The impact of Situated Learning for prospective primary teacher education and for the school

The impact of Situated Learning for prospective primary teacher education and for the school

Marisa Michelini [1,a], Emanuela Vidic [1,b]
[1] *Research Unit in Physics Education, University of Udine, Italy*
[a] *marisa.michelini@uniud.it*
[b] *emanuela.vidic@gmail.com*

Abstract. The apprenticeship and the in-context experience of the pre-service teacher play an essential role in the construction of a professional attitude. The model developed with over 20 years of research during the Physics Education Course (PEC) in the 5 years long Master degree for Prospective Primary Teachers (PPT) at the University of Udine includes situated learning. By means of a process of reflective design and planning of educational paths, the prospective primary teachers implement Teaching Intervention Modules (TIMs) in the classroom and monitor the learning process of children. The preparation, implementation and evaluation of the TIM in real classrooms is carried out within the PEC itself and has produced an institutional interaction between the PEC coordinators and the schools. The perception of 360 in-service teachers on the quality of the implementation of the TIM was collected over three years using a questionnaire probing different perspectives. The opinions collected included those about the role and way of working of the prospective primary teacher, those about the research-based innovation of the path proposals, those about the impact in the specific classroom, those about the teaching style of the host teachers and finally those about the cooperation between schools and university.

1. Introduction

The building of professional competence in prospective primary teachers in Physics Education is a long-standing research problem [1, 2] in which the role of content knowledge is relevant [3]. Recently, research has focussed on how teachers build their identity in relationship with their knowledge [4, 5], taking into account the relationship between practice and beliefs [6, 7]. The influence of the teaching practice on the beliefs and working methods of teachers [8] in particular, are relevant in the strategies used during practice [9] and in organizing the physics teacher's professional development [10].

As European studies show, pre-service teacher education is organized in two main ways: parallel and sequential for pedagogic and subject matter education [11, 12]. Teachers' scientific education in Europe is very often offered in an interdisciplinary form by means of a topic or problem-based approach [13]. Few situations offer education opportunities which take into account the role of the different subject contents in professional knowledge [3-5] or the relationship between knowledge, practice and beliefs in building teacher identity [7-8].

The Physics Education Course (PEC), on 9 cts in the five years Master Degree for Primary Teacher Education [14] of the University of Udine, has been implementing research-based approaches, tools and methods for the qualified professional education of prospective primary teachers (PPT) in Physics Education for over twenty years. Research implementation results during the last 20 years produced the MEPS model [15] which integrates M-metacultural, E-experiential, P-planning and S-situated activities,

in which each part serves to prepare for the Situated experience. Each thematic group of 10 prospective primary teachers plan individually and share Teaching Intervention Modules (TIMs) which are discussed in the Physics Education Course and which are then implemented in the primary classroom by the same trainee teachers [16]. Three important components in the acquisition of competence in science education by trainee teachers are the discussion of content and strategies in research-based educational paths (Metacultural), the personal involvement in tutorials based on key conceptual questions (Experiential) and the process involved in designing, discussing and revising educational paths to be implemented in schools (Planning). The planning process consists of a sequence of discussions and project revisions of the TIM and it helps prospective primary teachers to overcome the limits of fragmentation, to contextualize pedagogical ideas in a coherent content proposal integrated with exploratory activities and to give attention to the development of children's learning. The outcomes of such work produce operative competence, as evidenced by the specific research we carried out [17-21].

The Situated learning (S in MEPS) consists of the implementation of the TIMs revised in real classes and includes the monitoring and analysis of children's learning and outcomes. The responsibility for the implementation and evaluation of the TIM in real classrooms is of the teacher education course PEC itself, but the necessary interaction with school teachers produces also an institutional interaction between the PEC coordinators and the schools.

The analysis and evaluation of each revised TIM by PPTs is one of our research activities towards defining content and methods for professional education of prospective primary teachers and is studied separately [19-21].

Here we focus our attention on the role and impact for the schools, in-service teachers and pupils of the way in which we propose Situated learning for PPT. The perception by the in-service teachers about the role and quality of TIM and on their implementation is relevant for different research aspects, such as, for example: the role of preparation of each TIM, the contents offered, the artifacts used in the Inquiry Based Learning (IBL) explorations, the adopted strategies by PPTs, the contribution of the TIM for teaching/learning innovation and in-service teacher professional development and the cooperation between school and university.

The involvement of the classroom teachers who host the prospective primary teachers for the implementation of each TIM is done by means of a simple application by in-service teachers to a call consisting of the list of offered topics. Each in-service teacher analyses the prepared TIM and decides three possible moments for the activity, so the involved PPT can organize the TIM implementation. The current limit of this method is the lack of preliminary involvement of the in-service teachers in the design of the TIM.

In this paper we focus on the Situated phase of PPT education, describing its preparation, and we analyse its impact on PPTs' professional education. We also analyse the experience of the host schools from the point of view of in-service teachers, by means of a simple multiple-choice questionnaire, completed by 360 in-service teachers on different topics over three years.

2. Situated phase in the MEPS model

In the education programmes for prospective primary teachers, there is an apprenticeship phase which is very important for professional development [22]. However, this phase is generally an activity organized by dedicated tutors of apprenticeship, in collaboration with in-service teachers. The impact of the pedagogic and subject matter education of PPT in apprenticeship is difficult to analyse, due to the lack of involvement of each formative course for PPT in the apprenticeship activity [12, 21] which is often strongly linked to the practice of the host teacher and to the experience of the tutors. As far as we know, no research-based studies have been carried out in this area. Through the MEPS [15] model in the PEC course we promote a research-based perspective to address this need. In fact the Situated phase follows on from the Planning one and the previous Metacultural and Experiential one. The Situated phase becomes, in the MEPS model, a short part of a prepared apprenticeship, both from the point of view of the subject education, as well as from a teaching perspective. This involves in the Planning

phase the reformulation in pedagogical terms of each subject matter topic within the theoretical framework of the Model of Educational Reconstruction (MER) [23]. In conjunction with this, the PPTs attend a series of tutorials (Experiential phase E in MEPS) in order to gain a concrete idea of the inquiry-based learning (IBL) strategy [24]. In the light of that previous experience, in the Planning phase (the P in MEPS) the PPTs are requested to design an educational path, detailing the activities, the strategy and the questions for 2-4 hours in an operative way. The individual design of a topic by each trainee teacher is uploaded on the website of the PEC course and discussed with a group of ten trainee peers in order to produce a common educational path. Each part is elaborated upon by a different member of the group by means of inquiry questions, related activities, active learning proposals and ways to monitor the learning of children. The shared path designs of the groups are then presented and discussed in a plenary held by the PEC coordinators, where all the prospective primary teachers participate in the discussion.

For the trainee teachers the Situated experience represents a moment of growth which comes from the integration of pedagogical aspects in operational activities and offers the opportunity for innovation emerging from educational needs. Reflection on experience in TIM implementation completes the PPT professional education from a research-based perspective and results of previous studies [16-21] offer evidence of that.

The trainee teachers usually prepare two TIMs: the first in an open context of the Conceptual Lab of Operative Exploration (CLOE) using the materials and the proposal of our Games Experiment Ideas (GEI) exhibit [25], which consist of 12 thematic sections with a total of 650 experiments to be explored hands-on, minds-on. The second is done in a normal classroom after the approval in PEC. The activity in CLOE labs is the first inquiry-based learning activity implemented in the context of an exhibit by the PPTs. It fulfils the role of a useful preliminary experience to prepare the implementation of the TIMs in classrooms.

The evaluation of the portfolio of materials developed by PPTs and of the TIM implementation in terms of professional learning outcomes is carried out in different ways and is centred on three aspects:

1. the quality of the final TIM design;
2. the implementation of the TIM (documentation of the activity);
3. the analysis of monitoring data on children's learning.

The implementation in school of each TIM is carried out individually by each trainee teacher and observed by a peer. The list of TIM topics is offered to the local schools and each in-service teacher asks for the implementation of a chosen TIM in a specific class and period/date. The implementation of the single TIM, in relation to the requests of the host in-service teachers, is carried out according to a specific agreement between the Physics Education Course responsible and school teachers. In this way, every year, each prospective primary school teacher operates in a different class within the local area.

3. Research

Our research evaluates in different ways the outcomes for PPT education [16-21]. We believe it important to collect the perceptions of the in-service teachers hosting the trainee teachers. This helps to improve the TIMs through an external evaluation that represents the impact of this research-based teacher training education in schools. This is done through the questions shown in Table 1, implemented in the form of a simple multiple choice questionnaire.

The research sample includes 360 PPTs implementing their TIMs on the three themes of Astronomy, Energy and Sound with children in 360 classes of 275 schools. This research lasted three years and involved 360 in-service teachers, hosting the PPTs.

The research questions are:

RQ1) How do the hosting in-service teachers perceive and evaluate each TIM offered in their classroom activity?

RQ2) How do the host teachers perceive the professional competence of the trainee teacher during the TIM implementation?

RQ3) How does the TIM implementation contribute to the school?

4. Methods

We developed a multiple-choice questionnaire addressed to the hosting in-service teachers to reflect on the initiative offered to schools, that of TIMs prepared by trainee teachers. We collected the information on the initiative that we have re-proposed and examined over the course of 3 consecutive years, on the topics of Astronomy, Energy and Sound, receiving in total 360 responses by the hosting in-service teachers.

The multiple-choice questionnaire consisted of 14 questions in which in-service teachers are asked to express their opinions on the PPT implementation of the TIM and in particular, on the validity of the materials, on time management, on the impact on the teaching/learning activity. The questions are shown in Table 1. Each question was answered using the Lichert scale evaluation (1 to 5 where 5 is the highest score).

The questionnaire was divided into 5 sections (see Table 1). In Section A, the focus is on the perception of host teachers regarding the quality of the TIMs and on the preparation of the trainee teachers, on their ability to deliver the contents clearly using appropriate language, on their competence in children involvement and on their competence in acting on the stimuli coming from children during the teaching/learning process. In Sections B and C of the questionnaire we focus on how much, according to in-service teachers, the prospective primary teachers adopted an inquiry-based approach and how they supported the implemented paths by the preparation and management of valid, rich and content-supporting educational materials. In addition, we look at how the trainee teachers managed the time available in their implementation of the TIMs. For us, it is significant to understand whether the in-service teacher considered the use of time in the articulation of the activities as adequate so as to make the discussion of the topic complete.

Table1. Questionnaire addressed to in-service host teachers on PPT TIMs. Each question was accompanied by a Lichert scale from 1 to 5.

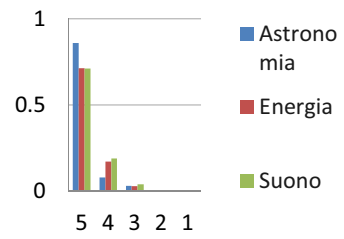
A) PPT in TIM implementation	Q1 Was the PPT adequately prepared?
	Q2 Was the PPT able to treat the proposed contents with clarity and consistency?
	Q3 Was the PPT able to involve children in activities?
	Q4 Was the PPT able to grasp the stimuli elements coming from the pupils?
	Q5 Was the PPT able to use a specific and age-appropriate language for the pupils?
	Q6 Was the PPT able to adopt a strategy in which pupils are actively involved?
B) MATERIALS	Q7 Were the materials used able to encourage curiosity, active role and critical thinking?
	Q8 Were the materials used valid?
	Q9 Were the materials used adequate to support the content presented?
C) TIME	Q10 Was the time managed properly?
D) SATISFACTION	Q11 Was the intervention carried out in accordance with your expectations?
E) EFFECTS ON TEACHING	Q12 Of the new elements introduced (laboratory approach, didactics for artefacts...) did you find any that you intend to introduce in your teaching?
	Q13 Did you find the opportunity to repeat the activities and contents proposed during the TIM implementation or do you intend to do that in the future?
	Q14 Do you think that experimentation has contributed to enriching the pupils' knowledge and skills?

Finally, in Sections D and E, we tried to understand the impact of the TIMs in terms of innovation for the praxis of in-service teachers. From our perspective it is important to know whether in-service teachers intend to adopt explorative experimental methods in their teaching and whether they consider the initiative of TIMs implementation useful and intend to use it in the future.

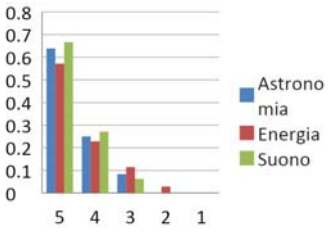
At the end of the questionnaire we also provided a section of open questions in which the host teachers could indicate comments and suggestions. These are discussed in Table 2.

5. Data Analysis

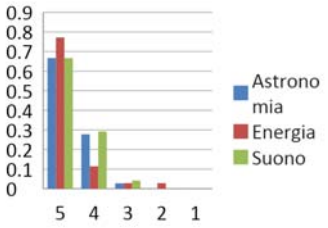
The answers of the host teachers were analysed in a quantitative way for the multiple choice questions and a qualitative way for the open questions. The following data represents the perception of the hosting in-service teachers in terms of the prospective primary teacher's preparation, professional competence, way of interacting with children (A), materials used (B), timing (C), satisfaction (D) and impact on school work (E).



Q1- Was the PPT adequately prepared?



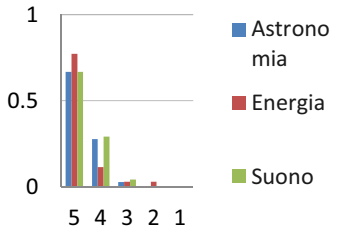
Q2 – Was the PPT able to clearly and consistently explain the concepts involved in the proposed path?



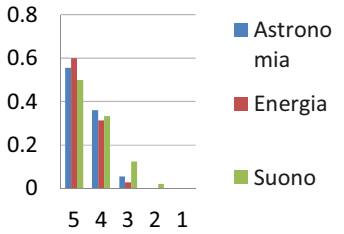
Q3 - Was the PPT able to involve the children in the activities?

Figure 1. Distribution of the answers to the questions Q1, Q2 and Q3

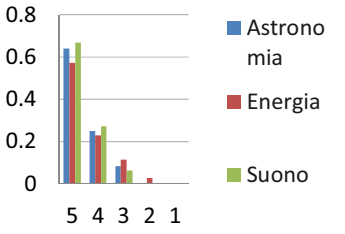
The perception by hosting in-service teachers regarding the PPTs preparation (Q1) is positive in more than 75% of the involved school in-service teachers, with comparable evaluations being given for the three themes of Astronomy, Energy and sound. A good evaluation was also given for language used (Q2) and ability to involve the children (Q3), with around 60 – 70% of host teachers awarding a value of 5.



Q4-Was the PPT able to grasp the stimuli coming from the pupils?



Q5-Did the PPT use specific language suitable for the pupils?

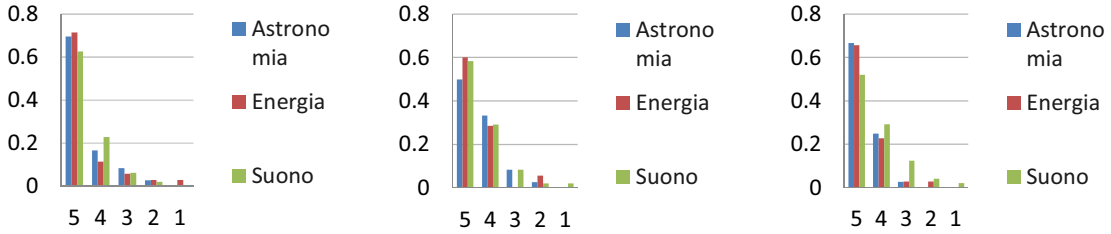


Q6-Did the PPT adopt a strategy in which pupils are actively involved?

Figure 2. Distribution of the answers to the questions Q4, Q5 and Q6

The Ability to grasp the stimuli coming from the children (Q4) is around 65% (see Figure. 2). In particular, concerning the language used, 60% of respondents underline that it was specific to the discipline and appropriate to the age of the children (Q5). A slightly higher percentage, appreciate the amount and quality of experimental activities proposed (Q6).

The Inquiry Based open and flexible approach of the TIMs was welcomed by in-service teachers as an innovative element. They also appreciated the interdisciplinary perspective of the TIMs, the management of the same by the PPTs and the attention paid to monitoring the learning of children which made the improvement evident. The active learning way of working based on engaging pupils in activities, by means of using a range of experiments, was another aspect which was appreciated and considered of great value for the school (Figure 3).



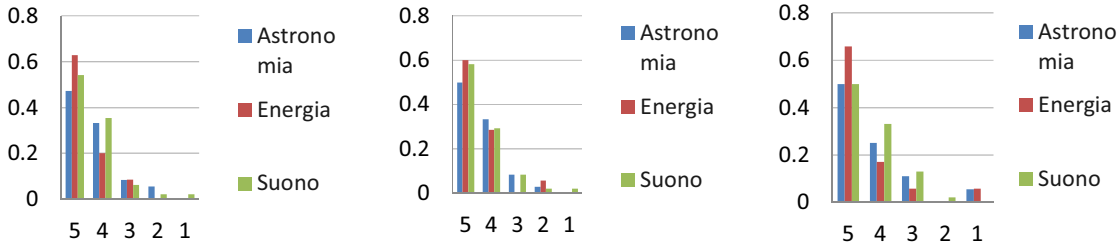
Q7 – Were the materials used meaningfully rich?

Q8 – Were the materials used valid?

Q9 – Were the materials used to support the content?

Figure 3. Distribution of the answers to the questions Q7, Q8, Q9

The simple and everyday materials used by the PPTs during the TIMs (Q7, Q8, Q9) obtained a good evaluation in terms of richness (65%), validity (60%) and support to conceptual learning contents (60%) (Figure.3). The results highlight the acquisition, perceived by in-service teachers, on the part of the PPTs of a way of working which goes beyond the transmissible style of the contents, in favour of engaging active IBL approaches.



Q10- Was the time managed properly?

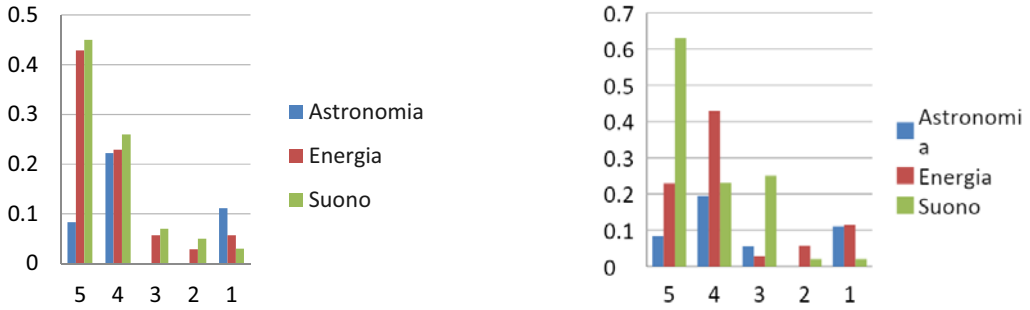
Q11- Was the activity carried out in accordance with your expectations?

Q12 Of the new elements introduced (laboratory approach, didactics for artefacts…) did you find any that you intend to introduce in your teaching?

Figure 4. Distribution of the answers to the questions Q10, Q11 and Q12

The time management (Q10) by the PPTs, in the articulation of the activities and in the development of the TIM, was assessed by in-service teachers as fully adequate for 60% and adequate for 35% of them.

The majority (80%) of hosting in-service teachers consider the TIM implementation a positive good quality experience (Q11, Q12) and they asked to repeat it (80%); more than half of them declare the intention to reproduce the activities of the TIMs (60%) by introducing them into their own teaching (Figure4).



Q13 -Do you intend to re-propose activities/contents?

Q14- Did the experimentation enrich the pupils knowledge/skills?

Figure 5. Distribution of the answer to the questions Q13 and Q14

TIM interventions meet appreciation at the highest level for over 40% of hosting in-service teachers for the topics of sound and energy; in qualitative answers and interviews 19% of them declare that these topics offered innovative proposals. An important element is represented by the intention of more than 40% of hosting in-service teachers to reintroduce activities and contents proposed by PPTs for energy and sound (62%) (Q14, Figure 5). In the interviews, 8% of them declare that they plan to introduce the proposed TIM paths in their teaching. Answers to Q14 by hosting in-service teachers are often based on the results of a satisfaction questionnaire they submit to children at the end of activity. We note that Astronomy obtains a lower evaluation both in the interest of repeating the experience, as well as in enriching the knowledge of pupils: in fact this topic differs from the others because it was a little bit rigid and was articulated in each TIM by means of many prepared concrete artifacts to explore astronomic latitude and longitude by means of a theodolite, the sun trajectories in our reference system during the whole year etc. This generated less enthusiasm by children and by teachers. The Energy topic was highly appreciated (grade 5 of Lichert scale) by 43% of hosting in-service teachers and appreciated (grade 4 of Lichert scale) by 22% of hosting in-service teachers (Q13), but the enrichment of pupils' knowledge was less appreciated, mainly due to the very different approach with respect to those in textbooks in so short a time, as revealed by interviews with the hosting in-service teachers

At the end of the questionnaire we introduce an optional open section for comments and suggestions. This open section, filled in by over 40% of the host in-service teachers, concerns the teaching strategies, the topics proposed, the organization of the interventions and the way of working in the classroom of the PPTs.

With respect to teaching strategies, the host in-service teachers found that the proposals enriched daily teaching from an innovative perspective (60%). The exploratory experimental approach and artefacts approach was also highly appreciated (80%) for the active role of children.

As for the organization of the interventions, the teachers expressed the request to increase the number of hours dedicated to experimentation and the willingness to make themselves available to repeat the experience (90%), hoping for the continuation of the initiative on other topics as well.

Regarding the PPTs, they underline that there was a serious preparation for the intervention in the classroom, highlighting that the TIM was stimulating and captivating for the children who enthusiastically responded to the proposals.

Table 2. The main aspects that emerged from the in-service teacher comments

Strategies and methods	**Contents**	**Organization**	**Implementation**
IBL strategy appreciated	Too much content in the available time	Request to take part in the research based design of TIMs	Very good PPT -children interaction
TIM implementation produced a rich learning environment with the children as protagonists, situation not common in school praxis	Rich and articulated content	Timing of the activities too dense	Correct behaviour and open mind of PPT
Active learning approach	Good results in the evaluation organized after TIM implementation	Request of a number of TIM implementations per year	Good motivation and involvement of children
Rich materials	Not a good idea to include waves in children paths	Suggestion for working in small groups for activities	Language used sometimes too complex for children (adult language)
Integration of experiments with conceptual reflection	Adequate selection of the main concepts	Good management of activities	Good preparation of PPTs

6. Conclusion

The research results offered us the opportunity to reflect on the ways of building trainee teachers' physics education and on the role and modalities of the internship from a new perspective, as well as the possibility to develop new models integrating different contributions of educational disciplines to situated learning experiences.

The responsibility for the planning, implementation and evaluation of the TIM within the PEC course itself, has produced a new way of introducing operative situated activities for professional education and institutional collaboration between the university and the school.

RQ1 The perception of the in-service teachers with respect to the adequacy of the preparation of the PPT was excellent for each proposed TIM topic. The implementation of the TIM was characterized by an explorative experimental approach supported by rich and valid materials designed to support the learning of the contents (Q1, Q6, Q7, Q8, Q9). The choice of the materials, inspired by the GEI Exhibition (Games, Experiments, Ideas) and the CLOE strategy by the trainee was appreciated. In the opinion of the host teachers, the prospective teachers involved the children in the activities through an active approach, using an appropriate language and showing the ability to grasp the children's reactions to stimuli and interests (Q2, Q3, Q4, Q5). Time management (Q10) represents an important aspect, considering that the time allotted of 2 - 4 hours for the classroom intervention was not flexible. It emerged that the educational path planned in the TIMs were completed by the trainee teachers in 95% of the cases, often carrying out a very intense and demanding activity for the children. Of the implementation of the TIM, the in-service teachers appreciated the coherence and respect for the scheduled time, the attention paid to the contribution of the children and to the enhancement of these contributions (Q11).

An indicator of the impact of the TIMs comes from the acknowledgement by the in-service teachers of the interest in repeating the initiative both by hosting the trainee teachers on other topics and as a starting point for reproducing the experience, highlighting the enrichment of knowledge and learning by children (Q12, Q13, Q14).

RQ2 A relevant aspect which emerged from the quantitative data of the questionnaire, which was also raised in the open comments section, highlights how the prospective teachers have proved to be

very well prepared both on disciplinary and didactic aspects. In particular, in relation to the didactic aspect, the in-service teachers appreciated TIM's experimental explorative approach, underlining the validity of the interventions in the classroom (80%). They underline the trainee teacher's ability to build an active learning environment for children, which they stated was not usual in school praxis. The way of involving the children during the activities was also very much appreciated (90%). The materials used to carry out the experiments, which were prepared by the trainee teachers and inspired by CLOE Labs and GEI Exhibit, were considered rich and user-friendly for children by the host teachers, even if they used common materials.

The proposed paths on Astronomy, Sound, and Energy have been developed in a clear and articulated way with a number of experiences. A group of host in-service teachers (30%) organized a further evaluation of the children's learning on the topics covered after TIM implementation, obtaining results judged satisfactory by them.

The majority of the hosting in-service teacher respondents to the questionnaire describe a framework of positive collaboration and find that our trainee teachers have distinguished themselves for correctness, reliability and availability and have shown the ability to fit into a flexibly structured context.

In the comment section, they expressed their interest in hosting more TIMs of prospective primary teachers and in their teaching, considering the quality of the scientific learning. The hosts also proposed to be involved in the research-based TIM development.

RQ3 With respect to the contribution made by the TIMs to schools, it emerged that four main goals are reached:

1) the intervention of the prospective primary teachers and their TIMs contribute to offering examples of active learning in a coherent way for science education in schools;
2) the research-based proposals offered a perception of how physics education research can contribute to scientific learning and how it is possible to innovate praxis;
3) the interaction between the host teachers and prospective primary teachers contribute to the reflection on the ways in which the competence of the expert teacher (host teacher) can be integrated with that of the PPT;
4) the implementation of TIMs plays a role in the professional development of in-service teachers and the improvement of the quality of science learning in primary school.

The prospective primary teachers' TIMs offer schools innovative proposals based on educational research for science education in primary schools. They also favour the integration of the professionalism of the expert teacher with that of PPT education.

The research results offer different ways of setting up the teacher education apprenticeship, implementing, in particular, short time sections of research based planned TIMs, as subject matter Situated Learning for the professional education of prospective primary teachers.

7. Author's ORCID iD

Marisa Michelini: 0000-0003-4764-9774

8. References

[1] Shulman L S l986 Those who understand: knowledge growth in teaching *Educational Researcher* **15 (Z)** pp 4-14
[2] Sassi E, Michelini M (2014) *Physics Teachers' Education (PTE): Problems and Challenges,* in *Frontiers of Fundamental Physics and Physics Education Research* eds G S Burra, M Michelini, L Santi Book of selected papers presented in the International Symposium Frontiers of Fundamental Physics-12th edition, Udine 21-23 November 2011, Springer, Cham, Heidelberg, NY, Dordrecht, London, [978-3-319-00296-5] pp 41-54
[3] Ball D L, Thames M H, and Phelps G 2008 Content knowledge for teaching: What makes it special? *J. Teach. Educ.* **59** p 389
[4] Abell S K 2007 Research on science teacher knowledge *Handbook of research on science education* ed N. G. Lederman pp 1105–1149

[5] Lawrence Erlbaum Associates. Bess, Nellista E. "Learning to Teach Physics: Exploring Teacher Knowledge, Practice, and Identity" (2018).*Theses, Dissertations and Culminating Projects*. 162. https://digitalcommons.montclair.edu/etd/162
[6] Mansour N 2013 Consistencies and Inconsistencies Between Science Teachers' Beliefs and Practices. *International Journal of Science Education* ***35*****(7)** pp 1230–1275 https://doi.org/10.1080/09500693.2012.743196
[7] Caleon I S, Tan Y S M and Cho Y H 2017 Does Teaching Experience Matter? The Beliefs and Practices of Beginning and Experienced Physics Teachers. *Research in Science Education* pp 1–33 http://link.springer.com/article/10.1007/s11165-016-9562-6
[8] Bess Nellista E, "Learning to Teach Physics:Exploring Teacher Knowledge, Practice, and Identity" 2018 *Theses, Dissertations and Culminating Projects*. 162 https://digitalcommons.montclair.edu/etd/162
[9] Kawasaki J and Sandoval W A 2020 Examining teachers' classroom strategies to understand their goals for student learning around the science practices in the Next Generation Science Standards *Journal of Science Teacher Education* ***31*****(4)** pp 384–400 https://doi.org/10.1080/1046560X.2019.1709726
[10] Etkina E, Gregorcic B and Vokos S 2017 Organizing physics teacher professional education around productive habit development: A way to meet reform challenges *Phys. Rev. Phys. Educ. Res.* **13** 010107
[11] Steps Two EU Project - 74 Univesities partner in 32 Countries - Working Group (WG3) on Physics Teacher Education. http://www.stepstwo.eu/
[12] Michelini M, Sperandeo Mineo R M 2014 *Challenges in primary and secondary science teachers Education and Training*, in *Teaching and Learning Physics today: Challenges? Benefits?* eds W Kaminski, M Michelini GIREP selected paper book Udine: Lithostampa, [978-88-97311-32-4] pp 143-148
[13] HOPE EU Project is an LLP network project involving 71 Universities. www.hope.org
[14] *Indicazioni Nazionali per il curricolo della scuola dell'infanzia e del primo ciclo di istruzione*, Ministero dell'istruzione, dell'università e della ricerca 2021 www.miur.gov.it
[15] Michelini M 2020 *Dialogue on Primary, Secondary and University Pre-service Teacher Education in Physics*. In: Guisasola J., Zuza K. (Eds) Research and Innovation in Physics Education: Two Sides of the Same Coin. Challenges in Physics Education. Springer, Cham. https://doi.org/10.1007/978-3-030-51182-1_3 [DOIhttps://doi.org/10.1007/978-3-030-51182-1_3] [Print ISBN978-3-030-51181-4; Online ISBN978-3-030-51182-1]
[16] Michelini M, Santi L, Stefanel A 2012 PCK approach for prospective primary teachers on energy *sel. Paper of World Conference on Physics Education* ed Tasar F
[17] Michelini M and Mossenta A 2011 *Building a PCK Proposal for Primary Teacher Education in Electrostatics*, in *Teaching and Learning Physics today: Challenges? Benefits?* International Conference GIREP-ICPE-MPTL 2010 Proceedings, Université de Reims Champagne Ardenne, Reims 22-27 August 2010, http://www.univ-reims.fr/site/evenement/girep-icpe-mptl-2010-reims-international-conference/gallery_files/site/1/90/4401/22908/29476/30030.pdf
[18] Michelini M, Santi L and Stefanel A 2014 PCK approach for prospective primary teachers on energy in *Proceedings of The World Conference on Physics Education 2012* ed Tasar F (Pegem Akademiel) pp. 473–477, ISBN: 978-605-364-658-7.
[19] Michelini M and Vidic E 2016 Research Based Experiment on the Concept of Time for Scientific Education on Transversal Perspective in Primary School, Communications to the HSCI 2016 congress, Brno 18-22 July 2016 *Hands-on: the heart of the science education* M Costa M.F.P.C, J B V Dorrio, J Trna,, E Trnova p 164
[20] Vidic E, Michelini M and Maurizio R 2018 Outcomes of a Research Based Intervention Module on Fluids for Prospective Primary Teachers in Junior College multi-disciplinary conference: *Research, practice and collaboration: breaking barriers* ed by Borg Farrugia C (University of Malta, Junior College, Malta) p 537

[21] Vokos S, Corni F, Vidic E, Maurizio R, Michelini M, Kapanadze M, López-Gay R, Martínez-Chico M, Jiménez-Liso M R, Castillo F J, Spyrtou A, Chaitidou M, Manou L, Kariotoglou P and Hatzikraniotis E 2021 Preparing teachers in grades K-6 to help young pupils learn physics: toward a common research agenda *Phys.: Conf. Ser.* **1929** 01208
[22] Perrenoud P 2008 *Dix nouvelles compétences pour enseigner. Invitation au voyage,* Paris : ESF, 1999, 5e éd.
[23] Duit R, Gropengießer H and Kattmann U 2005 Towards science education research that is relevant for improving practice: the model of educational reconstruction *Developing standards in research on science education* ed H E Fischer London: Taylor & Francis pp. 1-9
[24] Abd-El Khalick, F. et al. 2004 Inquiry in science education: international perspectives *International Journal of Science Education* **88(3)** pp 397-419
[25] Michelini M, Stefanel A 2016 Conceptual Lab of Operative Exploration (Cloe) As Research Contexts To Explore Pupils Reasoning In Physics, *IOP Proceedings of Krakow GIREP Seminar 2016*