PROCEEDINGS OF SCIENCE

AggiornaMenti: an INFN Project for the Education of Junior High School Science Teachers

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We present the "AggiornaMenti" project, a laboratory-based training course on physics for Italian junior high school teachers. Lessons are based on the Inquiry Based Science Education Method (IBSE), and teachers learn to perform simple experiments using materials that can be easily found at home. The topics are mechanics, fluids, electromagnetism, and thermodynamics. The impact of the course has been evaluated by a qualitative feedback questionnaire. Results show that our methodology was appreciated: the teachers implemented the "learning by doing" approach at school and they also felt that students will have benefits even for their future.

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1. Introduction

The junior high school represents the weakest sector of the education system in Italy and perhaps in other countries [1-2]. In most cases, science teachers do not receive specific training in physics, either in terms of content or teaching methodology and consequently they tend to avoid addressing aspects of physics and do not adopt more stimulating approaches than a traditional frontal lesson [3]. Students aged 11-13 are making choices that will affect the rest of their lives. Physics can offer them the possibility to foster their reasoning and problem-solving capabilities, and to cooperate in building experiments and understanding phenomena around us [4], a kind of activities that are not usually accessible to junior high school students. Moreover, teachers do not often explore the possibility to approach STEM disciplines by experimental activities and most schools have very limited laboratory equipment. The "AggiornaMenti" project was born to transform these limits into an opportunity, designing experimental activities that can be carried out in any context using inexpensive materials that can be found at home, activities that have the potential to let students discover how science enters every aspect of daily life.

1. Methodology

"AggiornaMenti" ("updating minds" in English) is an educational and outreach program of the Italian National Institute for Nuclear Physics (INFN) devoted to junior high school (middle school, students from 11 to 13 years old) science teachers. It is based on the cooperative "learning by doing" approach [5] and it currently involves 10 local units of the Institute throughout Italy.

The activities are carried on in close collaboration with the Universities of Cagliari, Ferrara, Genova, Perugia, and Pisa. Fruitful collaborations with social and educational agencies have also been established: Fondazione Golinelli (www.fondazionegolinelli.it), Next-Level (www.next-level.it) and Laboratorio Scienza (www.laboratorioscienza.it).

Every year, since 2017, about 100 science teachers have attended the training course, with topics including many aspects of classical physics: mechanics, fluid dynamics, thermodynamics, acoustics, optics, electromagnetism. From 2021 the project also includes an online coding school proposed by the INFN-Ferrara unit (with about 30 participants /year).

Figure 1. An example of a table with objects used for experiments with fluids (left). A group of teachers collaborating to realize an experiment on mechanics (right).

The hands-on approach to learning science was based on practical activities and carried out in small groups of teachers, to foster the cooperative learning. This approach is suitable for

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enhancing a wider range of skills than a traditional frontal lesson and brought some of the participating teachers to partially change the assessment criteria of their students [6].

The pedagogical method behind every lecture is mainly based on the Inquired Based Science Education (IBSE) [7-8], a modern implementation of the scientific method, where intuition is fostered in the understanding of a phenomenon before knowing the theoretical explanation of it. The lectures start with a question (Inquiry) about phenomena and teachers (or pupils) make hypotheses on it, mainly based on their everyday life experience. The hypotheses are confirmed by experiments, following a hands-on and minds-on methodology. Finally, a theoretical explanation of phenomena and what it has happened follow; lecturers act as a guide in a constructivist perspective [9]. The researchers share with the teachers, material such as slides and video-lectures, but also objects useful for experiments in a particular topic (such as springs, weight scales, dynamometers…). In the final meeting, at the end of the course, the teachers report their experience in applying the method in the class: the way they have organized the lessons, the experiences they have replicated and why (logistic, risks, easy replicability according to the class and so on), the materials they have chosen to perform the experiments.

1. Results and Discussion

In every edition, at the end of the course, we investigated the feeling of the teachers about the project on different topics: the replicability of the activity and the methodology in class; the use of supplementary material to organize a hands-on lesson. Moreover, we were interested in a qualitative measure of the possibility to implement our methodology in the class and the feedback of the students about it. To this extent, in 2022, we prepared a feedback questionnaire with 10 questions, sent it to all the teachers that had attended the course since 2017 (n=500), and collected 64 answers. The first part of the questionnaire (questions from 1 to 4) was meant to get an idea about the implementation of the activity at school, whereas in the second part (questions from 5 to 10), teachers could report the feedback of the students about the activity they propose. In the latter, they could answer using a 5-point Likert scale-like, from 1 (strongly disagree) to 5 (strongly agree).

Data collected show that most teachers implemented the methodology in their class (87.5%). In doing so, they also used the supplementary material (84.4%). Focusing on the assessments related to the hands-on activity they conducted, most of them (87.5%) also reported to have changed the way in which they evaluate the learning outcomes. The totality of them recommended the course to their colleagues.

The results show that the teachers liked the course and its related methodology (Fig. 2a). Students appreciated the introduction of hands-on activities and a more practical, laboratory-like lesson (Fig. 2b). The methodology had a positive influence on students regarding a possible choice of their future high school (Fig. 3).

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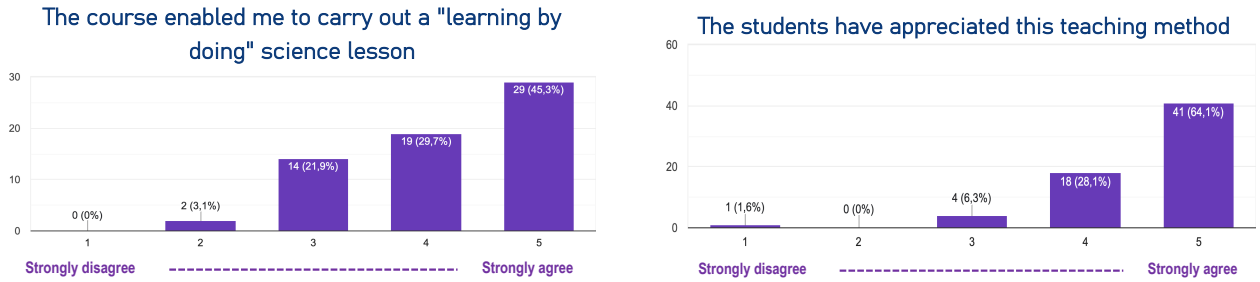

Figure 2. On the left (a) the number of answers and the related percentage about the implementation of the methodology in class. On the right (b), the feeling of the students about the method.

More than half of the sample proposed the activity to more than one class, thus reinforcing the idea of the replicability of the activities in middle schools. More interestingly, most teachers reported that this kind of lessons raised the participation of less interested students (Fig. 4a) and students' interest, in general, for science (Fig. 4b).

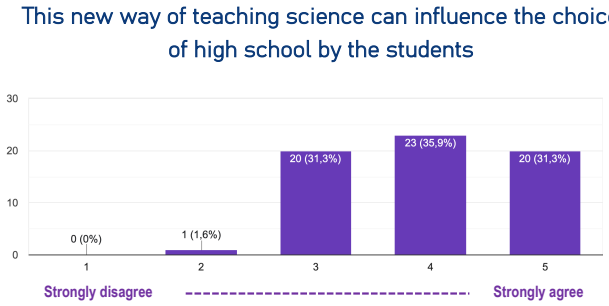

Figure 3. Teachers' feeling about how the method could influence students' choice of high school.

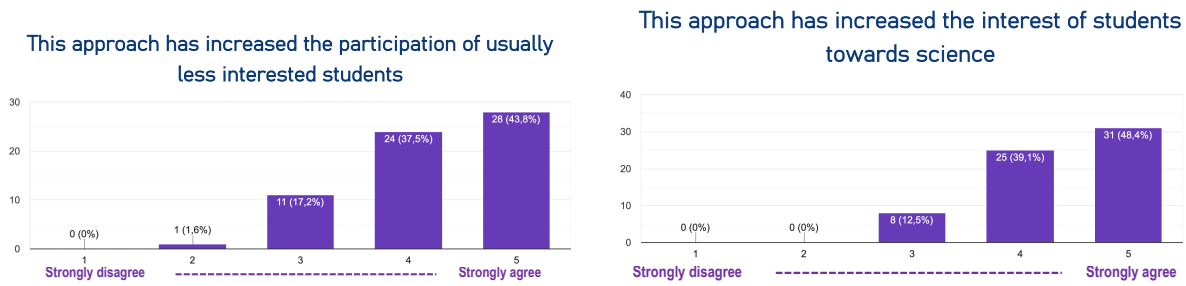

Figure 4. On the right (a) data about the participation to the in-class activities of less interested students. On the right (b), data about teachers' feelings on the increasing of students' interest in science.

This is an interesting result, suggesting the need for more practical and experiential activities related to the laboratory. From personal feedback during the course, we also report that teachers' feeling towards the use of everyday life objects is strongly positive, since it makes physics a real and tangible thing. Moreover, it strongly increases the possibility to perform in the class experiments and practical experiences typical of a lab, even without having a proper room devoted to it. In this way, it is possible to circumvent one of the main problems in school, from the primary to the high school level.

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1. Conclusions

We presented a hands-on and minds-on education program devoted to Italian middle school teachers called "AggiornaMenti". More than five hundred teachers have participated to the project since its start. We have shown our methodology, mainly based on the ISBE pedagogy and on the "learning by doing" approach. We qualitative measured the efficacy of our methodology with a feedback questionnaire. Most of the teachers made at least one experience using our methodology and were happy in performing it. They also reported very positive feedback about the replicability of the activity in class and the use of the supplementary material. The feedback of the students about the new methodology is very positive, showing that this kind of lessons increase the participation and the interest of pupils towards science. Only 10% of the sample answered to the questions and this is one big limitation of the study. Nevertheless, personal feedback obtained during the final meeting of the course in many INFN local divisions, confirm data collected through the questionnaire. More data are needed to make a quantitative study about the efficacy of the project. This is left for the future.

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