Journal of Research and Advances in Mathematics Education

Volume 10, Issue 1, January 2025, pp. 41 – 54
DOI: 10.23917/jramathedu.v10i1.6398
p-ISSN: 2503-3697, e-ISSN: 2541-2590

The agency of mathematics clubs as panacea for efficacious pedagogical praxis: A grade 3 case study

Headman Hebe[1*], Gasenakeletso Hebe[2]

[1] *Department of Science and Technology Education, University of South Africa, South Africa*
[2] *North West Provincial Department of Education, South Africa*

Citation: Hebe, H., & Hebe, G. (2025). The agency of mathematics clubs as panacea for efficacious pedagogical praxis: A grade 3 case study. *JRAMathEdu (Journal of Research and Advances in Mathematics Education),* 10(1), 41–54. https://doi.org/10.23917/jramathedu.v10i1.6398

ARTICLE HISTORY:
Received 20 August 2024
Revised 18 November 2024
Accepted 5 December 2024
Published 30 January 2025

KEYWORDS:
Early childhood education
Mathematics
Mathematics clubs
Play-based pedagogy

ABSTRACT

Mathematics is, universally, considered the heartbeat of the Science, Technology, Engineering and Mathematical (STEM) education. Accordingly, the learners must be equipped with strong mathematical proficiency very early in life. This behoves mathematics practitioners to use various impactful pedagogical strategies. The bigger action research from which this paper derives investigated, through the use of qualitative and quantitative approaches, the potential of mathematics clubs as a strategy to improve learner performance in early childhood education (ECE). Since there is already a published report on the bigger study, this paper focuses only on teasing out the factors that enabled the success of the maths clubs which participated in this study. The current study is essential because the literature reviewed underscores a paucity of research that focuses on factors enabling the efficacy of maths clubs. This qualitative study relied on interviews with participant-teachers and observations by the field researcher. Vygotsky's sociocultural framework and the Appreciative Inquiry model underpinned and guided the study. The findings of this study indicate the following as efficacy-enablers in maths clubs: play-based pedagogy, code-switching, the use of real-life scenarios in pedagogy, learner independence in problem-solving, participant collaboration and small classroom sizes. The study advocates for more research on factors enabling effectiveness in maths clubs and challenges policy decision-makers to transform everyday classroom settings to model mathematics clubs scenarios.

INTRODUCTION

The central role of mathematics in the field of education and human capital development requires little, if any, debate concerning its vitality as there is growing consensus among, inter alia, scholars, policy decision-makers and various stakeholders in the realm of education (Fitzmaurice et al., 2021; Human et al., 2015; Lundqvist et al., 2023) that this subject is invaluable. Within the space of Science, Technology, Engineering, and Mathematics (STEM) education; mathematics is considered "the language that underpins all other STEM disciplines" (Fitzmaurice et al. 2021, p. 1). In the broader field of education, strong foundational mathematical skills and proficiency have been found to help improve educational outcomes in later years (Vogt et al. 2018; Wickstrom et al. 2019). However, notwithstanding the well documented importance of mathematics, there is evidence that learners in many countries, globally, perform poorly in this crucial subject. South Africa, the country in which the current study was conducted, is one of those countries with notable poor performance in mathematics.

*Corresponding author: hebehn@unisa.ac.za

Like numerous other countries, globally, South Africa has participated in several assessments conducted as part of the Trends in International Mathematics and Sciences (TIMSS). TIMSS has a fundamental goal "to assist countries to monitor and evaluate" (Reddy et al., 2022, p. 5) their mathematics and science attainment in primary and secondary school education. In a quest to improve the pedagogical standards and learner performance, South Africa has participated in six of the seven TIMSS tests at grades 8 and/or 9 and twice at grade 5 TIMSS mathematics tests since its inception in 1995 (Reddy et al., 2012; Reddy et al. 2022). Apart from TIMSS, South Africa has participated in numeracy tests conducted by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) since its inauguration in 1995 (Hungi et al., 2010). However, owing to the global nature of TIMSS, this paper highlights a few points regarding the performance of South African learners in TIMSS tests.

Various TIMSS reports suggest that, compared to many other countries in the world, the South African Grades 5 and 9, respectively, perform poorly in terms of the international benchmarks used to reflect on the learners' mathematical proficiency. In essence, when measured in terms of the TIMSS international benchmark of the four points scale, namely, Low (400 to 475 points); Intermediate (475 to 550 points); High (550 to 625 points); and Advanced (>625 points), between 1995 and 2019; South Africa has consistently scored below 400 points in Grades 5 and 9, respectively (Isdale et al., 2017; Reddy et al., 2022). For example, in their first TIMSS Grade 5 mathematics participation, South Africa scored 376 and in 2019, the country dropped to 374 points (Isdale et al., 2017; Reddy et al., 2022). Likewise, in their Grade 9 mathematics TIMSS sitting in 2015, the country scored 372 and, even though there was an improvement in 2019; this improvement to 389 points still falls short of the lowest 'acceptable' average of between 400 and 475 points (Reddy et al., 2022). Accordingly, this suggests that there is a serious need for urgent, tangible, and on-going interventions to improve learner performance in mathematics.

The authors of this paper contend that, if they are to yield any positive results, such intervention strategies need to be conceived and implemented very early in the schooling years, preferably in the Early Childhood Education (ECE) stage. This assertion is predicated on extensive empirical evidence which suggests that early education interventions, particularly in mathematics education, tend to have a positive impact on the educational development and performance of a child in later years (Aunio et al., 2021; Björklund et al., 2020; Clements & Sarama, 2011). For this reason, a myriad of creative, meaningful, and long-lasting interventions must be developed to offset the current *status quo* in mathematics learner attainment in South Africa. Mathematics clubs have proven to be one of the most successful interventionary strategies both in South Africa and in other parts of the world (Graven, 2016; Papanastasiou & Bottiger, 2004). Nevertheless, the literature reviewed for this paper suggests that most of the research conducted on mathematics clubs in formal school settings tends to focus more on senior classes rather than on ECE (Graven, 2016). Furthermore, there is hardly any research that specifically focuses on the factors that (potentially) lead to the effectiveness or success of maths clubs. Hence, the dearth of research which focuses on the application and impact of mathematics clubs in ECE necessitated the current research. There is, therefore, a fundamental need to conduct more studies on maths clubs withinin the space of ECE, significantly, studies with focus on the factors that contribute to the effectiveness/success of mathematics clubs are needed.

Accordingly, this paper, which is a product of a bigger study whose aim was to explore possible strategies, within the context of mathematics clubs, to mitigate underachievement among the Grade 3 learners, teases out some of the aspects that the current researchers considered as key elements that enabled improved learner performance and thus, arguably, rendered the mathematics clubs (in the context of the study conducted) successful. This success was measured in terms of the results of the pre- and post-intervention assessments conducted in the study. These results were published in a different report; hence the current researchers do not reflect on the details of the results as this would be a repetition of what has already been reported. Nonetheless, for the purposes of this paper, in the research method section of this discussion, the current researchers reflect briefly on the results of those pre- and post-intervention assessments. Accordingly, the research question that this paper seeks to answer can be phrased as follows: What factors, within the maths clubs, led to the 'relaxed'

atmosphere culminating in overall improvement in learner performance as measured through the pre- and post-intervention assessment results?

However, for the purposes of this discussion and in view of the paucity of research in respect of mathematic clubs' efficacy, a brief reflection on the nature, purpose and some of the factors enabling the effectiveness of math clubs is essential.

Mathematics clubs: Nature, purpose and impact-enabling factors

As already stated, literature suggests that, globally, much work still needs to be done on mathematics clubs in the realm of research. Accordingly, Brodie (2022) writes, in respect of mathematics clubs, that "almost half of the clubs reported on took place in the United States, with others in Sweden, Australia and Israel, and only one in South Africa" (p. 239). Nevertheless, where they exist(ed) mathematics clubs, generally, tend to be effective. Owing to the dearth of research on mathematics clubs, and for the purposes of this study, this section provides a brief reflection on the purpose and nature of mathematics clubs, as wel as the factors enabling their positive impact.

Mathematics clubs are established for a variety of reasons. However, for the purposes of this discussion only a few that seem to stand out are mentioned. The establishment of mathematics clubs may be purposefully done for learners or students who are considered, based on their scores, outstanding or gifted in mathematics. Ostensibly, these 'elitist' establishments, specifically, target exceptional students in mathematics "to promote individual self-fulfilment" (Fenoll et al., 2021, p. 738). The people who establish 'elitist' mathematics clubs, exclusively for the 'gifted', are of the view that these learners or students have needs to interact with peers of equal talent for their growth and self-esteem to be (further) enhanced. Accordingly, Hornstra et al. (2023) claim that gifted children require "optimally challenging learning environment" (p. 1) to "address motivational problems encountered by gifted students in regular classes" (ibid). These clubs are found in numerous countries, for example, in the Unites States of America, Israel and etcetera (Amit & Naaman, 2014; Fenoll at al., 2021). Likewise, maths clubs can be established without specifically targeting 'exceptional' learners or exclusively "mathematically talented youth" (Amit & Naaman, 2014, p. 1403). However, these clubs can be established to mitigate poor performance in mathematics with the intent to strengthen learning and teaching dispositions for both teachers and learners (Graven, 2016; Morrison et al., 2023) as well as to foster enjoyment and love for mathematics (Lampen & Brodie, 2020).

By their nature and design, mathematics clubs are voluntary (of course this is not applicable to 'elitist' mathematics clubs that target 'exceptional' students) and are, usually, meant to cater for a few facilitators and learners. Mostly, they are established to try out and explore various learning and teaching strategies to enhance maths pedagogy, the love for the subject and ultimately improve(d) learner attainment; the last aspect being, arguably, the most important in advancing STEM education (Amit & Naaman, 2014; Graven, 2016). Although they are sometimes formed to cater for the students from a single institution and are, therefore, located within the institutions they serve, with activities conducted anytime deemed convenient for the participants and the institution (Foote, 2008); most mathematics clubs are meant to cater for learners from more than one institution, usually, in selected afternoons for a specific period (Lampen & Brodie, 2020; Stott, 2016).

Evidence suggests that, for a plethora of reasons, maths clubs tend to be successful in the attainment of the goals which prompt(ed) their establishment. However, owing to the paucity of research that specifically focusses on the reasons for the success of mathematics clubs, only a few are mentioned in this discussion. For example, one of the notable characteristics which, ostensibly, make mathematics clubs successful is the use of language. Practitioners in these clubs realise the importance of using the language that can be considered accessible and is thus learner friendly. For this reason, maths clubs do not confine themselves to 'official' languages of teaching and learning instead they permit code-switching (Diez-Palomar et al., 2006; Norén, 2015). Therefore, the language that is accessible to learners enables them to comprehend the instructions from facilitators, use their own creativity with ease to cognise and generate responses that have meaning to them. Furthermore, the pedagogical approaches that are learner-centred and closer to real life experiences of the learners are used to make learning, meaningful, fun and practical (Lampen & Brodie, 2020).

Another significant and central aspect that seems to enable maths clubs to be successful is collegiality and collaboration between and among participants, i.e., in respect of both the facilitators and learners. This is enabled through discussions, ongoing and meaningful interactions and shared expertise and approaches to pedagogy (Brodie, 2022). For example, in their research, Karp and Niemi (2000) observed that facilitators in maths clubs would hold meetings to share information and discuss ways in which they could help growth in learner mathematical proficiency. Likewise, Papanastasiou and Bottiger (2004) noted in their study on mathematics clubs that learners worked collaboratively and that this led to less stress and improvement in learning. Accordingly, they write that, "through their low stress environment, clubs enable students to learn about teamwork and the importance of cooperation and mutual support" (Papanastasiou & Bottiger, 2004, p. 161).

Certainly, there are multitudes of factors that enable success in maths clubs. However, as attested earlier, these factors are, virtually, not explored through studies. For this reason, this paper seeks to underscore the factors that could have led to the success of the clubs that participated in the current study. However, before this is done, a brief reflection on the theoretical framework underpinning this study is conducted and, thereafter, a discussion on the research method undertaken in this study is presented.

Theoretical framework

It is significant to mention that the bigger study on which this paper is based, was guided by Vygotsky's sociocultural framework. Likewise, the current study was guided by the same theoretical framework. This theory puts an emphasis on the role of social partners or people who engage in ongoing interaction within a specific social space to influence one another's behaviour (Topciu & Myftiu, 2015; Vygotsky, 1986). Accordingly, the study focused on how the social interaction between the teachers, the learners and the second author of this paper, hereafter referred to as the primary researcher, panned out to influence pedagogy and ultimately the improvement of learner performance as measured in terms of the pre- and post-intervention assessment results.

However, for the purposes of this paper, which specifically focuses on the factors that were deemed the reasons behind the success of the maths clubs that formed part of the study, the current authors were guided by the Appreciative Inquiry Model. This highly adaptable model (Mohr & Watkins, 2002) is attributed to the work entitled, *Appreciative Inquiry in Organisational Life* (Cooperrider & Suresh Srivastva, 1987) and has been applied in various fields, including education transformation (Giles & Alderson, 2008). The model was deemed appropriate for this paper because it (the paper) focuses on the positive aspects of a project and seeks to examine the factors that could have led to the effectiveness of an intervention process (Talcott & Scholz, 2015). This model consists of five stages, viz. defining, discovering (appreciating), dreaming, designing and delivering (Mohr & Watkins, 2002). These stages can be summed up as follows:

1) Defining – this entails conceptualising and clarifying the question which guides and narrows the scope of an inquiry.
2) Discovering – this step involves teasing out and highlighting the aspects or factors that enabled the project to be successful, hence this step is often referred to, aptly, as "appreciating" the factors that made all the difference to make a programme successful.
3) Dreaming – this stage is about imagining or envisioning a future that is characterised by more positives within an organisation or programme.
4) Designing – here the programme participants, guided by the positives identified, develop or enhance the positives of a programme, organisation or project by identifying and factoring in elements that lead to greater and more positive changes.
5) Delivering – this entails the implementation of the strategy designed to enable more positive changes

This model was deemed significant, particularly, considering the point made by Bushe (2001) who writes that, the "appreciative inquiry is the collection of people's stories of something at its best. If we are interested in team development, we collect stories of people's best team experiences. If we are interested in the development of an organization, we ask about their peak experience in that organization" (p.1). This point is accentuated by Mohr and Watkins (2002) who argue that "learning from moments of excellence serves as the foundation of Appreciative Inquiry (AI)" (p. 11). Therefore,

this model was considered relevant here as the authors of the current paper, sought to examine, through the lens of both the teachers who participated in this study and the observations made by the primary researcher who was the key tool in data collection the factors that enabled pedagogical success in the maths clubs. Significantly, because of its adaptability, this model is applicable even in completed projects to facilitate reflect on what could have made the project a success.

For the purposes of this study, it is significant to state that, the first three stages of the Appreciative Inquiry, mentioned above, were deemed relevant. The scope of the enquiry has already been highlighted earlier in this paper as summed up by the question of inquiry namely, what factors within the mathematics clubs led to the 'relaxed' atmosphere culminating in overall improvement in learner performance as measured through the pre- and post-intervention assessment results? In terms of the second stage, the responses of the participant-teachers during the interviews together with the observations by the primary researcher, as the key data collection tool, are used to tease out and 'appreciate' the factors that could have led to the positive outcomes of the project. The aspect of 'dreaming' or envisioning the future is addressed through the recommendations in the conclusions section of this paper.

METHODS

The participants were drawn from four schools which catered for Grade 3 learners in one township in the Maquassi Hills area which falls under the ambit of the Dr. Kenneth Kaunda Education District in the Northwest Province of South Africa. The sample consisted of 12 teachers (03 teachers per school) and 144 learners (36 learners per school). The research respondents were selected purposively and opportunistically; hence, their enlisting was predicated on their availability and willingness to partake in the study (Golzar et al.,2022; Nyimbili & Nyimbili, 2024). This was done with due consideration for time constraints and limited resources. The selection of the learners was done by the teachers with focus on the learners who achieved an average of less than 50% in the first term of the school year. In total, 12 Mathematics Clubs were formed and thus participated in the intervention action research.

Various activities took place during the 15 weeks of the project. These included three workshops conducted by the primary researcher for the participant-teachers. Furthermore, the learners wrote a pre-intervention test which focused on all four basic operations used in mathematics. Thereafter, the participant-teachers, with the guidance of and close observation by the primary researcher(the second author), conducted pedagogical actions (they facilitated teaching and learning in the maths clubs), which were centred on hands-on activities, individual and group activities by the learners. These included the use of games, collaborative learning and learner-initiated problem-solving approaches; all of which made learning and teaching fun. Additionally, as explicated later in this discussion, apart from guiding the activities in the mathematics clubs the primary researcher observed and journalled (recorded in writing) all the activities she observed in the maths clubs that formed part of the study.

During the final week of the project, the learners sat for a post-intervention assessment. The results of the pre- and post-intervention assessments were compared and there was a notable improvement in learner performance, discernible from the post-intervention assessment results as depicted in Table 1. Likewise, the accompanying Figure 1, indicates the overall average percentage (%) improvement in learner performance when the clubs are put together. It must be emphasised that these scores, which have been discussed in detail as part of the results and findings in a different (already published) paper, are presented here only as evidence that the interventions made during the 15 weeks of conducting a maths clubs programme yielded positive results.

It must be noted that owing to circumstances such as transport issues, 27 of the learners did not complete the whole duration of the project. For this reason, the results of the post-intervention assessment as shown in the table below, indicate a total of 117 learners. Therefore, not all learners who were part of the programme, upon inception, were able to sit for the post-intervention assessment on the 15th and final week of the programme.

Nevertheless, as indicated in Table 1, the post-intervention assessment results indicate that there was an overall improvement in learner performance in each club regarding all the four basic

Table 1
Data depicting pre- and post-intervention assessment scores in the 12 clubs

Club	No. of learners	Pre & post score analysis					% point change (4 operations)			
		Average Pre Score	Average Pre %	Average Post score	Average Post %	Overall average % point change	Addition	Subtraction	Multiplication	Division
CLUB O	7	8.57	42.86%	12.86	64.29%	21.43%	8.57%	20.00%	14.29%	42.86%
CLUB P	12	7.42	37.08%	10.58	52.92%	15.84%	15.00%	-3.33%	21.67%	30.00%
CLUB Q	7	7.57	37.86%	11.29	56.43%	18.56%	17.14%	22.86%	25.71%	8.57%
CLUB R	12	9.42	47.08%	12.08	60.42%	13.34%	8.33%	15.00%	21.67%	8.33%
CLUB S	3	6.33	31.67%	10.00	50.00%	18.33%	13.33%	6.67%	26.67%	26.67%
CLUB T	12	7.58	37.92%	9.75	48.75%	10.83%	13.33%	13.33%	13.33%	3.33%
CLUB U	10	8.70	43.50%	11.8	59.00%	15.50%	10.00%	12.00%	14.00%	26.00%
CLUB V	6	10.67	53.33%	11.67	58.33%	5.00%	6.67%	3.33%	23.33%	-13.33%
CLUB W	12	8.08	40.42%	11.42	57.08%	16.66%	25.00%	11.67%	16.67%	13.33%
CLUB X	12	8.50	42.50%	11.75	58.75%	16.25%	20.00%	8.33%	18.33%	18.33%
CLUB Y	12	7.92	39.58%	12.92	64.58%	25.00%	26.67%	21.67%	30.00%	25.00%
CLUB Z	12	7.42	37.08%	12.92	64.58%	27.50%	25.00%	21.67%	25.00%	38.33%
OVERALL AVERAGES		**8.18**	**40.90%**	**11.59**	**57.92%**	**17.02%**	**15.75%**	**12.77%**	**20.89%**	**18.95%**

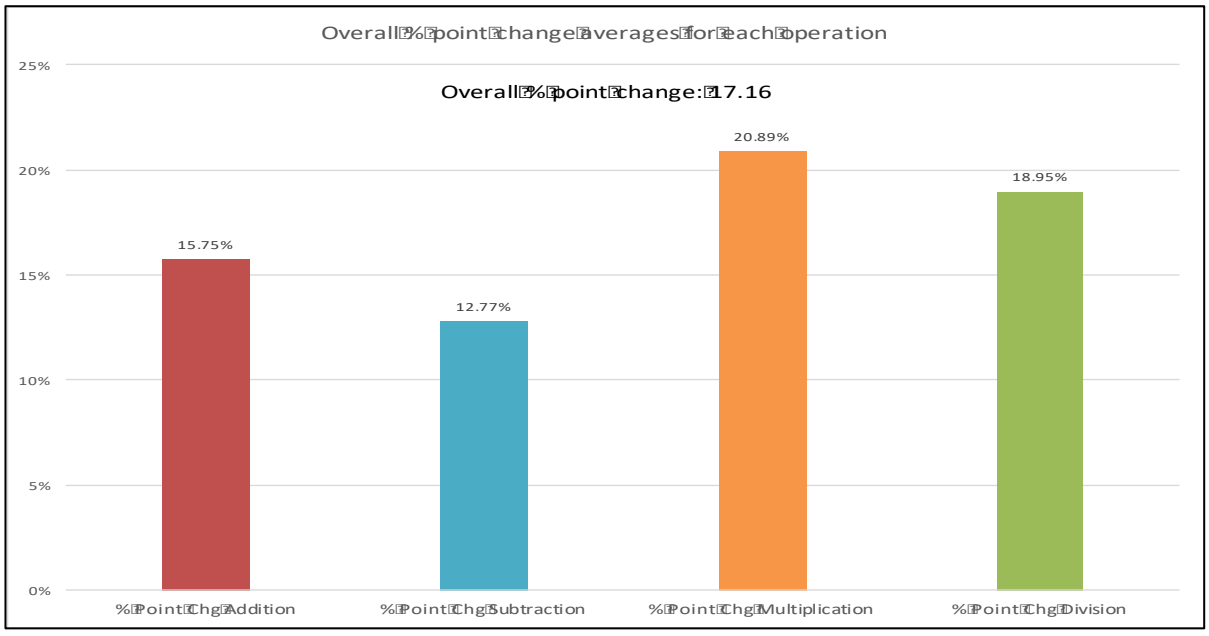

Figure 1. The overall post-intervention improvement for each mathematical operation

mathematical operations. For example, in respect of Club O, in a test set out of 20 marks, the pre-intervention assessment score yielded an average score of 8.57 marks per learner. In term of percentages, this score amounted to 42.86%. The post-intervention assessment score improved to 12.86 marks, which amounted to 64.29%. Overall, the same Club O recorded improvements in each basic operation assessment scores when the pre-intervention assessment results were compared to post-intervention results as follows: addition (8.57%), subtraction (20.00%) multiplication (14. 29%) and division (42. 86%). In terms of the 12 Maths Clubs put together, there was an improvement

in leaner performance, in each basic operation, as measured through the post-intervention scores as well. This improvement is depicted in Figure 1 as follows: addition (15.75%), subtraction (12.77%), multiplication (20.89% and division (18.95%). The Figure 1 highlights the overall improvement in learner performance in all twelve maths clubs that participated in the study as noted in the post-intervention assessment results.

As indicated in the introduction of this paper, the preceding points needed to be presented to underscore the assertion that there was notable improvement in the participant learners' performance, discernible from the post-intervention assessment results. This improvement depicts the effectiveness of the interventionary strategies used in the mathematics clubs in the study.

Furthermore, as part of the bigger study on which this paper is based, nine out of the twelve teachers were interviewed to obtain their impression of the intervention programme. The interviews were audio-recorded with consent from each participant. Furthermore, as indicated in the findings section, pseudonyms are used to conceal the identity of each interviewee. The other three teachers exercised their ethical right and, thus, chose not to participate in the interviews. Additionally, the current study uses evidence from data collected through participant observations by the second author, as the main qualitative researcher, to explicate the findings (Zahle, 2019).

Generally, the participant-teachers indicated that participation in the programme was beneficial to them and their learners. Significantly, the word 'relaxed' was a notable refrain used by the teachers interviewed to describe the atmosphere prevalent during their involvement with the maths clubs. Accordingly, the findings and discussion in this paper reflect on some of the reasons that led to the 'relaxation' among the participants, culminating in improved learner performance reflected in the post-intervention assessment results.

FINDINGS

In this study, the responses from the one-on-one interviews with the nine participant-teachers who agreed to be interviewed and the observations made by the primary researcher throughout the fifteen weeks of the action research project are used as the basis to tease out and 'appreciate' the factors that enabled the success of the mathematics clubs which formed part of this study. The following aspects standout as key enablers of the 'relaxed' atmosphere and, by extension, the effectiveness of the mathematics clubs in this study, namely: *play-based pedagogy*, *flexible language*, *learner-generated problem-solving methods*, *collegiality* and *classroom size*. Accordingly, the following is a brief appreciation of these aspects as seen through the lenses of participant–teachers and the primary investigator.

Play-based pedagogy

The participant-teachers observed that, unlike in the everyday school environments, the maths clubs were characterised by a less formal structure that enabled relaxation and camaraderie among the participant-learners. This culminated in learners enjoying mathematics and, thus, this could be said to be one of the key reasons that led to improved ways of solving problems and better results as measured through the post-intervention assessment results. For example, Teacher D49 stated that participation in maths clubs helped her learners realise that "*mathematics can be learnt through play and is not something that is only done formally*" as it is the case in their school settings. This observation was corroborated by Teacher D41 who asserted that "*I allowed them (the maths club learners) to play and learn at the same time*" and this "*made them to relax because they think that since it is after school there is nothing that is formal*" (Teacher D42). Furthermore, Teacher D43 noted that the game of dice as used in the maths clubs helped the learners to calculate quickly. Likewise, Teacher D48 observed that her club learners were motivated to participate in maths clubs because of the various games they played while learning. Significantly, Teacher D43 was able to transfer the use of games from the maths clubs context to her everyday school setting because her participation in the clubs made her realise that the pedagogical strategy that is centred on play-based activities helped the learners employ a variety of methods in solving mathematical problems.

Flexible language: Code-switching

Within the context of maths clubs, in this study, shared meaning and scaffolding (Vygotsky, 1986) characterised the daily activities and were enabled by using the language that was accessible to learners. For this reason, even though all participants shared the common understanding of Setswana, an indigenous South African language used for learning and teaching (from Grade R to 3) in all four schools selected for the study, the learners were allowed to do code-switching by using a language of their own choice. The primary researcher observed that whenever the learners worked in groups, they were more comfortable when using English as a scaffolding vehicle for calculations and working out mathematical poblems. Accordingly, they were granted freedom to vacillate between their home language (Setswana), which is the medium of instruction, and English when interacting within the learning space. This was necessitated by the reality that participant-learners used English both in the playgrounds and in the classroom settings more than they used Setswana whenever their activities involved numbers. The teachers appreciated the importance of enabling learners to use the language of their preference so that the learning of mathematics was not hindered by language restrictions and rigid adherence to education policy requirements concerning language use in pedagogy.

Real life scenarios and learner independence

One of the key elements that characterised the maths clubs in the current study is the propensity to present mathematical problems that were pertinent to the everyday life experiences of the learners. Largely, facilitated through mathematics games and cooperation between the learners, this approach enabled learners to work independently, worked efficiently and faster than in the usual formal classroom situations; and employed various problem-solving methods. This enhanced enjoyment and relaxation of the learners; hence, mathematical proficiency was notable in the post-intervention assessment results. Accordingly, Teacher D49 highlighted that learners could count independently and work out the sums on their own. This observation was also made by Teacher D43 who stated that "*the learners in my class are now able to do activities individually*". Likewise, this was also noted by Teacher D41 who argued, in respect of her learners that, "*they like doing maths mentally, calculating it mentally without using sticks*". This could be partly ascribed to the effect of games and the real-life scenarios that were used in the maths clubs. For example, there were numerous activities where the learners would be asked about real-life experiences which involved buying items at the local shop and computing the total cost-price of the items in the shopping basket and the change they would expect if they went shopping using a specific amount of money.

Collaboration and collegiality

In line with the undergirding sociocultural theory postulated by Lev Vygotsky, the mathematics clubs in the current study were, by design, aimed at encouraging cooperation and collaboration between the various participants. On the one hand, the learners had a plethora of opportunities to interact with one another in pairs and small groups. On the other hand, teachers would work together as colleagues and with the primary investigator to share experiences and good practices emanating, mainly, from their engagements within the space of maths clubs. This approach was underpinned by the understanding that learning takes place at social level, during the interaction between participants and at an individual level. Significantly, the relaxed atmosphere and high spirits and excitement that characterised the maths clubs space made this working together possible.

For example, participant-learners would discuss among themselves how to work out certain mathematical problems and/or how they arrived at their answers when solving specific problems. This fostered camaraderie, cooperation, freedom, relaxation and interdependence among the learners. Likewise, the learners would also engage their teachers on how they arrived at their answers when they solved problems involving one or more of the four basic operations. Interestingly, the mathematics club learners also transferred their mathematics club learning behaviour to their respective schools. This is discernible from a comment by Teacher D48 who stated that some of the "*club learners shared club activities with non-participants of maths clubs at their school as they did when they worked together with their classmates in maths clubs*".

Classroom sizes

Wherever they occur in the world, maths clubs are designed to accommodate few learners. This presents enormous advantages for meaningful and effectual pedagogy; hence maths clubs tend to be successful in their educational endeavours. Accordingly, even in the current study, the teacher-learner ratio is one of the factors that are worth appreciating as a key contributor to the success of these clubs. Ordinarily, based on the observations of the primary investigator in this study who worked with the participants as a mathemathics specialist, the teacher-learner ratio in the four schools selected for this study hovered around a minimum of 1:55 with most of the grade 3 classrooms accommodating way more than 55 learners. Contrariwise, the maths clubs in this study commenced with a ratio of 1: 36 and, owing to the withdrawal of some learners, as indicated earlier in this text; this ratio declined slightly. The lower teacher-learner ratio enabled a healthy, meaningful and impactful interface between the learners and eased their interaction when group activities were conducted. Likewise, the teachers were able to move around freely and provide individual attention to the learners, thereby, facilitating learning and teaching with ease. Significantly, unlike in everyday formal school-based classrooms that tend to be overcrowded, the small and manageable classroom sizes made it possible for all participant-learners to have access to relevant Learning and Teaching Support Materials (LTSMs) used in the maths clubs.

The ease brought by the small classroom sizes and the positive impact this had on pedagogy was also observed by some participant-teachers in the current study. For example, Teacher D41 stated that, "*we were working with a group consisting of a small number of children. Therefore, they were given more attention, unlike in the everyday school classroom situation*". Likewise, Teacher D49 observed that "*because of a small group of learners, the club learners could participate individually. This made it easy to engage with each learner*". Undoubtedly, based on the preceding assertions, the small class sizes had a positive impact on the pedagogical processes and eased interaction among the particpants in the maths clubs.

DISCUSSION

Undoubtedly, as highlighted in the preceding findings, there are substantive factors that enabled the success of the maths clubs in this study. Significantly, as illustrated in this section, these findings corroborate numerous findings from studies, globally.

It should be evident from the preceding points that the use of games, interspersed with well-designed and learner-friendly, thought-provoking workbooks as the main LTSMs in mathematics, provided learners with, virtually, infinite possibilities to learn meaningfully while enjoying themselves in the process. For this reason, maths clubs deserve appreciation as they foster opportunities for learning. Furthermore, they prove(d) to be safe spaces for education because they encourage(d) relaxation and thereby optimise(d) meaningful mathematical learning. Hence, Murtagh et al., (2022) write that, "to optimise learning, children must engage in playful learning in which they are facilitated with fun child-centred opportunities to explore and discover while being scaffolded, guided, supported and provided with feedback towards a learning outcome" (p. 409).

In the same breath, Vygotsky's sociocultural framework attaches a lot of significance to the role played by language as the main vehicle for intrapersonal and interpersonal interaction, learning and cognitive development. This is applicable to children and adults alike. For this reason, Vygotsky (1986) asserts that there is "the fusion of thought and speech in adults as well as in children" (p. 89). It stands to reason, therefore, that for meaningful learning to take place, children need to interact with peers and teachers at social level while, simultaneously, processing their thoughts and, ultimately, assign meaning to their experiences through inner thoughts propelled by language. Accordingly, Vygotsky (1986) argues that:

> *Thought development is determined by language, i.e. by the linguistic tools of thought and by the socio–cultural experiences of the child. Essentially, the development of inner speech depends on outside factors; the development of logic in the child...is a direct function of socialised speech. The child's intellectual growth is contingent on his mastering of the social means of thought, that is, language* (p. 94).

Therefore, the approach to language use in the current study enhanced relaxation, ease of communication and enjoyment of mathematics for learners. Notably, code-switching, as one of the vehicles used occasionally by learners in this study, is supported by various scholars as an essential vehicle to enable learning. For example, Setati et al. (2002) assert that "code-switching is a language practice that could support classroom communication in general and the exploratory talk that is such a necessary part of learning" (p. 133). Likewise, in the study with focus on the role of language in mathematical performance in Australian classrooms, Norén (2015) found that code-switching between Vietnamese and English enabled the students of Vietnamese origin, to perform exceptionally well in mathematics. Accordingly, in the current study, the teachers and the primary researcher were mindful of "language's power to either include or exclude certain groups of students from opportunities for genuine engagement with, and participation in school mathematics" (Robertson & Graven, 2020, p. 80). For this reason, they appreciated and enabled the use of more than one language to facilitate the ease of mathematical learning and enjoyment in the maths clubs.

Apart from the facilitation of pedagogical processes using familiar languages, the infusion of real-life scenarios in mathematical problems also aided the learning and teaching processes in the maths clubs. Significantly, the use of various games further enhanced meaningful learning and created excitement and fun within the learning space, culminating in the enjoyment of learning mathematics. Subsequently, a notable improvement in learner performance was recorded as measured through the post-assessment results. The preceding point gels with Mani's (2015) assertion that, when used correctly, maths games can enhance the logical thinking of learners and "build upon their everyday understandings" (p. 74) of lived experiences. Likewise, this validates the claims by Lampen and Brodie (2020) that mathematics should help "support connections with learner's everyday lives realities and reasoning" (p. 13). Furthermore, this observation amplifies the assertions by Diez-Palomar et al., (2006) that mathematical learning should be linked to the lived experiences of learners. These authors write that, "recent research shows that an individual's home, related to history and the social context, is the source of funds of knowledge that students could potentially bring to learning situations if the learning environment encouraged it" (Diez-Palomar et al., 2006, p. 451).

As stated in the findings, another key enabler of success in the maths clubs of the current study was the collaboration and collegiality among the participants, both the participant-learners and participants-teachers. The collegiality and collaboration among the participants cohere with the established practices that are adopted and pursued by math clubs, globally. This collaboration among participants is, ostensibly, enabled by the stress-free nature of math clubs and the understanding that teamwork brings about success. The preceding claims accentuate the point made earlier in this paper that, "through their low stress environment, clubs enable students to learn about teamwork and the importance of cooperation and mutual support" (Papanastasiou & Bottiger, 2004, p. 161). Similarly, these assertions cement the observation by Brodie (2022) that within the space of maths clubs, learners "enjoyed the social interaction and the mathematical collaboration around challenging problems" (p. 245). In the same breath, Norén's (2015) suggestion that the sharing of experiences and good practices among facilitators in maths clubs amount to "reform-oriented discourse characterised by emphasis on communication and collaboration" (p. 173) is apt in the context of the current study.

Also worth noting is that classroom overcrowding is one of the challenges hindering meaningful and impactful pedagogy in most South African schools, especially, in underprivileged communities such as the one in which the current study was conducted. The norms and standards of the South African National Department of Basic Education recommend that, ideally, the teacher to learner ratio should be 1: 40 at primary school level (Hart, 2023). However, anecdotal and empirical evidence suggests that most primary schools have a minimum ratio of about 1: 50 with some schools having a ratio of 1: 70 or even double the ratio recommended by the department of education (Hart, 2023; Venketsamy, 2023). Inevitably, learner overcrowding in classrooms poses a plethora of challenges including, inter alia, insufficient Learning and Teaching Support Materials (LTSMs), difficult teacher and leaner mobility, constrained relaxation and freedom in the classroom, decline in learner concentration, inadequate furniture, lack of motivation and concentration by learners,

challenges in the formation of learner teams and groups, virtually, non-existent individualised attention per learner and poor learner performance (Ayanwoye, 2023; Oruikor, et al., 2023, Venketsamy, 2023). Invariably, all these and other challenges hamper the kind of relaxation and active experiential learning required in an ideal learning space and, thereby, contribute to poor learner performance (Rands & Gansemer-Topf, 2017).

However, as already stated, just like in many countries where they occur, the maths clubs in this study were designed to enable effectiveness by ensuring that the learner numbers were manageable. This was made possible by enlisting fewer learners, ensuring that the teacher-learner ratio was lower than the national setting in South African public schools. For this reason, the maths clubs were a success, mainly, due to the teachers being able to give each learner maximum support and individual attention while also enabling free and easy interaction among the learners. Consequently, as stated numerously in this text, there was measurable improvement in learner performance as discernible from the juxtaposition of pre-assessment and post-assessment results.

CONCLUSION

The paper sought to tease out the factors that enabled an improvement in mathematical performance resulting from an interventionary programme developed for selected Grade 3 learners in a mathematics club setting. This exercise was prompted by the paucity of research that focuses on the factors that enable success in maths clubs. Numerous factors were identified as affordances of success in the maths clubs that formed part of the current study. These factors included, play-based pedagogy, flexible language usage, collaboration among participants, the use of real-life experiences in pedagogy and small and manageable classroom sizes. Accordingly, based on these findings, arguably, an improvement in mathematical attainment, commencing from lower classes, could be realised if regular everyday classrooms are designed or modelled in line with maths clubs. Nevertheless, this ideal could only be accomplished through concerted investment on time, money and resources aimed at creating relaxed and enabling pedagogical atmospheres within formal pedagogical spaces.

Furthermore, owing to the dearth of research that focuses on identifying factors that support efficacious pedagogical practices in mathematics clubs, more studies need to be conducted within this realm. Conceivably, a vigorous uptake of enquiries in this under-researched area coupled with meaningful engagements with various stakeholders might yield positive results, culminating in an overall improvement in mathematics education – a subject considered the heartbeat of STEM education.

ACKNOWLEDGMENT

The authors would like to acknowledge and thank the reviewers whose insightful and constructive critical reviews meaningfully contributed to the refinement and improvement of this paper.

AUTHOR'S DECLARATION

Authors' contributions	Both authors (HH & GH) contributed to the conceptualisation of the methodology, the undergirding theoretical frameworks, data collection and analysis processes as well as the writing of the manuscript. However, the second author (GH) was responsible for the data collection and other pertinent methodological processes of the main (Master of Mathematics Education) study which inspired the penning of this paper.
Funding Statement	This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. However, the second author is will be forever grateful for the funding obtained from Rhodes University during her completion of the MEd study, from which the bigger study that inspired this paper derives.
Availability of data and materials	All data are available from the authors.

Competing interests The authors declare that the publishing of this paper does not involve any conflicts of interest. This work has never been published or offered for publication elsewhere, and it is completely original.

BIBLIOGRAPHY

Amit, M. & Naaman, K. (2014). Kidumatica – the mathematics club for creativity and excellence among multicultural pupils: Practice and research. *Procedia – Social and Behavioural Sciences*, 141: 1403 – 141. https://doi.org/10.1016/j.sbspro.2014.05.242

Aunio, P., Korhonen, J., Ragpot, L., Törmänen, M. & Henning, E. (2021). An early numeracy intervention for first graders at risk for mathematical learning difficulties. *Early childhood Research Quarterly*, 55: 252 – 2262. https://doi.org/10.1016/j.ecresq.2020.12.002

Ayanwoye, O.K. (2023). Implications of large class size on effective teaching and learning in Nigerian tertiary institutions: Lecturers' perception. https://www.qeios.com/read/67MZ0F.

Björklund, C., van den Heuvel-Panhuizen, M., & Kullberg, A. (2020). Research on early childhood mathematics teaching and learning. *ZDM Mathematics Education*, 52 (4): 607 – 619. https://doi.org/10.1007/s11858-020-01177-3

Brodie, K. (2022). Learning mathematics in an after-school mathematics club. *African Journal of Research in Mathematics, Science and technology*, 26 (3): 237 – 247. https://doi.org/10.1080/18117295.2022.2131267

Bushe, G, (2001). Five theories of change embedded in appreciative inquiry. In Cooperrider D, Sorenson P, Whitney D, Yeager T (eds) *Appreciative Inquiry: Rethinking Human Organization Toward a Positive Theory of Change*. Champaign, IL: Stipes.

Clements, D.H. & Sarama, J. (2011). Review: Early childhood mathematics intervention. *Science*, 333: 968 – 970. https://doi.org/10.1126/science.1204537

Cooperrider, D.L., & Srivastva, S. (1987). Appreciative inquiry in organizational life. In Pasmore, W.A., & Woodman, R. (Eds.), *Research in organizational change and development* (pp. 129 – 169). Greenwich, Connecticut: JAI Press.

Diez-Palomar, J., Varley, M., & Simic, K. (2006). Children and adults talking and doing mathematics: A study of an after-school math club. In S. Alatorre, J.L. Cortina, M. Sáiz, & A. Méndez, (Eds). *Proceedings of the 28th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. Mérida, México: Universidad Pedagógica Nacional.

Fenoll, A. A., Moscarola, F. C., & Zaccagni, S. (2021). Mathematics camps: A gift for gifted students? *Journal of Economic Behaviour & Organization*, 191, 738-751. https://doi.org/10.1016/j.jebo.2021.09.036

Fitzmaurice, O., O' Meara, N. & Johnson, P. (2021). Highlighting the relevance of mathematics to secondary students: Why and how. *European Journal of STEM Education*, 5 (1); 1– 13 https://doi.org/10.20897/ejsteme/10895

Foote, M. Q. (2008). Addressing the needs of struggling learners. *Teaching Children Mathematics*, 14 (6): 340 – 342. https://doi.org/10.5951/TCM.14.6.0340

Giles, D. & Alderson, S. (2008). An appreciative inquiry into the transformative learning experiences of students in a family literacy project. *Australian Journal of Adult Learning*, 48(3): 465 – 478

Golzar, J., Noor, S., & Tajik, O. (2022). Convenience sampling. *International Journal of Education and Language Studies*, 1(2): 72 – 77.

Graven, M. (2016). Strengthening maths learning dispositions through math clubs. *South African Journal of Childhood Education*, 5(3): 1–7. http://doi.org/10.4102/sajce.v5i3.342

Hart, S. A. (2023). Identifying the factors impacting the uptake of educational technology in South African schools: A systematic review. South African Journal of Education, 43(1): 1 – 16. Art. #2174, 16 pages, https://doi.org/10.15700/saje.v43n1a2174

Hornstra, L., Mathijssen, A. C. S., Denissen, J. J. A., & Bakx, A. (2023). Academic motivation of intellectually gifted students and their classmates in regular primary school classes: A multidimensional, longitudinal, person- and variable-centred approach. Learning and Individual Differences, 107, 102345. https://doi.org/10.1016/j.lindif.2023.102345

Human, A., Van der Walt, M. & Posthuma, B. (2015). International comparisons of foundation phase number domain mathematics knowledge and practice standards. *South African Journal of Education*, 35 (1): 1 – 13. https://doi.org/10.15700/201503062351

Hungi, N., Makuwa, D., Ross, K., Saito, M., Dolata, S., van Capelle, F., et al. (2010). *SACMEQ III project results: Pupil achievement levels in reading and mathematics*. Paris: Southern and Eastern Africa Consortium for Monitoring Educational Quality.

Isdale, K., Reddy, V., Juan, A., & Arends. F. (2017). TIMSS 2015 GRADE 5 National Report Understanding mathematics achievement amongst Grade 5 learners in South Africa. Cape Town, South Africa: Human Sciences Research Council.

Karp, K.S., & Niemi, R.C. (2000). The math club for girls and other problem solvers. *Mathematics in the Middle School*, 5(7): 426–432. https://doi.org/10.5951/MTMS.5.7.0426

Lampen, E., & Brodie, K. (2020). Becoming mathematical: Designing a curriculum for a mathematics club. *Pythagoras*, 41(1): 1 – 15, a572. https://doi.org/ 10.4102/pythagoras. v41i1.572

Lundqvist, J., Franzén, K. & Munter, A. C. 2023. Early childhood mathematics: A case study. *Early Years,* 43(4 – 5): 763 – 777. https://doi.org/10.1080/09575146.2021.2014404

Mani, A. (2015). Maths games: An effective pedagogical tool to enhance learning. *Scholarly Journal of Scientific Research and Essay*, 4(5): 74 – 76.

Mohr, B. J., & Watkins, J. M. (2002). The essentials of appreciative inquiry: a roadmap for creating positive futures. Sheffield, South Yorkshire: Pegasus Communication

Morrison, S., Graven, M., Venkat, H., & Vale, P. (2023). A 20-year review of South African early grade mathematics research articles. *African Journal of Research in Mathematics, Science and Technology Education*, 27 (3): 304 – 323. https://doi.org/10.1080/18117295.2023.2226547

Murtagh, E. M., Sawalma, J., & Martin, R. (2022). Playful maths! The influence of play-based learning on academic performance of Palestinian primary school children. *Educational Research for Policy and Practice*, 21 (3): 407 – 426. https://doi.org/10.1007/s10671-022-09312-5

Norén, E. (2015). Agency and positioning in a multilingual mathematics classroom. *Educational Studies in Mathematics*, 89:(2): 167–184. DOI 10.1007/s10649-015-9603-5

Nyimbili, F., & Nyimbili, L. (2024). Types of Purposive sampling techniques with their examples and application in qualitative research studies. *British Journal of Multidisciplinary and Advanced Studies*, 5 (1): 90 – 99. https://doi.org/10.37745/bjmas.2022.0419

Oruikor, G. E., Ewane, H. D., Durotoye, M. P., & Akomaye, C. U. (2023). The impact of classroom design on student learning: a case study of Cameron Schools. *Journal of Global Issues and Interdisciplinary Studies*, 1(1): 21 – 40.

Papanastasiou, E. C., & L. Bottiger, L. (2004). Math clubs and their potentials: Making mathematics fun and exciting. A case study of a math club. *International Journal of Mathematical Education in Science and Technology*, 35 (2): 159 – 171 https://doi.org/10.1080/00207390310001638395

Rands, M. L., & Gansemer-Topf, A. M. (2017). The room itself is active: How classroom design impacts student engagement. *Journal of Learning Spaces*, 6 (1): 26-33.

Reddy, V., Prinsloo, C., Arends, F., Visser, M., Winnaar, L., Feza, N., Rogers, S., Janse van Rensburg, D., Juan, A., Mthethwa, M., Ngema, M. & Maja, M. (2012). Highlights from TIMSS 2011: the South African perspective. Cape Town, South Africa: Human Sciences Research Council. http://hdl.handle.net/20.500.11910/2877

Reddy, V., Winnaar, L., Arends, F., Juan, A., Harvey, J., Hannan, S. & Isdale, K. 2022. The South African TIMSS 2019 Grade 9 Results: Building achievement and bridging achievement gaps. Cape Town, South Africa: Human Sciences Research Council.

Reddy, V., Winnaar, L., Harvey, J., Hannan, S., Isdale K., Fabian Arends, F., & Juan, A. (2022). The South African TIMSS 2019 Grade 5 Results - Building Achievement and Bridging Achievement Gaps. Cape Town, South Africa: Human Sciences Research Council

Robertson, S. A., & Graven, M. (2020). Language as an including or excluding factor in mathematics teaching and learning. *Mathematics Education Research Journal*, 32(1): 77-101. https://doi.org/10.1007/s13394-019-00302-0

Setati, M., Adler, J., Reed, Y., & Bapoo, A. (2002). Incomplete journeys: Code-switching and other language practices in mathematics, science and English language classrooms in South Africa. *Language and education*, 16 (2): 128-149. https://doi.org/10.1080/09500780208666824

Stott, D. (2016). Five Years On: Learning Programme Design for Primary After-School Maths Clubs in South Africa. In Proceedings of the 24th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) 2016, edited by W. Mwakapenda, T. Sedumedi and M. Makgato, 250–60. Pretoria: Tshwane University of Technology.

Talcott, F., & Scholz, V. (2015). Methodology guide to process tracing for Christian Aid. Oxford, England: The International Non-Governmental Training and Research Centre.

Topciu, M., & Myftiu, J. (2015). Vygotsky Theory on Social Interaction and its Influence on the Development of Pre-School. *European Journal of Social Science Education and Research*, 2(3): 172–179. https://doi.org/10.26417/ejser.v4i1.p172-179

Venketsamy, R. (2023). Exploring the teacher-learner ratio and its effect on invitational teaching and learning: A South African study. *Journal for the Education of Gifted Young Scientists*, 11(1): 33 – 43. DOI: http://dx.doi.org/10.17478/jegys.1237615

Vogt, F., Hauser, B., Stebler, R., Rechsteiner, K., & Urech, C. (2020). Learning through play–pedagogy and learning outcomes in early childhood mathematics. *European Early Childhood Education Research Journal*, 26(4): 589 – 603, DOI:10.1080/1350293X.2018.1487160

Vygotsky, L. (1986). Thought and Language, Massachusetts: The MIT Press.

Wickstrom, H., Pyle, A., & DeLuca, C. (2019). Does theory translate into practice? An observational study of current mathematics pedagogies in play-based kindergarten. *Early Childhood Education Journal*, 47; 287 – 295. https://doi.org/10.1007/s10643-018-00925-1

Zahle, J. (2019). Data, epistemic values, and multiple methods in case study research. *Studies in History and Philosophy of Science*, *78*: 32-39. https://doi.org/10.1016/j.shpsa.2018.11.005