers to fulfil the project tasks and prepare reports on their PI on time. Inclusion of this presentation session also develops teachers' IT skills.
9. The organization of the ME sets a deadline to the teachers and encourages them to work according to the course schedule, not lagging behind at any point. In our opinion the ME the format of: 1) short presentation of the project and its principles, 2) oral presentations given by teachers, 3) coffee break with a poster session, 4) IBL workshops, suits the project best. We would recommend it for the future courses.