Beliefs About the Active, Bodily Experience Mathematics Learning Activities: An Explorative Teacher Survey in Australia

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The exploratory study combined an online survey and interviews with Australian primary and secondary mathematics teachers to examine their views on *Active, Bodily experience Mathematics learning activities*. The research sought to identify teachers' expectations, challenges, and limitation for their implementation. Initial results indicate teachers recognise the value of such activities in deepening students' understanding and increasing engagement but encounter obstacles such as time constraints, insufficient resources, and difficulties in managing the classroom, underscoring the need for further investigation into effectively incorporating these activities into teaching practices.

The educational field broadly recognises the importance of integrating physical movement and bodily experience into mathematics education, drawing on various research backgrounds (Abrahamson et al., 2020). Over the years, both theoretical and experimental studies coming from general pedagogical and mathematics education traditions, the philosophy of mathematics, neurosciences, and cognitive psychology research fields have consistently shown the benefits of actively engaging students in experiential activities and the significant impact of movement and sensory experiences on learning math. Theories of embodied, enactive, embedded, and extended cognition (Lakoff & Núñez, 2000; Varela et al., 1991) have inspired diverse research directions in mathematics education, and multiple research groups have designed learning activities, materials, and tools to enhance the teaching and learning strategies in this direction (Palatnik et al., 2023). Although there is not an explicit reference to the implementation of activities designed from an *enactive-embodied* perspective in the Australian curriculum (ACARA, 2022), there are some aspects that can be linked to them. Indeed, within the curriculum, a specific focus is on the dynamic use of digital tools for virtual manipulation, and some general references to "experience with mathematical concepts using multisensory methods to stimulate thinking skills" and "access to familiar objects to represent and solve mathematical problems", in order to meet the needs of diverse learners. Looking at specific strands within the curriculum, in the strand Space it is mentioned "the ability to make pictures, diagrams, maps, projections, networks, models, and graphics that enable the manipulation and analysis of shapes and objects through actions and the senses". In the strand Probability, something is said about learning that is based on "experimentation through exploration and play-based learning in the early years". Even if some general guidelines, possibly relating to the implementation of activities *embodied designed* (Abrahamson et al., 2020), are illustrated in the curriculum, more has to be inquired on the school realm and the integration of these approaches in teaching practice (Boscolo, 2023). In line with the approaches of *Implementation Research in Mathematics Education* (IRME) (Jankvist et al., 2017), our study intends to make an initial exploratory move in this direction. In our research, we refer to activities designed for enactive-embodied learning or, more broadly, any activities that involve students actively exploring mathematical concepts through the use of manipulatives, tools (either virtual or physical), or simply body movements, as *Active, Bodily Experience Mathematics Learning* (ABM) activities. These ABM activities are grounded in the belief that experiencing mathematical meanings with the body and senses can enhance their understanding and retention. The use of an all-embracing construct, which includes a wide range of activities, and has also roots in different research perspectives, is essential for closely aligning with and

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investigating the realities of the school practice (Boscolo, 2022). Particularly, due to teachers' pivotal role in the implementation of educational innovation (Century & Cassata, 2016), we focus on the investigation of teachers' perspectives on the implementation of ABM activities in their teaching practice. We aim to uncover what teachers expect from integrating ABM activities, as well as the main challenges, constraints, and limitations they anticipate when integrating them into educational settings.

Research Design and Methodology

The explorative study consists of a teacher survey. Primary and secondary school mathematics teachers were invited to fill out an online questionnaire and, after completing it, they were asked if they would be willing to participate in an individual interview intended to elaborate on the issues raised in the survey responses. The administration of the questionnaire took place between November 2021 and May 2022. Primary and secondary schools' mathematics teachers were recruited from across Australia, via National and State mathematics teacher professional associations' Facebook pages/groups, or associations' newsletters. This entailed posting an anonymous link to the questionnaire on Facebook pages/groups/newsletters with a request for it to be completed by participants. In addition to advertising via Australian mathematics associations' Facebook organisations newsletters, we sought to advertise through umbrella organisations (for example, the Independent Schools Queensland; Catholic Education Offices), and broader teacher organisations bringing together Australian teachers (e.g., the Australian Teachers Association). Furthermore, we sent the questionnaire to a list of mathematics educators who have indicated their interest in participating in ILSTE (Institute for Learning Sciences & Teacher Education) mathematics research projects. Following multiple strategies, we reach a convenience sample of 81 mathematics teachers. Upon completion of the questionnaire, 16 teachers provided their email indicating that they were willing to be contacted again by the researchers to conduct an individual follow-up interview. With nine of them, it was possible to arrange a 30-minute interview between April 2022 and May 2022.

The Questionnaire

The survey items cover dimensions derived from the literature concerning teachers' beliefs on mathematics teaching and learning (Van Zoest et al., 1994; Dionne, 1993; Ernest, 1989), 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 (e.g., OECD TALIS 2018, IEA TIMSS 2019), along with new items concerning explorative dimensions from our research on ABM activities, framed on the results of a former study in which international researchers were interviewed to explore their beliefs about ABM activities implementation and research direction for the teacher survey (Boscolo, 2022). The survey, tailored for both primary and secondary school teachers through two parallel versions with slight modifications to better align with their teaching contexts, is structured into five main sections:

1. *The School*—Collects basic information about the teacher's current school, including its type (government/non-government), educational approach, as well as the levels taught.
2. *General*—Gathers details on the teacher's educational background and experience.
3. *Beliefs (general)*—Explores general beliefs about teaching and learning mathematics, such as the role of teachers and peers.
4. *Beliefs (ABM activities)*—Focuses on specific beliefs about ABM activities, including their appropriateness for different school levels, expected impact, limitations and constraints, and assessment strategies.
5. *Implementation Inquiry*—After a filter question about the use of ABM activities in teaching, the survey splits based on the response (Yes/No), asking for reasons, other effective strategies, and comments on implementation if applicable.

The questionnaire is a web-based tool created with Qualtrics software, and it combines Likert-type, multiple-choice, short open-response, and vignette items; a copy of the questionnaire can be found online (Boscolo, n.d.). The estimated time for filling out the questionnaire is around 20 minutes.

The Sample

The convenience sample consists of 81 respondents, however only 39 completed the entire questionnaire. Among the ones who answered the first part, 15 were primary school teachers and 64 were secondary school teachers. Most of them work in Government schools (45), while more than a third (29) are in Catholic or Independent schools. While 58 teachers work in Comprehensive (open) schools, 11 respondents were working in schools with streamed classes into attainment groupings, and 5 were in selective, special, specialist, or international schools. Almost all (71) work in traditional method schools. Concerning their expertise, the majority (43) are expert teachers (more than ten years of experience), 15 are middle-expertise teachers (4–10 years of exp.), and 15 are new to the teaching profession (1–3 years of exp.).

Follow-Up Interviews

Although the online questionnaire enabled us to reach a certain sample of teachers, the information gathered, especially through closed-ended items, deserved to be further investigated with follow-up interviews, in order to deepen the interpretation of the main themes and trends that emerged. For this reason, we sought to explore in depth some significant issues with some of the teachers who completed the questionnaire, through a semi-structured online interview. These interviews began with an introduction of the respondents, including their teaching expertise and their school contexts, followed by a discussion on their experiences of completing the questionnaire. The conversation then shifted to a comprehensive investigation of the teacher's experience and key beliefs concerning ABM activities. This included inquiries into examples of ABM activities they had implemented (if any), their reasons for valuing these activities, and the outcomes they anticipated. Additionally, we explored the challenges and limitations they encountered in integrating ABM activities into their classrooms, the difficulties faced during implementation (both from the students' and the teacher's perspectives), and the strategies employed to address these challenges. The discussion also covered instances of unsuccessful implementation, teaching strategies, and instructional guidance believed to be crucial for the effectiveness of ABM activities. Finally, we discussed factors that hindered or facilitated the integration of ABM activities, personal motivations for adopting such activities, constraints that may have limited their implementation, and the role of collaboration and support in this context.

Description of Interviewees

Table 1 shows a brief description of the interviewed teachers' profiles. The majority of the interviewees are highly experienced teachers currently working in non-government secondary schools, in different states of Australia (with a prevalence from Queensland). Some of them work with students with a middle-high socio-economic background but others with students of low socio-economic situation and non-English speaking (e.g., O).

Discussion of Results

Due to space constraints, this section focuses on key insights from the survey, concerning exclusively the beliefs on expected outcomes of ABM activities implementation and the perceived obstacles to their integration in classrooms. Additionally, it emphasises how follow-up interviews have further delved into these topics, offering deeper understanding and perspectives.

Table 1

Teachers' Profiles Description

Teacher	Where is the school	Type of school	Year levels taught	Teaching experience
G	Canberra	Government, Traditional, Open entry, Secondary school	11–12	38 years
K	Gunnedah	Non-Government (Christian Catholic), Secondary school	7–10	30 years
R	Brisbane	Non-Government, Single sex (girls), Open entry, from Prep to 12 school	7–12	25 years
St	Sydney	Independent (Roman Catholic), Single sex (girls), Boarding and day, Secondary school	7, 8 10 (high achievers) 11,12 (specialists)	37 years
Su	Queensland	Non-government (Catholic school), Single-sex (boys), Secondary school	7–12	40 years
T	Brisbane	Independent, Boarding and day, Single sex (girls) school, from Kindergarten to Year 12	11–12	Long-time experience
X	Canberra	Government, Traditional, Streamed classes, Secondary school	7–12	Over 20 years
O	Melbourne	Non-Government (Catholic School), Open entry, Secondary school	11–12	25 years
J	Near Brisbane	Non-Government, Traditional school, from Prep to 12	5, 10, 12	21 years

Importance and Expected Outcomes

Examining the responses to Likert-type item Q16, teachers in our study report that ABM activities significantly enhance *deep conceptual understanding*, improve *mathematical visualization skills*, and effectively engage *students' interest*. However, there is less consensus on the effectiveness of ABM activities in boosting students' *performance in standardised tests*. Additionally, when considering other anticipated impacts (Q17), most teachers believe ABM activities enrich their understanding of students' learning processes but are less effective in including students with special educational needs. This perspective is further supported by a response to Q18, where one teacher (in the alternative *Other*) noted, "Students with special needs are often 'lost' in these tasks even with peer and teacher support. They benefit more from direct instruction and explaining". In the follow-up interviews, similar themes recur and are further explored. For teachers, promoting deep learning involves having a long-lasting imprint in students' minds, "I think the more senses and the more parts of your body you use, the greater the, the retention of the knowledge, and the skills is going to be" (Teacher Su).

> I also just think that the more senses that are involved in your learning, which, moving … involves your feelings and stepping out something. I just think you are involving more of your brain … it's more memorable that we talked about. So … it stays deeper in their consciousness, I think. (Teacher K)

> They will learn it a lot better and, basically, rather than just writing something down, and trying to learn it by rote, if they're actually involved in carrying out the activity, it will have a lasting imprint on their minds and all that makes you remember it a lot more clearly. And, yeah, it should be more relevant, too. (Teacher St)

Further, Teacher R emphasised how, in experiencing ABM activities, students can build cognitive roots, essential to recalling mathematics concepts:

> I think muscle memory is very important. … I think also the experiential, learning experiences that kids have, where it's embedded in their memory, they can recall it, and then the teacher, at a later time, can also then recall it, and, talk about "well, remember when we did this" … So, you're drawing on their personal account of their personal experience, and I think that's a very valuable learning experience for the kids. (Teacher R)

Finally, having a deep understanding includes having a more meaningful learning:

> Give meaning. So they get a sense of either number, measurement, umm, what these abstract things are … understand the concepts better … avoid misconceptions. So, if they, for example, drew an angle and they, they turn, you know, and they realise that the angle is a turn, it's the size of the turn, it's not being anything to do with the lines. They always think about the lines—as the lines are big and all that. So, I hope that it gives them an understanding of the concept. Initial concept, yeah. (Teacher O)

Even in interviews, expected outcomes also concerns to enhance students' interest, "learning should be, engage you, should be interesting, should be fun and the more senses that you can use, the more you involve the student in any learning, the better they will learn" (Teacher K), for instance showing the relation of mathematics and the world, "it also helps them see that maths is connected to life, to the world" (Teacher K), "they can see the real world—you know, like why they're doing something. So, I think that's important for students to understand that, yeah, it's not just pen and paper" (Teacher J).

Limitation and Constraints

Looking at question Q18: *In your experience, what are the most relevant limitations for this type of learning activities' implementation?* (to answer, respondents could select up to 3 options from a list, the total number of answers was 157), the main limitations highlighted in the questionnaire were *classroom management* (42 respondents), *time factors* (41 respondents), and *lack of resources and appropriate spaces* (36 respondents). These themes also recur in follow-up interviews. Concerning classroom management, the interviewees mentioned, in particular, the number of students in classrooms and the diversity of students within the same classroom, "I think a big issue is the, ah, difference in understanding within a class" (Teacher X), and the behaviour of students, such as loudness during ABM implementation, "Because they're noisy that they're not on task" (Teacher St). The class size issue is also related to the availability of appropriate spaces and resources:

> When you first do this with students it can get noisy, it can get a bit chaotic, and it also depends on the class size, … So how can we approach this? Maybe having a classroom designated for this, where you can have some time al-, where you're away from the rest of maths classrooms, where the noise is not going to be an issue—next to the drama room, or something—dance room or whatever. (Teacher Su)

> And the other limitation is cost because you can propose lots of activities that, that require costly materials or costly equipment to implement, and so, we're restricted by budget to some degree as to how far we can go with activities, but we can do a lot with what we've got. (Teacher G)

One other main limitation identified in the responses to the questionnaire was the time factor. This theme emerged in the wide majority of interviews, concerning two different time constraints. On the one hand, it concerned the time required for the activities preparation (i.e., designing the activities, searching for resources, structuring, and integrating the activity into the curricular program), e.g., "A lot of preparation to adapt to the class that is in front of the teacher" (Teacher G), "I think it's mainly the time to talk about ideas and map them into the curriculum, into lessons. So, having time to share best practices … One of the biggest barriers is just communication with each other and time to be able to collaborate and come up with ideas" (Teacher J). On the other hand, the time factor concerned class time spent in performing the activity (i.e., the ABM activities are quite time-consuming), "the time it takes. We don't

have a lot of time to get through a lot of content" (Teacher J). Indeed, time considerations were almost always related to the difficulty of addressing all curricular contents:

> The theoretical limit is you still have a certain amount of curriculum to cover in the time. And some of these activities take more time than traditional teaching, so there's a limitation on how many of these activities you could fit into a term or a semester. (Teacher G)

> Here in Australia, given that we have a very content driven curriculum, that is extremely challenging, and particularly in secondary. And it's almost imposs-, I would go so far as to say that in senior secondary, in our Year 11 and our Year 12, here in Queensland, it's virtually impossible to have hands-on activities and sort of activity-type situations. Because it's just, it's s- so heavily content-driven. (Teacher R)

Along with a content-driven curriculum, preparation for mathematics tests was identified as a fostering factor:

> But I often have this tension between time and the curriculum content and making up new activities and engaging activities that might take us even off track from that content. I think most maths teachers would say that there is some kind of tension there with teaching to the tests that we know children are going to encounter, but trying to engage them in thinking and learning and being involved in their learning. That's a bit more open-ended. … We seem to be very locked in to pen and paper formative testing. (Teacher K)

A further constraint, mentioned in interviews, is an unsupportive school culture with mathematical views on what is expected of a math lesson, which can be an obstacle:

> Parents' and kids' views of what mathematics is [is a limitation] as well. Umm, they have a particular view of what mathematics is and if what you do doesn't fit within that view, then (in our school anyway) they're very vocal about, you know, this, this is not what it should be. So, there's a fine line that you've got to walk with, getting kids involved, and also making sure that, umm, see the other side of it is that, whatever I do, everybody's got to do it. (Teacher T)

Implementation

Answering Q21: *Do you include the ABM activities in your instructional practice?*, 41 teachers stated that they included such activities (eight from primary and 33 from secondary school) while 16 answered no (only one from primary and 15 from secondary school). Asking (Q22 Alternative) the reasons why they did not implement, the principal factors were the *lack of time*, the lack *of resources, tools and materials*, the *difficulties in classroom management*, and the belief *they are not appropriate for one's school level*. Looking at the interviews, some teachers indicated that they do have wide expertise with ABM activities, while others (Teachers St, J, X) stated that they were only familiar with such activities on a theoretical level:

> Far removed from my reality. In the ideal world, it would be wonderful to be able to offer that. There are lots of working parts, there are lots of activities going on that impact on the students. Umm, lots of little things that interrupt throughout. [..] It's not taking into consideration the reality of my experience of schooling. (Teacher X)

The answers in the questionnaire showed a tendency for greater resistance to the proposal of ABM activities for secondary school teachers than for primary school teachers. Indeed, the general belief that these activities may be suitable only for children in the lower grades emerged also in follow-up interviews, "In the high school setting, the active body idea really makes it tokenistic. … I think it's more for the early conceptualisation of, basic ideas, in the primary years" (Teacher X). Concerning primary school, teachers described a different situation, "In primary school, they do lots of—I would say they use lots of materials and movement in maths, but then when they get to high school, it just stops, that's it. And it's just books, writing, reading" (Teacher O). Teachers pointed out that in secondary school ABM activities were generally rarer and less suitable, for example, not necessarily applicable to much content, "In my experience, there are few topics that high schools allow themselves to be presented that way without it becoming tokenistic" (Teacher X), "being honest, two lessons out of the 50 are hands-

on and the rest is traditional" (Teacher J). Generally, teachers claimed that they did not carry out ABM activities as often as they would like or give as much space for exploration as desired:

> I think we don't do enough movement. … Occasionally we'll do something with movement in the school, but Yeah, … I can remember reading it and thinking 'oh, we really need to do more of this' of what you could see what you were asking in the questions and I was thinking 'yeah, we don't do enough movement'. (Teacher J)

Conclusion

The survey highlighted teachers' beliefs in the positive impacts of ABM activities, particularly in promoting deep conceptual understanding, enhancing mathematical visualization capabilities, and fostering student interest. Follow-up interviews delved deeper, revealing that teachers believe ABM activities have a long-lasting impact on students' memory by involving multiple senses. Teachers also emphasised the importance of experiential learning for building cognitive roots essential for recalling mathematical concepts and the role of ABM activities in making learning meaningful and engaging, connecting mathematics to the real world. However, several limitations and constraints for implementing ABM activities were identified. One of the main limitations pointed out by teachers is the lack of available time. In the follow-up interviews, we were able to get a better understanding of what teachers meant: on the one hand, the activities require a lot of time both in the classroom and in research and planning; on the other hand, with the time available for face-to-face instruction it is difficult to implement such activities, more time-consuming than traditional transmissive approaches, aiming to cover curricular contents. These statements highlight many subtexts, which can also be deduced from the analysis of other issues. Indeed, teachers do not seem to be so convinced that these activities bring results that are then reflected in standardised tests. Instead, good results in these tests are often the main goal of schools, which tend to measure themselves against NAPLAN assessments and align with the view of mathematics that students and parents have. It is therefore clear that the proposal is perceived by many teachers as ancillary to the planning and goals they are called upon to achieve, particularly in secondary school. Indeed, despite the recognised benefits, there was a tendency among secondary school teachers to view ABM activities as less appropriate compared to their primary school counterparts. This perception was partly due to the curriculum demands. Nevertheless, some teachers expressed a desire to incorporate more ABM activities into their teaching but felt hindered by various practical constraints, such as classroom management and resource availability. This relates both to affordability and, again, to the availability of materials and resources, without spending a lot of time looking for them.

In summary, the exploratory study highlighted that while ABM activities are believed by teachers to be of value for their potential to enhance learning experiences, their integration into classroom practice faces significant barriers, including logistical challenges, curriculum pressures, and differing perceptions of their suitability across educational levels. While the context may therefore limit the implementation of ABM activities, the beliefs of teachers in prioritizing more traditional teaching methods geared toward content transmission, to cover the curriculum and prepare for mathematics tests, should not be underestimated. Although about one-third of students in Australia attend non-government schools, the over-representation in the sample of non-government, especially Catholic, school teachers, as well as highly experienced teachers, must be taken into account for the exploratory teacher survey results interpretation.

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