Why that game? Factors primary school teachers consider when selecting which games to play in their mathematics classrooms

James Russo
Monash University
<james.russo@monash.edu>

Toby Russo
Spensley Street Primary School
<Toby.Russo@education.vic.gov.au>

Leicha A. Bragg
Deakin University
< leicha.bragg@deakin.edu.au>

Research examining teachers' decision making is abundant for pedagogical activities, yet a neglected area is the study of factors influencing teachers when selecting mathematical games. This article sheds light on the factors considered when teachers' select a specific game to use in their primary mathematics classroom. Data from 248 Australian primary teachers was gathered via a questionnaire and thematically analysed. Results indicated four strongly endorsed factors: Mathematics is central; Accessibility and differentiation; Classroom management; and Engagement and enjoyment. Implications are discussed of how this study can inform the decision making of educational leaders, policy makers, and game designers.

Mathematical games are an integral component of primary mathematics instruction. Although there is scant empirical evidence about the frequency of game use, one recent study of Australian early years primary teachers (Foundation-Year 2; n = 135) found that almost all study participants used games at least once per week, with half of teachers incorporating games in almost every mathematics lesson (Russo & Russo, 2020). Given the frequency of game use, we recently wrote a conceptual paper outlining five principles of educationally rich mathematical games to support teachers and pre-service teacher educators identify worthwhile games. These principles included: students are engaged; skill and luck are balanced; mathematics is central; flexibility for learning and teaching; and home-school connections (Russo et al., 2018). However, although we have made normative claims about factors teachers *should* consider when deciding which games to play, we could not identify any studies that examine those factors that teachers *do* consider when deciding which games to play. The purpose of this paper is to address this gap in the literature.

Background Literature

It is a widely held view amongst educators that mathematical games have the potential to support student learning in mathematics. Over three decades ago, Ernest (1986) put forward a rationale for using games in the mathematics classroom, suggesting that games could be used to teach a variety of mathematical ideas, and were perhaps particularly powerful for supporting student understanding of mathematical concepts; allowing for consolidation and practice; developing problem-solving skills; and, enhancing student motivation to engage in mathematics. In addition, it has been argued that opportunities to play mathematical games supports social skill development (Koay, 1996), encourages mathematical reasoning (Olson, 2007), allows for a differentiated approach to instruction (Buchheister et al., 2017; Trinter et al., 2015), and can be used to explore multiple connected mathematical ideas (Clarke & Roche, 2010). Indeed, there is empirical evidence to suggest that games are efficacious for engaging students in mathematics learning (Bragg, 2007; Campos & Moreira, 2016) and improving student learning in mathematics (Bragg, 2012b;

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Bright et al., 1985; Swan & Marshall, 2009), including for students in the early years (Cohrssen & Niklas, 2019; Elofsson et al., 2016). A recent meta-analysis exploring the effectiveness of mathematical games across all levels of education revealed that games had a medium positive impact on academic achievement compared with what were described as "traditional methods" of mathematics instruction, such as worksheets (Turgut & Temur, 2017, p. 196).

Although there has been substantial research into the impact of games on the student mathematical learning experience, especially in relation to digital games (see Abdul Jabbar & Felicia, 2015), how teachers use mathematical games in classrooms has been far less of a focus. One exception was a study by Heshmati et al. (2018), who examined the use of a game to support the teaching of fraction concepts in a naturalistic classroom based setting. The authors videotaped and analysed mathematics lessons across 14 US fifth grade classrooms during the teaching of a unit of work focussed on fractions. They found that 20% of lessons involved the use of a game to support fraction instruction for at least part of the lesson, and that games were used almost exclusively to consolidate student understanding, rather than introduce concepts. This latter finding is consistent with the literature that teachers frequently use games to support practice and the development of procedural fluency, particularly with number (Godfrey & Stone, 2013; Graven & Roberts, 2016). However, whether this is the predominant rationale for teachers using games in mathematics classrooms remains to be systematically investigated.

The current study

In order to address some of the gaps identified in the literature around primary teachers' use of games to support mathematics instruction, we invited teachers to complete a questionnaire. In total, 248 Australian primary teachers responded. We have published our initial, predominantly quantitative, findings focussed around primary teachers' motivation for and frequency of game usage, their game execution within lesson routines and structures, and their perceptions of the efficacy of games to achieve particular pedagogical objectives (Russo et al., 2021). Some key findings include:

- Consistent with Russo and Russo (2020), 98% of teachers reported using games at least once per week to support their mathematics instruction, whilst 79% reported using games multiple times per week.
- Teachers used games in a variety of contrasting ways to support mathematics instruction. For example, whilst three-quarters of teachers indicated they employed games multiple times per week as a warm-up to begin a mathematics class, almost half of teachers (45%) responded that they used games multiple times per week as a context for launching rich mathematical investigations.
- Reaffirming perhaps the most consistent finding in games research (Bragg, 2003; 2007; Campos & Moreira, 2016), all teachers agreed that games were an effective means of engaging students in mathematics, with 82% of teachers strongly agreeing with this statement.
- There was strong evidence that teachers preferred using non-digital games and tactile materials. When asked about their favourite mathematical game to use in a classroom, only 4% of teachers described a game which involved students or the teacher interacting with a digital technology in any capacity (e.g., calculator, random number generator, interactive number chart, supportive software), whilst only 1% selected a digital game specifically. This stands in stark contrast to the relative focus

on digital games within the education research literature (Abdul Jabbar & Felicia, 2015).

- Perhaps surprisingly, given the oft-remarked connection between games and building mathematical fluency (Godfrey & Stone, 2013), teachers indicated that they viewed games as being equally effective for developing all four proficiencies highlighted in the Australian Curriculum: Mathematics (ACARA, 2019): fluency, understanding, problem-solving, and reasoning.

The purpose of the current paper is to present additional qualitative analysis from the questionnaire data. Specifically, we focus on one specific free text response item in the questionnaire to shed light on the factors teachers consider when deciding which games to use in their mathematics classroom.

Method

Two hundred and forty-eight teachers completed the questionnaire focused on how they use mathematical games in their classrooms. Participants were spread across all years of primary education in Australian classrooms: Foundation-Year 2 (31%); Year 3-4 (25%); Year 5-6 (29%); taught across multiple year level groups (15%). Respondents were relatively experienced primary school teachers, with a median period of 10 years classroom teaching experience (mean = 13.2; SD = 9.3; Min = 1 year; Max = 51 years).

The questionnaire was administered through an online survey platform, Qualtrics. Snowball sampling was employed to disseminate the questionnaire, with the questionnaire link being distributed via email to 15 key informants based in three Australian states, as well as through social media platforms. Teachers currently teaching in an Australian primary education context were invited to complete the questionnaire. Two hundred and thirty-six teachers responded to the qualitative item that serves as the focus of the current paper. This item was: Which factors do you consider when selecting which games to play in your classroom?

Data was analysed thematically, approximating the process outlined by Braun and Clarke (2006). We began by reading and rereading questionnaire responses, the purpose being to immerse ourselves in the data. As we reread the responses, several proto-categories emerged. These proto-categories were clarified, refined, combined, and then elaborated to comprise our final ten themes (see Table 1). For example, the proto-categories ‘materials easily sourced’, ‘simple game mechanics’, and ‘time’, were eventually aggregated into the theme *classroom management*.

Results and Discussion

Table 1 displays the results of our thematic analysis, noting the number of teachers whose response was coded to each of the ten themes, as well as two quotations from teachers that help to illustrate this theme. Note that teacher responses could be coded to multiple themes. For example, the following response was coded to two themes, *mathematics is central* and *enjoyment and engagement:*

> Will these games increase mathematical awareness, do they tie into the maths lessons and how much do they promote engagement in the lesson and maths in general? Teacher Number 111 (T111)

From viewing the table, it is apparent that there were four themes frequently endorsed by participants: *mathematics is central; accessibility and differentiation; classroom management; and engagement and enjoyment*. Each of these four major themes will now be discussed, with relevant links made to the academic literature.

Table 1
Thematic analysis of factors teachers considered when selecting which games to play

Theme	Number (%) (n = 236)	Example quotations
Mathematics is central: connection to mathematical learning focus and/ or suitability of game for building conceptual understanding and procedural knowledge	183 (78%)	Linked to a specific mathematical focus, connected to the needs of the student group. (T1) How it enables the student to practice the concept that has been introduced if it is the main activity of the lesson. (T196)
Accessibility and differentiation: accessible for students and capacity for differentiation across age, mathematical performance, reading abilities	127 (54%)	How can the game be modified with enablers or extenders to cater for all students? (T63) Something that will provide a level of challenge for students working at all levels, possibly with progression or layers. (T183)
Classroom management: organisation, availability of required materials, setup time, noise level.	110 (47%)	How much equipment is needed? Do I need to make any of the resources? Are the instructions simple? Is it easy to get started/independent? (T8) The time it will take (set up, finding the materials, providing the instructions). (T82)
Engagement and enjoyment	91 (39%)	We want our kids to develop a love for numbers and maths and approach the subject without fear. Games are perfect for that reason. Kids love them. (T61) If the activity will engage the students for a sustained period of time. (T65)
Communication and reasoning: opportunities for encouraging mathematical dialogue, student reasoning and language development	24 (10%)	A way to share mathematical language, thinking and reasoning. (T2) The relevance of the maths language used in the game. (T224)
Supporting social and emotional development: opportunities for collaboration, interaction and learning how to play with others	21 (9%)	I like to make sure that games can be played with a partner to ensure students get to work together. (T76) Teams. Usually random so not necessarily 'fair', just like in real life! (T230)
Thinking strategically: developing strategic thinking, skillful behavior and providing opportunities to solve problems	21 (9%)	Opportunity for the move that a player makes to effect the move of their opponent/s…Opportunity for strategies to be articulated and developed (T15) One that allows students to stop and reflect on the mechanics of the game and explore ways to become more efficient in playing the game. (T35)
Skill and luck are balanced	16 (7%)	Games that allows children to experience success based on skill and also an element of luck (T49) Games that involve a bit of luck as well as skill/ strategy so that all students have a chance at winning regardless of their ability. This means that struggling students are more likely to want to keep playing the game. (T87)
Game adaptation and inquiry: opportunities to transform the game into an investigation and extend student mathematical thinking	12 (5%)	Does it support rich mathematical investigation? (T55) Does the game have the ability to be 'ramped' up over the week with further investigations into the strategy or reach a higher level of thinking. (T67)
Supporting assessment of student thinking and mathematical knowledge	4 (2%)	Quick formative assessment 'check in' (T2) What would assessment of game look like (T210)

Note. The mean number of themes a teacher response was coded to was 2.8

Mathematics is Central

The most frequently endorsed theme that emerged from the data related to choosing games with explicit connections to an identified mathematical learning focus, as well as games that could further student conceptual understanding of a particular concept, or their application of a particular procedure. This reaffirms the supposition that primary teachers tend to use games for specific mathematical purposes, rather than for engaging students in mathematics irrespective of the content.

Several teachers referred to the fit between the chosen game, and the intended learning intention. For example:

> The learning intention - what is it that I want the children to understand? The maths knowledge required - are there any barriers or misconceptions that might come up? (T181)

However, others indicated that the game may not always be connected to the learning objective of the current lesson, but instead be used to reinforce previous learning or as a cognitive activation device:

> Does the game support the learning intention of the lesson? Not always, however, sometimes they are selected to consolidate learning from previous units or just to get their 'maths' brains attuned. (T96)

In fact, the notion of using a game to build number fluency, practice a skill, or to consolidate student understanding was an important sub-theme to emerge that was explicitly noted by over one-quarter of teachers coded to this theme (n = 48).

> Does it help to consolidate a skill? Is it for reviewing a skill? (T70)

Interestingly, on occasion, teachers noted how the purpose of a game might evolve over time, initially using a game to build conceptual knowledge, and then using the game to reinforce understanding in subsequent lessons:

> I will teach a new game to introduce then consolidate a new skill. Once the game is understood and knowledge in the concept understanding is at a reasonable level, the game becomes a more regular warm up. (T88)

Accessibility and Differentiation

Over half of teachers noted that when considering which games to play in the classroom, they contemplated the extent to which the game was inclusive of all students and whether they could modify the game to align with the learning needs and performance levels of a diverse group of students. This is consistent with literature suggesting the flexibility of games to support differentiated instruction is a comparative strength of this pedagogical approach to teaching mathematics (Buchheister et al., 2017; Trinter et al., 2015). Some teachers specifically commented on the capacity to adjust game mechanics to optimise the level of challenge:

> Ability to differentiate to cater for different skill levels. For example, games where the rules can be changed or built on as students develop or where 6 sided dice can be replaced with 10, 12 etc. sided dice to make it more challenging. (T87)

Other teachers emphasised the need for the game to have various entry levels, so that a student's prior mathematical knowledge was not a barrier to them participating in the game:

> I ensure it is fun and engaging and has different entry points for different students based on what they understand. (T196)

Similarly, there was a reference to the value of a game having a 'low-floor, high-ceiling':

> Whether it has a low entry point and high ceiling to cater and challenge all students. (T107)

In the words of one teacher, considering "how the game could be extended or scaffolded" was principally about supporting "maximum participation" in the lesson (T210), a sentiment consistent with both high quality and equitable mathematics instruction (Sullivan, 2011).

Classroom Management

Approximately half of teacher respondents (54%) described practical considerations as being a critical factor when deciding which specific games to play in their classroom, encompassing aspects such as the accessibility of materials, the time needed to explain and set up the game, and whether student groups could play independently and remain on-task. The emphasis on classroom management is noteworthy, particularly given such factors have generally not been highlighted in the games research literature in the few empirical studies that have focussed on teachers' use of games (e.g., Heshmati et al., 2018).

Indeed, the importance of incorporating easily available materials was one of the reasons teachers tended to endorse dice and card games over more elaborate alternatives that involved the need to create, locate, or purchase specialised equipment:

> Resources. Can I use materials I already have, or does the game need special equipment? I usually go for games that use dice, playing cards, or readily available equipment over those that have a specialised game board. (T181)

To some extent, it appeared that the reluctance to use games involving specialised materials was due to the time investment needed:

> Resources. For example, games that use dice, cards, counters etc. are better than games where I have to make game boards etc. which can be time consuming; although I do do this. (T87)

As alluded to earlier, time was also mentioned in relation to minimising lost instructional time by ensuring the game is easy to set up and play.

> Materials required. Being able to be play the game and pack up in under 10 minutes. (T77)

Engagement and Enjoyment

In contrast to the theme of classroom management discussed previously, engagement and enjoyment are concepts frequently mentioned in connection to games in the literature (Attard, 2012; Bragg, 2003; 2007; Bright et al., 1985). Indeed, as reported elsewhere, our study teachers highlighted engagement as the principal pedagogical benefit of games (Russo et al., 2021), whilst other studies have concluded that the comparative advantage of games over other activities relates to their capacity to engage and maximise on-task behaviour (Bragg, 2012a; 2012b). Consequently, it is not surprising that many teachers emphasised that the game be engaging and enjoyable to play:

> Engagement - the more students that are interested in math and learn to see math as an enjoyable everyday part of life is a win in my opinion. (T166)

> It needs to be engaging and fun. (T223)

What is surprising, at least ostensibly, was that only a minority of teachers (39%) mentioned levels of student engagement and enjoyment as being relevant when choosing which games to play in their classroom. One possible interpretation of these data is that teachers primarily associate high levels of engagement with the general category of games, whilst the specific level of engagement generated by a particular game is only a secondary consideration. To put it another way, if (almost) all games are considered engaging, then this dimension might be less important when deciding which specific game to choose.

Conclusions and Implications

In conclusion, to deepen the understanding of games usage from the teachers' perspective, this paper presents an investigation of the factors influencing teachers when selecting mathematical games for inclusion in their primary classroom. Ten themes were drawn from these data, with four of the themes taking prominence. Mathematics being central to the selection of the games was the leading consideration for teachers. Hence, key to games selection was the enhancement of students' mathematical understandings. These teachers recognised the usefulness of games as a tool for mathematical learning.

More than half the teachers were cognisant about extending their students' knowledge and skills from different starting points through games. This aligns with initiatives across Australia to include differentiated teaching as a high impact teaching strategy recommended in schools (e.g., Department of Education and Training, 2017). The emphasis on differentiation in these teachers' responses provides possible evidence for policy makers of the effect these initiatives are having on teachers and their classroom decision making.

Classroom management, with an emphasis on organisational matters, was a consideration for many teachers. While educators may appreciate the mathematical value inherent in some complex, expensive, or time-consuming games, the practicalities of utilising such games were considered and potentially discounted. This factor has implications for game designers and individuals responsible for purchasing and organising educational resources (e.g., numeracy coordinators). It emphasises the significant practical considerations that primary school teachers need to consider on a daily basis, and the premium placed on simplicity and ease of access when planning and implementing learning tasks.

Enjoyment and engagement are often presented as key factors for inclusion of this non-traditional approach to teaching mathematics; and indeed were emphasised by all our study teachers as reported elsewhere (Russo et al., 2021). Although still a prevalent theme when choosing which specific game to play, as discussed earlier, it may be that engagement was a secondary consideration for many teachers because engagement is associated with games as a pedagogical category, more so than specific games. What these teachers mean by engagement requires further investigation and will be explored in future research.

Encouragingly, the findings of this research support four of the five principles of educationally rich mathematical games raised in our earlier conceptual paper (Russo, et al., 2018). Absent from these teachers' considerations was mathematical games providing opportunities for fostering home-school connections. The questionnaire was administered prior to the COVID-19 pandemic forcing school closures and children learning from home with family support. Hence, the relevance of selecting games which support home-school connections may be more pertinent to teachers today. Making a home-school connection via games will raise the status of games amongst the broader school community from merely an enjoyable pastime to a valuable educational tool to be played at home and school.

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