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Implementation of active, bodily experience mathematics learning activities: Differences among primary and secondary school teachers

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In the research, we look at the implementation of mathematics learning activities consistent with an enactive-embodied perspective in Italian schools. Teachers are both users and responsible for the dissemination of educational innovations, thus their involvement is critical for the study. With an exploratory teacher survey, consisting of a self-completed online questionnaire and follow-up interviews, we investigated possible differences between Italian primary and secondary school mathematics teachers, concerning their beliefs and practices. The availability of adequate spaces and resources is the main factor hindering the implementation. Time pressure to cover the curriculum is of particular concern for secondary school teachers, who, otherwise, believe less in the effectiveness of these activities. Nonetheless, the lack of confidence and guidance is the second hostile factor, and the teaching training undergone before entering the profession seems to be significant.

Keywords: Mathematics education, teacher survey, embodied learning, enactive pedagogy, implementation research.

Introduction

The relevance of students' perceptual-motor involvement in active and experiential activities to promote mathematics learning in school is a long-discussed matter that has been endorsed by numerous research studies, theories, and experimental findings, including recently (Abrahamson et al., 2022; de Freitas & Sinclair, 2014). Particularly in Italy, a long tradition (Montessori, 2011; Castelnuovo, 1963) and contemporary research group in mathematics education (Ferrara & Ferrari, 2020; Baccaglini-Frank et al., 2020) focus on these themes for different school grades.

Despite this, we have no clear indication of how far this idea has permeated into the school. Investigating what may be the reasons for limiting its proposal in classrooms may be an essential step, such as for properly intervening in promoting such approaches. However, hindering factors may differ in diverse school grades. Indeed, the users of educational innovation, both teachers and students, and diverse school contexts may influence the implementation (Century & Cassata, 2016).

In our research, we consider active, bodily experience mathematics learning activities, hereafter abbreviated as ABM activities, as the object to be investigated from an implementation research perspective (Jankvist et al., 2017). With ABM activities we refer to activities designed in the perspective of enactive-embodied learning (Abrahamson et al., 2022) or, more generally, to activities in which students are actively engaged in exploring mathematical concepts using manipulatives, tools (virtual or physical), or the whole-body movement.

Having identified the core elements that characterize the ABM activities and possible influencing factors in and for their implementation (Century & Cassata, 2016), through a desk audit and interviews with expert researchers, as described in Boscolo (2022), we proceeded in the research looking at implementation by investigating teachers' perspective. Indeed, teachers hold a leading

position for our goals: they are both users of educational innovations and also responsible for their proposal and diffusion in classrooms. Particularly, in our study, we explored possible differences in the implementation of ABM activities among primary and secondary school Italian mathematics teachers. The specific research question we will try to answer in this contribution is the following: *what are different and common hindering factors for ABM activities implementation at different school grades?*

The context

Italian school system¹ is divided into a first cycle, consisting of primary school (grades 1 to 5) and lower secondary school (grades 6 to 8), and a second cycle consisting of upper secondary schools or regional vocational training system (grades 9-13). Compulsory education starts at 6 years of age and lasts for 10 years, consequently, the first cycle has quite different objectives than the second, where only the first two years may be compulsory and, moreover, is divided into different specializations (general, technical, vocational).

However, we decided to design the teacher survey grouping primary and secondary school mathematics teachers, due to different pre-service training requested to teach². Indeed, nowadays, a university degree in primary school education, consisting of a 5-year-long course that includes a consistent period of internship, is a requirement for obtaining teacher qualification at the primary and pre-primary levels. Instead, secondary school teachers must have completed a disciplinary-specific university course and, for a recent reform, they must also have acquired specific competencies in anthropology, psychology, and pedagogy, as well as in teaching methods and technologies. Particularly, to teach Math in upper secondary schools, it is needed to graduate in a math-intensive course (e.g., Mathematics, Physics, Engineering), while in lower secondary school teachers may have completed science studies even with less focus on math.

Methods

To reach our goal we designed an exploratory teacher survey which consists of an online questionnaire, focused on teachers' beliefs and practices regarding teaching and learning mathematics in general, and particularly to ABM activities. The web-based instrument combines rating items, multiple-choice items, two vignette items, and a few short open-ended questions, differentiating primary and secondary school teachers using filter questions. After completing the questionnaire, teachers interested in participating in an online follow-up focus group were asked to provide their email (in the form) for further potential contact by the researchers. Then, focus groups with a restricted number of respondents were arranged to provide greater insight into issues raised in the participants' survey responses and to delve further into some topics for which the questionnaire might

1 <https://eurydice.eacea.ec.europa.eu/national-education-systems/italy/overview> (consulted on 15/02/2023)

2 <https://eurydice.eacea.ec.europa.eu/national-education-systems/italy/teachers-and-education-staff> (consulted on 15/02/2023)

not yield sufficient information. Due to space reasons, we can only present here the results of the questionnaire analysis, however, these data are sufficient for the purpose of the paper.

The questionnaire

The survey items cover dimensions derived from the literature concerning teachers' beliefs on mathematics teaching and learning (Dionne, 1993; Ernest, 1989; Van Zoest et al., 1994), conceptions of educational material usage (Skoumios & Skoumpourdi, 2021), and beliefs and instructional practices with manipulatives (Carbonneau & Marley, 2015; Golafshani, 2013). Other items were adapted from items on existing surveys (i.e., IEA TIMSS, 2019; OECD TALIS, 2018). Moreover, there are additional items concerning new explorative dimensions specific to our research interests.

There are two parallel versions of the survey, one for primary and one for secondary school teachers, with minor adaptations to suit the teaching context. The survey consists of five sections:

1. The school – concerns general information about the current school (e.g., government / non-government school; traditional / school based on a specific educational method such as Montessori) and school level/s that the respondent is currently teaching.
2. General – designed to provide information about the teacher's educational background and teaching experience.
3. Beliefs (a) – including broad beliefs about teaching and learning mathematics (e.g., the teacher's or peers' role in the learning process).
4. Beliefs (b) – specific beliefs about the ABM activities (e.g., for which school level these activities are considered appropriate, what kind of educational impact is expected to be achieved, what factors can possibly limit their use, what kind of evaluation/assessment strategy may be appropriate).
5. At the end of the fourth section, a filter question concerning the actual use of these activities in daily teaching practices splits the questionnaire into two alternative parts on the basis of the teacher's use of these activities in their teaching practice (Yes/No). This next section asks teachers for additional information such as the reasons for this choice, what other teaching strategies they deem to be effective, and comments about their implementation in classrooms (if used).

The entire survey can be seen at the following link: <https://tinyurl.com/BMALM-Questionnaire>.

Descriptive statistics (e.g., frequencies, percentages, cross-tabulations with Chi-squared test) and correlations resulting from recording the similarities and differences among the basic variables of the sample have been used to analyse the Likert-type and multiple-choice item responses. Open-ended questions were initially coded following an analytic induction from the content (Cohen et al., 2017). Then the initial codes have been grouped into categories or themes, which have been examined for patterns across school levels. The number of comments from teachers at each school level in each broad category has been counted for reporting the relative emphasis on each category/theme across school levels, and to identify the main trends and recurring themes.

Participants

Respondents to the questionnaire are a voluntary, non-probabilistic sample of primary and secondary school mathematics teachers, recruited throughout Italy. The dissemination was carried out with multiple strategies: in addition to posting on teachers' Facebook groups and pages, and spreading

through mailing lists of teachers' associations, we directly contacted most Italian schools with an e-mail directed to the principals, asking them to circulate the link among mathematics teachers working in their school. We thus reached a convenience sample of 1301 respondents: 1206 of them answered at least the first filter questions, but only 877 completed the questionnaire. The sample of respondents is composed of a minority of newly hired teachers (194), who have less than 3 years of teaching experience, and medium-experienced (4-10 years of teaching experience) teachers (305), while the vast majority (614) are experienced (more than 10 years of teaching experience) teachers. Among the 1206 respondents to question Q1, 540 reported being primary school teachers and 666 secondary school teachers. Among the respondents to the third question (Q3), 1109 said they currently teach in a public school and 43 in a peer school. Subsequently, 58 teachers were involved in online follow-up focus groups, two groups for each school order.

Results

Within our sample, it emerged a tendency for low integration of ABM activities in the teaching practice of secondary school teachers than primary school teachers. Indeed, nearly all (approximately 90%) primary school teachers who participated in the survey state integrating ABM activities in their teaching practice, while the number decreases significantly among teachers belonging to secondary school. In particular, the situation differs when looking at lower secondary schools, where just under one in three teachers (27%) do not implement ABM activities in their classroom, and in upper secondary schools, where the majority of teachers (56%) state they do not integrate such activities in their teaching practice.

In the majority of cases, teachers who state that they implement ABM activities carry out them more than once a month, although the declared frequencies decrease as the school grade of teaching classroom increases. Predominantly, teachers state that the carrying out of ABM activities involves 1 to 3 lessons, a duration that appears suitable for exploratory activities. However, for the greater number of teachers in the second cycle who implement ABM activities (in significant superiority within the sample, where the percentage is around 14%) the inclusion of such activities is rather sporadic, occurring less than 4 times a year. Indeed, in some instances, teachers indicated that they only implement ABM activities once a year and exclusively in specific classes with particular supportive characteristics. This finding appears aligned with a general belief that emerged from the teachers' answers (e.g., as stated in the short open-ended item Q14 in the questionnaire): these activities are mainly, if not exclusively, suitable for younger students in lower grades. Particularly, teachers in the second cycle often consider ABM activities unsuitable for their school grades (see Figure 2).

As highlighted by the content analysis of the short open-ended item Q15, within our sample, mathematics teachers working in the primary school reported addressing, with ABM activities, a wide range of topics, spanning various content areas. However, they tend to focus more frequently on fundamental topics within the arithmetic and geometric domains. Conversely, among teachers working in secondary schools (both lower and upper), we observe less variety in the content areas mentioned while stating the topics addressed by these activities, with an overwhelming prevalence of the geometric domain over all others. Indeed, among secondary school teachers (both lower and

upper), it emerges a consideration that such activities are suitable for conveying only a limited number of topics; a belief that, in contrast, wasn't commonly shared by primary teachers (Figure 1).

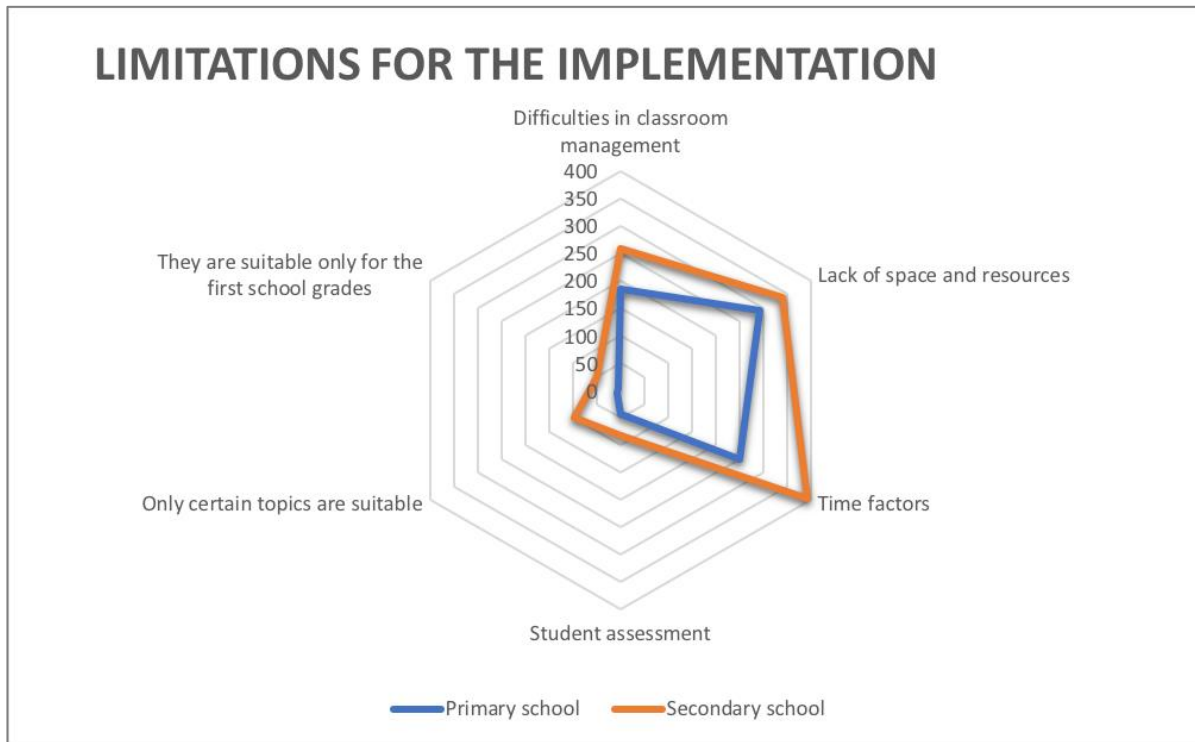


Figure 1. Kiviati diagram shows how beliefs regarding the main limitations for proposing ABM activities are distributed among primary (in blue, N_Respondents=790) and secondary (in orange, N_Respondents=1248) school respondents. Respondents could indicate at most 3 alternatives to this question. The diagram shows the macro-categories into which the response alternatives are grouped

To answer the research question, the limitations perceived by the primary and secondary school teachers in our sample, whether they implement ABM activities or not, are more or less the same (Figure 1): availability of resources and adequate spaces, challenges related to classroom management, time constraints due to the curriculum, and, although less significant, concerns about student assessment. However, secondary school teachers, in particular, perceived also a limitation related to their ability to cover only a limited number of topics with these activities. Furthermore, time factors are significantly considered as the major constraints by these teachers, while, primary school teachers are more concerned about the lack of space and resources.

However, looking at the reasons why the teachers in the sample did not implement ABM activities (Figure 2), it is evident that the most common obstacle across all grade levels is the lack of resources, followed by the lack of familiarity, with an appropriate training for these activities. The issue of large class sizes is primarily a concern for secondary school teachers, especially in the upper secondary, along with the time constraints, as also mentioned in the previous paragraph. Furthermore, the belief that ABM activities are not effective or suitable for the own grade levels is proper for second-cycle teachers. Finally, it's worth noting that a less common reason, mentioned almost merely by some secondary school teachers, concerns having unsuccessful previous experience, which may be possibly linked to a feeling of insufficient preparation to implement ABM activities, which is one of the major hindering factors.

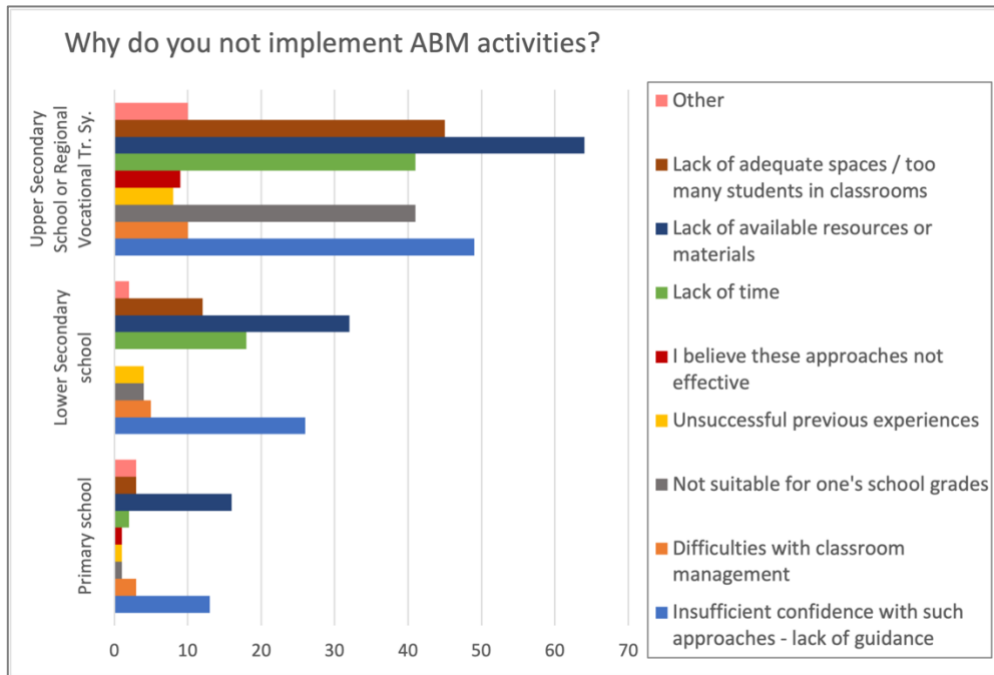


Figure 2. Distribution of the answers to question Q21A, comparing teachers from different school grades. Only teachers who stated in Q20 not integrating ABM activities in their teaching practice answered this question, which investigates the reasons for such negative answers. Respondents could indicate at most 3 alternatives. (N_{primary}=43, N_{lower secondary}=103, N_{upper secondary}=277)

Among secondary school teachers, particularly those in the second cycle, there is a noticeable difference in the willingness to carry out ABM activities and the belief in their importance (Figure 3). This difference is apparent between those who, although having strong disciplinary training in mathematics (such as individuals with undergraduate degrees in Mathematics, Physics, Engineering, Statistics, etc.), have not attended a university program specialized in the didactic-pedagogical aspects of the discipline, i.e., who do not have specific training in mathematics education. This trend doesn't involve teachers who attended university courses with a lesser focus on mathematics. However, they work almost exclusively at the lower secondary school, as explained in the introduction.

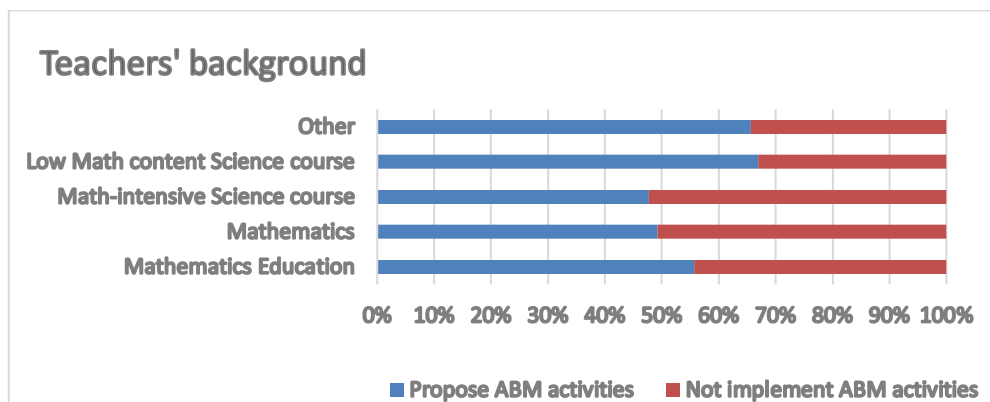


Figure 3. Distribution of secondary teachers' answers to question Q20, which asked whether ABM activities are implemented or not, compared to the typology of the university course completed. (N=518). Differences were statistically significant (Chi_{square}=13.825, df=4; *p=0.008<0.05)

Discussion of results and limitations of the research

Before stating our conclusions, we will briefly illustrate the main limitations of this study. First of all, the exploratory nature of the research, with an unrepresentative sample of teachers, limits the possibility of making generalized claims or identifying overarching trends. Indeed, in our research, we could only hypothesize potential factors relevant to and for ABM activities implementation. Secondly, there is a heavy bias within the teacher sample we surveyed. Despite our efforts to try and track down teachers from outside the circuits close to the world of research and universities, the research design itself led to the selection of teachers who willingly participated. Indeed, as participation in the research was voluntary, this likely means that the participating teachers were inherently interested in the subject matter. We thus expect them to present a more general openness towards the idea of incorporating these practices. Therefore, all results should be interpreted while assuming that the research exhibits this imbalance. Furthermore, in a survey, investigations might be limited to teachers' statements, which are often far removed from their actual teaching practice. To gain a more comprehensive understanding of the teaching practices behind the declared intentions, classroom observations of a select group of teachers may be necessary.

Despite the aforementioned limitations, looking at the results, we can conclude that, within our sample, the tendency to integrate ABM activities decreases as the school grade level increases. In particular, among secondary school teachers, especially those in the second cycle, the implementation of these activities is more unusual or lower in frequencies and topics covered. Teachers at these grade levels, in addition to the limitations identified in the practical organization and management of these activities, such as the availability of resources and adequate spaces, the numerosity of the class, and the variety of student populations, consider the time to be spent as the predominant limitation. Although, on the one hand, lack of time can be seen as an external limitation, i.e., stemming from the context, it also reflects internal resistance driven by teachers' beliefs that perceive ABM activities as supplementary and scarcely integrable in their teaching daily practice. If primary teachers seem to be more concerned about the logistical complexities of implementing ABM activities, secondary teachers, in addition, seem to harbour hostile beliefs. Indeed, many upper secondary teachers within our sample consider such activities unsuitable for their teaching grade levels and appropriate only for a limited range of contents, a perspective that differs from primary school teachers. Furthermore, a substantial number of teachers who stated to not implement ABM activities identified insufficient confidence and preparation to propose and manage them as the primary reasons, including concerns about adopting appropriate assessment strategies. The role of teachers' lack of specific training is also evident in the results obtained by cross-referencing the background information of teachers and the implementation of ABM activities. It can be hypothesized that undergoing specialized training in disciplinary education might allow teachers to modify their beliefs and preparation, thus, presumably, potentially leading to more widespread adoption of these practices, especially in the upper secondary schools where ABM activities seem to be less commonly implemented, at least in our sample.

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