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December 2021 Volume 14 Issue 2

www.iejee.com

international electronic journal of elementary education

KURA group Education & Publishing

INTERNATIONAL ELECTRONIC JOURNAL OF ELEMENTARY EDUCATION

ISSN: 1307-9298

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International Electronic Journal of Elementary Education
December 2021, Volume 14, Issue 2

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ISSN: 1307-9298

iejee

International Electronic Journal of Elementary Education
December 2021, Volume 14, Issue 2, 119-133

International Programs and Resources to Support Children from Military Families: A review

Marg Rogers[a], Vanessa Bible[b], Amy Johnson[c], Jo Bird[d], Ingrid Harrington[e], Pep Baker[f]

Received : 13 June 2021
Revised : 28 December 2021
Accepted : 30 December 2021
DOI : 10.26822/iejee.2022.233

[a]**Corresponding Author:** Marg Rogers, University of New England, New South Wales Australia.
E-mail: marg.rogers@une.edu.au
ORCID: https://orcid.org/0000-0001-8407-7256

[b]Vanessa Bible, University of New England, New South Wales, Australia.
E-mail: vbible3@une.edu.au
ORCID: https://orcid.org/0000-0002-9516-2154

[c]Amy Johnson, Central Queensland University, Queensland, Australia.
E-mail: a.johnson2@cqu.edu.au
ORCID: https://orcid.org/0000-0003-4228-6265

[d]Jo Bird, University of New England, New South Wales, Australia
E-mail: jo.bird@une.edu.au
ORCID: https://orcid.org/0000-0002-3345-1815

[e]Ingrid Harrington, University of New England, New South Wales, Australia.
E-mail: iharring@une.edu.au
ORCID: https://orcid.org/0000-0002-1898-4795

[f]Pep Baker, University of New England, New South Wales, Australia.
E-mail: pep.baker@une.edu.au
ORCID: https://orcid.org/0000-0001-6775-178X

Abstract

Parental deployment and frequent relocations exert significant stress on children from military families. This stress can be extremely disruptive to young children's social, cognitive and behavioural development. It can result in negative social, emotional, and physical responses. There are a broad range of programs, resources, and services available mainly in the US, but also internationally. The programs endeavour to mitigate the impacts of military life on young children by providing support to families. This paper explores the programs for families with young children and the need for culturally and age-appropriate resources. It also discusses how the Early Childhood Defence Programs (ECDP) project is responding to this need by developing three free, online Australian early childhood programs for parents, family workers and educators. This scoping review of currently available programs and resources will determine how the project, and others wanting to support children from military families, can best address this need.

Keywords:

Military Families, Deployment, Family Support, Community Education, Early Childhood

Introduction

This paper explores the effect of military family life on children from Australian and international studies, and the need for programs and resources for these children and their families and educators. International programs and resources from the United States, Canada and the United Kingdom are examined and then compared to what is available for children and their families and educators in the Australian context. The need for resilience-based and evidence-based programs is also discussed along with the need for age and culturally appropriate programs and resources for Australian children from defence families.

The Context

The Australian Defence Force (ADF) 2019 census revealed that there are 92 666 defence personnel in Australia. Of this number, there are 58 476 permanent ADF members, and 17 328 Reserve ADF members. Thirty eighy percent of permanent ADF members had dependent children at

the time of the census, while 44% of Reserve ADF members reported at least one dependent child (Australian Government Department of Defence, 2020a). This equates to nearly 30 000 children in ADF families in Australia at risk of the negative impacts of parental deployment. Indeed, 25% of ADF parents cite deployment as the 'most important consideration for families with dependent children regarding the Defence lifestyle' (Tan, 2020), and this is not surprising given what is known about the impacts of parental deployment and training.

Children can experience separation from their parents lasting from weeks to months due to training episodes and deployment (Baber, 2016). In Australia, Siebler & Goddard (2014, p. 17) found that children who experienced parental deployment 'generally fared poorly in terms of physical and mental health, and behavioural outcomes', while McFarlane (2009, p. 369) contends that 'the deployment of a parent to a combat zone may be one of the most stressful experiences that a child faces.' The impacts upon young children are even more pronounced; Rogers' (2017) research found that attachment relationships of babies and young children suffer as a result of parental separation, while Scandlyn & Hautzinger (2019, p. 235) found that young children with deployed parents were more frequently referred to paediatricians for mental and behavioural health issues than children who do not experience parental deployment. Chartrand, Frank, White, and Shope (2008) found that children over the age of 3 with deployed parents exhibited significantly higher levels of depression, and were more likely to externalise behaviours. Non-deployed parents also experience significant stress while their partner is absent, and this in turn also impacts upon the child, and the parent's ability to effectively support their child (Rogers, 2019; Cai, 2020).

As a result, a broad range of voices, including military families, academics, researchers, health professionals, and educators have called for support programs, services, and resources (Cramm, et. al., 2015). These calls for intervention include a specific focus on the need to mitigate the impacts of parental deployment (Kritikos & DeVoe, 2018), as well as the need to build resilience in young children and military families on the home front (Meadows et al., 2016). However, such programs and resources have been identified as lacking in meeting the specific needs of families with young children. There is quite a broad range of programs for military families, including those addressing mental health and trauma, disruption to children's education, and support during relocation, but as Friedberg & Brelsford (2011, p. 231) found, 'a review of the literature and available programs reveals that there are a scant number of available programs to assist families with problems resultant from deployment.' Some progress has been made since 2011 as this review will explore, but this progress has been limited. To guide our review, the following research questions were used:

1. What programs exist in other English speaking allied countries?
2. What are the features of these programs?
3. How have these programs been evaluated?
4. What are the practical implications of these findings for the ECDP project?

The Early Childhood Defence Programs (ECDP) Project

Research about military families with young children is limited across the globe, but particularly so outside the US (which has a strong military culture), and even more so within Australia. There is an urgent need for research into the unique issues experienced by ADF families (Rogers-Baber, 2017; McFarlane, 2009; Siebler, 2009). There is also 'a distinct lack of Australian data about the impact of deployment on families', as found by Baber (2016, p. 142). The ECDP is a three-year project funded by The Ian Potter Foundation and UNE and the Foundation of Graduates of Early Childhood Studies to address a need identified in Rogers' previous research (Rogers, 2020; Rogers, Bird & Sims, 2019; Rogers & Bird, 2020) identifying a lack of age and culturally appropriate resources and programs for early childhood. The ECDP, therefore, is a response to requests from both parents and educators for resources such as apps, eBooks, and physical resources and programs to help them support their very young children with the stresses associated with military life. Three free, open access, research-based online programs containing ten modules each, one each for parents, educators, family and social workers have been produced. They are being evaluated in 2021-2022, for public release them to the public in 2023. The programs are targeted to assist parents and educators supporting children aged 2-5 years, but many of the resources within the program are useful for babies and children in the early school years. To ensure that the programs are as effective and accessible as possible, the project is being built upon knowledge-based practice and careful consideration of the strengths and limitations of existing programs and resources. While there are very few early childhood resources available in Australia for defence families, family workers, and educators, it is the intention of the ECDP research team that the programs will be accessible for English-speaking military families across the globe, and most content could be freely adapted depending on country and context.

Methodology

In this full scoping review, programs were searched from English speaking countries that are considered allies with Australia, that is, UK, USA and Canada. All programs that supported military families with children, or children from military families were included. To find the programs, a range of methods were used,

including general internet searchers, Google Scholar search, searching programs referred to in other papers, word of mouth from our stakeholders (Rogers et. al. 2021), and searching military websites from these nations.

This review uses publicly available data in the form of academic articles and websites. Although a research project is discussed, it is only discussed in general terms that is available on the project's website, rather than specifically about individuals or participants. The research project has ethics approval from the Human Research Ethics Committee at the University of New England, Australia.

Results

International Programs and Resources

To contextualise the ECDP, this review will explore international programs and resources across the US, the UK, Canada, and Australia which either focus specifically on addressing the impacts of deployment or have a wider focus that includes deployment as a key concern. It will call particular attention to those programs and resources that are aimed at children in early childhood, but it must be noted that very few existing programs are aimed at children aged 5 and under (Julian et. al., 2018). There have been numerous calls to ensure that any program that targets children from military families must be evidence-based, and should ideally undergo control trials or another evaluation process (McFarlane, 2009; Julian et al., 2018; Creech et.al., 2014; Rowan-Legg, 2017). This could be considered to constitute best practice; many of the programs and resources described below are evidence-based, however, while some have undergone a form of evaluation, others have not. Table 1 provides summary of the programs this paper explored, the country of origin, targeted age groups, delivery methods, the main features of the program and how the programs have been evaluated.

Table 1

Program Name	Country, Date	Age Group	Keywords
Families OverComing Stress (FOCUS) & Families OverComing Stress- for Early Childhood	USA	All ages	Resiliency
After Deployment, Adaptive Parenting Tools (ADAPT)	USA	4-12 years	Managing stress, parenting approaches
Strategic Outreach to Families of All Reservists (SOFAR)	USA	All ages	Treatment focused
StRoNG Military Families	USA	Birth- 8 years	Parenting approaches, relationships
Strong Families Strong Forces	USA	Under 6	Parenting approaches, deployment & reunion
Operation Purple	USA	5- 12 years	Resilience, communication, coping skills, belonging
Operation Military Kids	USA	3-18 years	Community support, increased social capital
Military Child Educational Coalition (MCEC) & Student 2 Student program	USA	School aged	Resilience, community support, information, coping skills
Soldiers', Sailors' & Airmen's Families Association (SSAFA)	UK / 1885	All ages	Information, peer support
Armed Forces Covenant	UK / 2020	All ages	Information
Service Pupil Premium	UK	School aged	Financial payment only
Families Activity Breaks (FAB)	UK	All ages	coping skills, peer support, activities
Moving Schools Children's Activity Packs	UK	School aged	Support, relocation
Strengthening Families	UK	All ages	Resilience, social connections, child development
Military Family Resource Centres (MFRC's)	Canada	All ages	Resilience, community connection, parenting approaches
The Mind's the Matter	Canada	12-18 years	Information, coping skills
E=MC3	Canada	4-12 years	Well-being, child development, parenting approaches
iStep Program	Canada	6-12 years	Coping skills, peer support, personal coping skills

Programs and resources in the United States

In countries where the military is large and military culture is strong, and particularly in the US, wider safeguards help to protect children from some of the negative impacts of living in a military family. These safeguards include healthcare, housing, school programs, and supportive communities (Mogil et. al., 2019). Additionally, the great majority of literature that details the experiences of the modern-day military family 'focuses overwhelmingly on the US experience' (Cramm et al., 2015). It is perhaps not unexpected then, that most of the well- known programs and resources are US-based.

Families OverComing Under Stress

Among the most widely cited, studied, and used programs, the exemplar is Families OverComing Under Stress, or FOCUS. The program was commissioned by the US Navy Bureau of Medicine and developed by a joint team UCLA and Harvard, and FOCUS is available in active duty military installations across the US and beyond. It delivers a wide range of services, but its central aim is to offer family resiliency training (Lester et al., 2013). The program

> teaches practical skills to help families and couples overcome common challenges related to a military life. It helps build on current strengths and teach new strategies to enhance communication and problem solving, goal setting and creating a shared family story (FOCUS, 2017).

FOCUS is rigorously evidence-based, and the program has undergone extensive study, review, control trials, and adaptation (FOCUS, 2017; Beardslee et al., 2013; Kudler & Porter, 2013; Brendel et. al., 2013; Julian et al., 2018).

While resilience training is very frequently cited as being central to any effective military family program (Bradbury, 2015; Hoshmand & Hoshmand, 2007; Kudler & Porter, 2013; Saltzman et al., 2011) and is a feature of many programs and resources, among FOCUS' key tools is the program's highly-regarded family narrative approach. Families who participate in the program create a shared narrative that evolves as a result of separate sessions with parents and children, to build understanding about the overall family experience of deployment. As a key contributor to the program William Saltzman (2014, p. 55) explains,

> a graphic representation provides a way to bridge misunderstandings across the care-givers, as well as to provide an opportunity to see the whole context of the multiple stressors they have been through. It is a way to normalize and validate their current levels of distress.

Siebler (2014) calls for a child-centred approach to ensure that programs respond to the needs of children, and FOCUS employs family-oriented approaches and works within the family rather than in a clinical setting (Kudler & Porter, 2013). Evaluations of FOCUS's approach demonstrate that the program 'improves psychological health and family adjustment for service members, spouses, and children alike', according to Kudler & Porter (2013, p. 24).

Julian et al. (2018, p. 110) argue that FOCUS 'is not specifically focused on addressing the struggles faced by military families with young children,' however, the program is 'scalable and portable' and can be freely adapted to cater for the different needs of individual military families and their communities (Kudler & Porter, 2013). FOCUS-EC (Families Overcoming Under Stress – for Early Childhood) has been developed to respond to the unique needs of young children, and the lack of available programs for 3-5-year-olds. This adaptation has been built upon community consultation, which has also aided the program's implementation (Beardslee et al., 2013). Randomised trials found reduced stress and a reduction in instances of acting out in young children (Nolan & Misca, 2018). More broadly, Lester's study of the FOCUS program found 'improved longitudinal psychological health outcomes for military children affected by parental deployment' (Lester 2013, p. 844).

After Deployment, Adaptive Parenting Tools

Another popular, highly-regarded, and evidence-based program is After Deployment, Adaptive Parenting Tools, or ADAPT. The program focuses on mitigating the impacts of deployment, but it works directly with parents rather than children. ADAPT offers 14 weeks of group-based sessions targeting positive parenting practices (Skomorovsky, 2019). Skills include managing combat stress and using contingent positive reinforcement rather than coercive parenting (Gewirtz et. al., 2018). The program accepts military families with children between the ages of 4-12; some of the early childhood groups are catered for (Julian et al., 2018). ADAPT was co-developed by a leader in the field Abigail Gerwirtz, and Gewirtz and her team have conducted extensive reviews and evaluations of the program to ensure its effectiveness. Randomised control trials have found that children whose parents have taken part in the program exhibit better adjustment, and parents report improved parenting and reduced psychological distress (Gewirtz et. al., 2016; Gewirtz et al., 2018; Piehler et. al., 2018).

Strategic Outreach to Families of All Reservists

Strategic Outreach to Families of All Reservists (SOFAR) is a free mental health service specifically targeted

towards US military members (National Guard and Reservists) deployed in Afghanistan and Iraq. The project also provides resources to parents, teachers, and paediatricians to equip them with the skills to support children with deployed parents (Heiner, 2009). One of the criticisms of this type of approach is that it addresses the deficit, rather than focusing on building resilience pre-crisis. As Wright, Riviere, Merrill, and Cabrera (2013) explain, SOFAR does aim to cultivate resilience in military families during the stress of deployment, but the focus is on treatment (usually via clinical referral) rather than prevention. Wright et al. (2013) do however explain that SOFAR's 'community-based orientation' can be utilised in different contexts, and be adapted for both reservist and active-duty members. They acknowledge that 'the community-based approach of SOFAR is an advantage because it the circle of awareness and involvement within the community that may facilitate access to services for those families who need them' (Wright et al., 2013, p. 181).

STRoNG Military Families (Support to Restore, Repair, Nurture and Grow)

StRoNG Military Families is specifically for military families with young children and provides ten weeks of intervention in a group setting as well as home-based resources. It builds parents' understanding of their children's needs and promotes the kinds of parenting skills necessary to cultivate strong relationships (Nolan & Misca, 2018). Like other programs, the community emphasis is a strength; Dayton, Walsh, Muzik, Erwin, and Rosenblum (2014, p. 4) argue that the group setting connects military families, helps to foster community, destigmatises the experience, and is 'consistent with military culture.' A study of the program found better outcomes in those families that engaged in the group-based program rather than those who participated in a home setting only (Julian et al., 2018). The study concluded that

> the SMF intervention is tailored to military families with young children. This target population is especially vulnerable because of their level of stress and separations that are inherent to deployment, and this intervention specifically responds to their needs. Further, while existing interventions for military families may include some children under 7 years of age, few existing Infant military family interventions specifically target children in early childhood and address issues that are most relevant to this age group (Julian et al., 2018, pp. 115-116).

While programs that specifically target early childhood are rare, Julian et al. (2018) have also identified another valuable program within this important space.

Strong Families Strong Forces

Strong Families Strong Forces (SFSF) was developed 'specifically with young children in mind' (Julian et al, 2018, p. 110), to address the challenges of parenting during the deployment cycle (DeVoe, Paris, Emmert-Aronson et. al., 2017). It is a home-based program for military families with children under the age of 6, delivered across 8 modules, and it aims to build an understanding of both parents' and the children's experience of deployment and reintegration (Nolan & Misca, 2018). Randomised control trials found that the program generated a high level of interest from military families, reduced levels of parenting-related stress, improved reflective capacity, and resulted in greater perceived self-efficacy (DeVoe et al., 2017; Julian et al., 2018). There is scope for 'for implementation in broader military and community service systems' (DeVoe et al, 2017, p. 25).

Operation Purple

Operation Purple is another well-cited and well-studied program. Operation Purple offers a free summer camp, family retreats to help reconnect post-deployment, 'healing adventures', and a buddy camp for children aged 5-12 (National Military Family Association, 2020). The family retreats highlight the need for such programs given the challenges of reintegration post-deployment, but it does not address stress arising during deployment. The summer camp, however, does offer this support – of the 64 000 children who have taken part since 2004, 47% had parents who had deployed or were deploying (National Military Family Association, 2020). During these camps, children are taught psychological strength, resilience, communication, and positive coping skills, and have the chance to cultivate a sense of community and belonging with other military children (Skomorovsky, 2019). Chandra, Burns, Tanielian, Jaycox, and Scott (2008) conducted a study of the summer camp component of Operation Purple's programs (Operation Purple Camp) and found that children and parents alike saw the benefits in meeting other children from military families, copying deployment, and gaining independence. Another study of Operation Purple Camp undertaken by Chawla and MacDermid Wadsworth (2012) found an improvement in children and adolescents' social acceptance, athletic competence, and global self-worth. While this program is well-suited to older children and serves as a distraction from the separation occurring at home, it is not easily adaptable or suitable for early childhood.

Operation Military Kids

Operation Military Kids takes a different approach to other programs in that it aims to provide a support

network for children from military families with deployed parents within the wider community. Kudler and Porter (2013) refer to this approach as 'innovative', citing that in 2011, the program was accessed by 103 000 children across 49 US states and the District of Columbia. The program builds community support around these children via 'partnerships with formal networks that can provide the social capital children need, and increase(d) community capacity to support military-connected children at the local level' (Brendel et. al., 2013). Partner organisations include National 4-H, American Legion, Army Child and Youth Services, Boys and Girls Clubs of America, and the Military Child Educational Coalition (Brendel et al., 2013).

Military Child Educational Coalition

The Military Child Educational Coalition (MCEC) also takes a different approach to other programs, and while it is not specifically aimed at deployment support or early childhood education, it is an important program within the wide range of offerings in the US, and it provides some valuable approaches. The MCEC eases the frequent transition between schools that military children so often experience. The program 'encourages military families to enhance their children's resilience, fosters community support for military children and their families, and provides concerned adults with information about helping military children cope with uncertainty, stress, trauma, and loss' (Kudler & Porter, 2013, p. 176). The MCEC Student 2 Student (S2S) program educates the educators, taking a child-centred approach and providing resources and training to teachers of children from military families in middle and high schools (Brendel et al., 2013). The 2020 MCEC Summary Report found that 10% of professionals expressed a desire to learn more about how to support children coping with parental deployment, and/or the return from deployment (Military Child Education Coalition, 2020). The report also found that the most popular form of access to training materials is via websites, followed by social media (Military Child Education Coalition, 2020).

Other US Programs and Resources

There is a wide range of other programs and resources available, although many are not well-cited and very few attract the same level of interest and attention as those already outlined.

Some additional school-based programs exist including the *Children of Deployed Parents-Group* which offer counselling to children whose parents are about to be or have been deployed (Brendel et al., 2013); *Adjusting to a Family Member's Deployment: A Resiliency Program for Children and Adolescents,* which builds resilience by encouraging students to express their feelings about parental deployment (Friedberg & Brelsford, 2011); *Our Military Kids*, which acknowledges that 'military kids serve too' and aims to empower children from age 5 to grade 12 via funding for sports, arts, and other activities (Our Military Kids, 2020); and the *Military Impacted Schools Association (MISA),* an alliance of school superintendents that serve school districts with high numbers of children from military families.

One of the key reasons why there is such a strong range of support programs in the US is because of the level of investment the US Government makes in such programs (Cramm et. al., 2018; Hess & Skomorovsky, 2019; Skomorovsky, 2019). The US Department of Defence also directly sponsors *Military OneSource*, a wide-ranging service that provides free counselling, other support and advice, assistance with parenting, health (including deployment-related health problems), education, relocation, and 'everything from managing a checkbook to changing a tire' (Kudler & Porter, 2013, p. 173; Military OneSource, 2020). Other government-supported assistance includes *U.S. Army Operation READY* resources, including the *U.S. Army Deployment Readiness Handbook for DA Civilians and Family Members* (Cornell University, 2010), with a focus on keeping children connected to their military parent while on deployment, and the *U.S. Army Deployment Support Handbook: Children and Youth* (Cornell University, 2007), produced to aid professionals and parents in their support of children during the deployment cycle. Lastly, the Obama Administration founded *Joining Forces* under the leadership of former First Lady Michelle Obama and current First Lady Jill Biden, which aims to raise awareness of the lives of these children and their families within the wider community. Like *Operation Military Kids,* the initiative aims to build community support around the military family by engaging with a wider range of public and private sector entities and organisations (Joining Forces, 2011). note that Joining Forces also operates within the clinical realm,

> challenging professionals to integrate evidence-based practices and licensing and credentialing processes across disciplines and national professional organizations, aiming to ensure that knowledge of military culture and training in deployment mental health are ubiquitous (Kudler & Porter, 2013, p. 179).

Other notable counselling and mental health services include the *American Red Cross,* who provide resources for military families, including deployment services; the organisation's free course claims to be the 'only national-level course specifically designed for military families, including parents and significant others, that bridges all branches of the Armed Forces and provides hands-on tools to help families cope with deployments (American Red Cross, 2020). *ZERO*

TO THREE provides resources and tools in the birth and early childhood space, notably via the Babies on the Homefront App, which can be easily accessed my military families outside the US (ZERO TO THREE, 2020).

Other programs and resources also utilise digital technologies. Friedberg and Brelsford (2011, p. 232) acknowledge that there is a variety of multimedia resources such as DVDs, websites, and online workbooks that help children cope with parental deployment, 'but implementation of these programs is not well documented and success rates are unclear.' It must be noted however that Friedberg and Brelsford's statement is now nearly 10 years old, and it is likely that considerable progress has been made in this space. For example, *United Through Reading (UTR)* promotes parental bonds by allowing parents to read to their children across great distances. Rather than relying on video call services such as Skype and Zoom, UTR has a dedicated app that allows for story sessions to be pre-recorded, addressing time zone differences and scheduling challenges, and children can re-watch the recordings. Other child-oriented resources include *Military Kids Connect,* an online community for 6-17-year-olds that creates connections between children from military families. There is a special portal for children experiencing parental deployment, including videos from children discussing their experiences, and an anonymous advice message board (Military Kids Connect, 2020). It also offers 'activities, games, videos, and surveys that promote understanding, resilience, and coping skills. In monitored online forums, children share their ideas, experiences, and suggestions with other military children, letting them know they are not alone' (Kudler & Porter, 2013, p. 174).

Finally, there is another US program in the digital space which deserves particular discussion in this paper. *Talk, Listen, Connect: Helping Families During Military Deployment* is a resource developed by the well-loved children's television program Sesame Street. It includes online tools and videos for children featuring Sesame Street characters, mobile apps, and information for parents (including about the impact of deployment upon children). It also includes 'bilingual videos, storybooks, activities, Sesame Street/USO family tours, television specials, "Sesame Rooms" in military spaces, and more' (Sesame Street Workshop, 2020). It is aimed specifically at children aged 2-5, and it has been developed in consultation with military families as well as mental health, child development, and military program experts (Wright et al., 2013). Program evaluations have found a reduction in child behavioural issues and an increase in positive interactions. More than 80% of families reported that the program helped cope with the stress of deployment and parental separation (Nolan & Misca, 2018; Wright et al., 2013). A case study by Desens & Hughes (2013) found that the Talk, Listen, Connect 'Entertainment-Education' model is particularly effective as a type of strategic communication. The resource is easily accessible outside the US; Kudler & Porter (2013, p. 177) report that the program

> has reached hundreds of thousands of households around the world through free DVDs and related materials as well as direct downloads from the Sesame Street website. Few public health interventions are as likely to be taken home and enthusiastically put to use by military children and their families.

It is no surprise that such US-based programs are widely accessed across the globe, given that no other country comes close to the volume of resources and materials produced by and for one of the largest militaries in the world. Indeed, a review conducted by Mogil et al. (2019, p. 98) found that 'at the time this article was prepared (winter 2018), we could not identify any citations for evidence-based, family-level, and military-specific interventions with child outcome data in countries outside the United States.'

Programs and Resources in the United Kingdom

In the United Kingdom, a range of public services and resource-based organisations offer support for military families, including the *Soldiers', Sailors' & Airmen's Families Association (SSAFA),* founded in 1885, which offers support groups, housing, and adoption services (SSAFA, 2020); the UK-Government administered *Armed Forces Covenant* (2020), which offers support with children's education and childcare; *Service Pupil Premium,* a school-based program that provides a government subsidy of £300 per child for (usually pastoral) support in transitioning between schools (Skomorovsky, 2019); and *Families' Activity Breaks (FAB),* a private charity that provides camps for bereaved military families with support from specialised bereavement counsellors (Families' Activity Breaks, 2020).

None of these services, however, come close to the level of collaborative, well-funded, evidence-based and evaluated programs in the US, and there appear to be no programs with a focus on deployment or early childhood. As Bradbury argues (2015, p. 73), while a range of US-based programs for military families aims to cultivate positive attachment relationships, 'no evidence was found of similar interventions in (the) UK'. Misca (2018, p. 3) remarks that 'there is very limited research and evidence exploring risk and resilience, parenting and child adjustment in military families within the UK', while Nolan & Misca (2018, p. 14) warn that there is a 'yawning hole in the British literature that urgently needs to be filled to ensure the wellbeing of young children in British military families in relation

to the deployment cycle.'

There have however been at least two reports that have aimed to evaluate programs for military children in the UK. One report conducted by the Centre for Social Justice (2016) found that *Moving Schools Children's Activity Packs,* designed to ease the transition between schools, have helped to address the lack of communication between schools. The report also found, however, that communication breakdown is still a problem, and teachers require better support, resources, and data on the number of military children in schools (Centre for Social Justice, 2016). Another useful report conducted by the National Society for the Prevention of Cruelty to Children (NSPCC) in 2019 evaluated the organisation's own early intervention programs at drop-in centres within or near two military bases, at Tidworth in Wiltshire and Catterick in North Yorkshire (McConnell et. al., 2019). The centres utilise the *Strengthening Families* approach to build on family strengths, aid child development and reduce the possibility of child neglect (McConnell et al., 2019). Five protective factors are cultivated: parental resilience; social connections; knowledge of parenting and child development; support in times of need; and the social and emotional competence of children (McConnell et al., 2019). The evaluation found that the strengths-based approach has reduced anxiety levels and increased some protective factors for those parents who have taken part.

Programs and Resources in Canada

While Canada is similar to the UK regarding the distinct lack of effective programs and resources for military children, they do a more robust support package than what is available in the UK. Cramm et al. (2018) explain that Canada does not have a dedicated federal government department to fund military programs and resources like the US does. However, the Canadian government does provide two important and well-utilised federal services. Similar to Military OneSource, *Canadian Military Family Resource Centres (MFRCs)* are found across the country and offer a wide variety of resources and support services. They are run by the Canadian Armed Forces (CAF) and aim to 'build strong, resilient individuals, families and communities' by offering assistance and advice with parenting, employment, acquiring skills, and making community connections (Canadian Forces Morale and Welfare Services, 2020). The centres also offer guidance and support for military families facing deployment. Skomorovsky (2019) reports that some MFRCs offer dedicated programs for children, including Children's Deployment Workshops, Roots of Empathy, and Seeds of Empathy, but comments that more needs to be done in terms of psychological support, and raising awareness within military families of the vital need to equip children with coping strategies.

Rowan-Legg (2017) has called for resources to support children from military families in Canada, particularly to support children through the deployment cycle, and to assess family stress levels and cultivate coping skills. Such programs and services also need to be assessed for their effectiveness. Cramm et al. (2015, p. 9) acknowledge that several programs do exist, but 'the extent to which most of these program(s) and services have been based on evidence or rigorously evaluated for efficacy is unclear.' The US' highly successful FOCUS program has been adapted and implemented in Canada, although it has not been evaluated (Mogil et al., 2019). Other available programs include *The Mind's the Matter,* a webinar series for adolescents that educates teenagers about Operational Stress Injury (OSI) that may affect their military parent (Cramm et al., 2015; Canadian Forces Morale and Welfare Services, 2020). Two other programs also offer support to children from military families that are experiencing the impacts of OSI; *E=MC3* is for families with children aged 4-12 and uses a strengths-based model to improve individual and family wellbeing, while the *iStep Program* is for children aged 6-12 that helps children to understand their parents' injury, fosters coping skills, and normalises and validates the feelings and experiences of children in the military family (Skomorovsky, 2019). Additionally, Cramm et. al., 2016) explain

> there are multiple ways in which parental OSIs (operational stress injuries) can impact children and youth. Families need to renegotiate parenting roles and responsibilities, experience changes in spousal relationships that can cascade into parenting, and face shifting family dynamics .... children and youth can experience secondary traumatization, be at risk for child maltreatment, and manifest general impacts on their mental health and development (p. 334).

There is still much work to be done in this space, however, and Cramm et al. (2015, p. 9) warn that 'it is critical that unique health issues and needs be carefully defined and understood in a Canadian context.'

Programs and Resources in Australia

Finally, we turn to Australia, where many of the issues arising in the UK and Canada in terms of a lack of research into the experience of military families, and effective programs and resources, are also a significant issue (McFarlane, 2009; Rogers, 2020; Siebler & Goddard, 2014). Table 1 provides a summary of the programs this paper explored in this review.

Table 2

Summary of major programs in Australia

Program Name	Age Group	
KidSMART Program	6-11 years	Resilience, skills
Open Arms Counselling Service	5-15 years	Coping skills,
Kookaburra Kids	8-18 years	Resilience, peer support
Legacy	All ages	Information, support
Defence School Transition Aide (DSTA) program	School Aged	Information, support

Within Australia, specific programs are very limited to date, but several key organisations offer resources and support to defence families. *Defence Member and Family Support (DMFS)*, formerly Defence Community Organisation (DCO), is the major organisation who support defence families with services and programs. They offer services and programs to families to support them to manage military family life. Their staff include military support officers, social workers, family liaison officers, community development officers, and (regional) education liaison officers (REDLOs). The DMFS is administered by the Australian Government Department of Defence and also offer a range of resources – including counselling support, 24-hour advice and referrals, links to informative videos about deployment on their website, absence from home support teddy bears, some primary school-aged books (see https://www.defence.gov.au/DCO/Family/Kids/Programs-products.asp), and information booklets including the Absence from home support' handbook (Defence Community Organisation, 2020). The DMFS also offers *SMART Programs*, provided by Defence Social Workers, with a focus on improving family resilience and other psychological resources. *KidSMART* is a four-week program with one-hour weekly sessions, specifically targeted towards primary school children to help manage stress arising from relocations and deployment (Defence Community Organisation, 2020). However, while these DMFS resources have promise, it seems that they have not always been well promoted; Rogers' (2017) study of ADF families found that the families who partook in her research were not aware that the children's resources existed.

Defence Families of Australia (DFA) is an advocacy group who reports to the Minister for Defence Personnel and the Chief of Defence. They are a group who are positioned outside of government, although their staff are paid for by the Australian Government. The organisation only employs partners of current serving Australian Defence Force (ADF) members. DFA provides advocacy, as well as a social space for defence partners (Defence Families of Australia, 2019). In collaboration with the *DFMS and Defence Housing Australia,* they run the Defence Community Hub - an online resource for ADF families that provides information specific to posting locations, including 'information from schools and community groups through to public transport' (Defence Families of Australia, 2019). *Defence Housing Australia's (DHA)* sole purpose is to facilitate housing for defence personnel and their families.

Organisations that provide counselling and other mental health services include the *National Welfare Coordination Centre (NWCC),* coordinated by the DMFS specifically for families of deployed ADF members (Defence Community Organisation, 2020); *Open Arms,* which directly supports mental health professionals to provide specialised care to ADF members and their families, including children from aged 5-15 (Open Arms, 2020); and *Kookaburra Kids,* which offers camps, activity days, and mental health education for children age 8-18 who have a parent with military service-related mental illness (Australian Kookaburra Kids Foundation, 2020). *Legacy* also offers camps and mentorship programs for children in ADF families and can provide financial assistance to contribute to education and development (Legacy, 2020).

One of the most wide-reaching programs in Australia offers school-based support to ADF children. The DMFS facilitates the roles of *Defence School Mentors, and Regional Educational Development Liaison Officers (REDLOs).* Defence School Mentors help children to integrate into a new community setting after relocation, including welcome and farewell activities; facilitate the transition between different schools and schooling systems; monitor child wellbeing and foster resilience, self-confidence, self-reliance; promote a wider understanding of defence families within communities; redirect children to other services where required, and provide support during parental deployment (Australian Government Department of Defence, 2020b). Previously known as the *Defence School Transition Aide (DSTA)* program, a comprehensive study by Gail Macdonald (2016, p. 98) found that

> through constructing cultural knowledge DSTAs were able to anticipate students' needs throughout a deployment cycle thereby helping teachers to recognise the need for additional student support. By integrating cultural knowledge with practice DSTAs helped students to normalise parental deployment and build on their innate strengths. Furthermore, many of the DSTAs' activities encouraged engagement between ADF members and the schools. Involvement of ADF members with the school community enhanced students'

> and teachers' understanding of ADF work and helped by building the schools' capacity to support students throughout a parental deployment.

However, Macdonald (2016) also found that teachers were not fully aware of the impact of parental deployment upon ADF children. REDLOs are specially trained education officers who can be found throughout Australia, with knowledge of both the unique needs of ADF children and local knowledge of the school system and available resources. Because of this specialised role, REDLOs are also positioned to advise relevant government departments about issues affecting ADF children and their families and contribute to education policy (Australian Government Department of Defence, 2020c). Rogers (2017, p. 239) warns however that while REDLOs can promote specialised programs, 'REDLOs need to ensure educators, personnel, parents and schools know about these programs and evaluate and update these programs regularly.' Rogers' (2017, p. 188) overall message is that

> targeted support programs and access to age-appropriate and culturally appropriate resources were identified as inadequate by parents of children under five years old. This had not been identified in any known studies before within Australia. Clearly, more work is necessary to effectively support young children and families during these critical early years to scaffold their understandings of parental deployment.

Discussion

Within the programs outlined in this paper, a number of themes were identified. These themes are identified and listed in Table 3 and matched with military family literature.

Overall, while there is a wide range of programs and resources for military children on an international level, including many more in countries not represented here (see Skomorovsky, 2019), it has been widely demonstrated that the calibre and volume of programs found within the US are not replicated beyond its borders. Some US programs have been adapted for other nations, and some online/app-based content is accessible beyond the US, however, it is critical that issues impacting upon military families be understood in context (Cramm et al., 2015).

This highlights the need for culturally-specific studies in Australia, as well as programs that are specific to Australian Defence Force families. ADF families have their expression of military culture, and specific

Table 3

Themes within the programs

Theme	Program	Theories within military families
Resiliency	FOCUS; Operation Purple; MCEC; Strengthening Families; MFRC's; KidsSMART, Kookaburra Kids	Parenting together and apart Protective factors Children's responses Managing transitions Parent's responses Communication
Parenting approaches	ADAPT; StRoNG; Strong Families Strong Forces; MFRC's	Resilience Communication Parenting together and apart Protective factors Children's responses Managing transitions Parent's responses Health/mental health impacts
Coping Skills	Operation Purple; MCEC; FAB; The Mind's the Matter, iSTEP program, Open Arms Counselling Service	Protective factors Risk factors Grief and loss Health/mental health impacts Community connections
Information	MCEC; SSAFA; Armed Forces Covenant; The Mind's the Matter; Legacy, DSTA	Communication Military support Community connections Resilience Protective factors Risk factors Health/mental health impacts
Peer/Community Support	Operation Military Kids; MCEC; SSAFA; FAB; Moving Schools Activity Packs; iStep program; Kookaburra Kids; Legacy; DSTA	Protective factors Resilience Managing transitions Community connections Health/mental health impacts

community and family rituals (Baber, 2016; Huebner et. al., 2009). Differences in accents, flags and uniforms, special days, and terminology depend on one's national context. Rogers et al. (2019) and Rogers et al. (2020) explain the need for children to be able to see themselves and their family situation reflected in the content of a program for the resources to be effective. Gribble et al. (2018) found that even the term 'military family' is defined differently across the United Kingdom, United States, Australia and Canada. There should also be diversity in portrayals of ethnicity, and gender. In many studies, there is an over-reliance on male voices and perspectives, and female serving members are rarely represented (Creech et. al., 2014). Nolan and Misca (2018) also found that programs tend to ignore the possibility of the mother as the serving member, and many services assume that the deployed serving member is the father. In addition to the fact that the ECDP project is specifically targeting Australian military families, the ECDP is ensuring that content reflects the diversity of ADF families, with portrayals of both mothers and fathers as serving members. There is also a diversity of recorded voices in the children's eBook resources content, including people from a non-English speaking background and Indigenous Australians.

Skomorovsky's (2019) review of 36 international programs for military children found that programs should be easily adapted to different cultural contexts and national systems of care. The research team intends to ensure that the ECDP will be a free, open-access resource that can be adapted to different cultural contexts around the globe adding to other programs and resources for families and educators. The program is also online, responding to calls for easily accessible programs. This is particularly important in Australia, that is geographically vast and where military bases can be quite isolated from larger population centres. Apps are also part of the project, building on an emerging body of research which suggests that digital learning and engagement is important for children in early childhood, particularly as we advance into the digital age (Palaiologou, 2014; Rogers et al., 2019; Taufik, et. al., 2019).

Another critically important theme to emerge from this review is the need for programs to be evidence-based and evaluated to ensure the best possible outcomes for military families. There is a strong argument that evidence-based practice produces better programs, particularly when assessed and evaluated (Gerwitz, 2016; Gewirtz, 2018; Beardslee, 2013; McFarlane, 2009). Rogers' work (2017, 2019), also Rogers (2017) and Baber (2016) is among the only research into the experiences of parental deployment for young children from Australian military families to date, and this in-depth body of research underpins and drives the ECDP. The project, informed both by Australian and the international literature, draws upon many of the themes discussed throughout this review. Strengths-based approaches and resilience, the central focus of so many programs and resources, is also a key focus in the ECDP project. The need to provide training to educators, family workers and social workers is also addressed, with programs for parents, educators and family and social workers. A family-centred and strengths-based approach is also utilised, and the project has been informed from the start by a Steering Committee comprising of ADF parents, veteran parents, educators, counsellors, social workers, and researchers, ensuring grassroots, bottom-up approach that responds directly to end-users and stakeholders. The narrative approach featured in the children's resources within the project is a style that has been well-used by Rogers previously, and her research is cited by others in the field (Nolan & Misca, 2018). In turn, it is hoped other military family researchers will research with young children in Australia to increase our knowledge of their specific cultural needs. Most importantly, the sore lack of resources targeted towards early childhood, and the impact of deployment, is the motivation for the development of this vitally important program.

Conclusion and practical implications

Thus, programs and resources for young children from military families are needed to support them through developmentally sensitive stages as they cope with the stresses of military family life. Within the US, there are many quality educational programs and resources available. The UK and Canada have far fewer options and there is an identified need to develop programs that specifically cater to their context. Within Australia, culturally appropriate programs are needed so children and families can relate to the programs and see their lives reflected in them (Rogers et. al., 2019). Importantly, programs need to promote resilience, be easily accessible and evidence-based or evaluated well to be considered effective. It is vitally important these potentially vulnerable children and families and the educators, family workers and social workers who support these children are well equipped to assist them in these endeavours.

Acknowledgements

The Early Childhood Defence Program project is funded by The Ian Potter Foundation, the University of New England and the Foundation of Graduates of Early Childhood Studies. The authors do not make any money from the project, nor any publications arising from the project.

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International Electronic Journal of Elementary Education
December 2021, Volume 14, Issue 2, 135-146

Dancing is Thinking for Children: Working Memory, Inhibition, and Mental Flexibility

Erie Siti Syarah[a], Mohamad Syarif Sumantri[b], Yuli Rahmawati[c], Fasli Jalal[d], Elindra Yetti[e]

Received : 16 August 2021
Revised : 8 December 2021
Accepted : 29 December 2021
DOI : 10.26822/iejee.2022.234

[a]**Corresponding Author:** Erie Siti Syarah, Universitas Negeri Jakarta, Jakarta, Indonesia.
E-mail: ErieSitiSyarah_9920919003@mhs.unj.ac.id
ORCID: https://orcid.org/0000-0001-7629-7806

[b]Mohamad Syarif Sumantri, Universitas Negeri Jakarta, Jakarta, Indonesia.
E-mail: msyarifsumantri@unj.ac.id
ORCID: https://orcid.org/0000-0002-7354-4477

[c]Yuli Rahmawati, Universitas Negeri Jakarta, Jakarta, Indonesia
E-mail: yrahmawati@unj.ac.id
ORCID: https://orcid.org/0000-0002-1603-3320

[d]Fasli Jalal, YARSI University, Jakarta, Indonesia
E-mail: faslijalal@yahoo.com
ORCID: https://orcid.org/0000-0001-9914-7595

[e]Elindra Yetti, Universitas Negeri Jakarta, Jakarta, Indonesia
E-mail: elindrayetti@unj.ac.id
ORCID: https://orcid.org/0000-0002-3232-5438

Abstract

Sharpening working memory skills, inhibition, and mental flexibility of children in many studies have proven school readiness and long-term academic success. The aim of this research is to determine the impact of dancing and listening to music on children's executive functions using the interpretive paradigm with a qualitative case study method. The respondents were seven parents of children aged between 7-8 years. This study used online interviews for the data collection. A typological analysis of qualitative data acquired during the COVID-19 pandemic in the dimensions of working memory, inhibition, and mental flexibility was used to categorize how children's executive functioning might develop in parental care. Several typologies were identified, giving rise to three ideal typologies as a result of the analysis of research questions. Firstly, it is important to develop children's working memory through different new strategies (typology 1); secondly, positive reinforcement was the strongest factor in inhibition development (typology 2); and finally, dancing with music as a support for mental development and development of thinking (typology 3). The research outcomes require increasing adults' abilities around children to manage diverse learning stimuli and integrate art in them to build working memory, inhibition, and ideal mental flexibility of children.

Keywords:

Dance for Children, Inhibition, Mental Flexibility, Working Memory

Introduction

During this COVID-19 pandemic, there are limited opportunities for outdoor physical activity, with most individuals being forced to stay at home or adopt isolation protocols to prevent viral transmission. This situation has affected the children. Distance learning has a major impact on social development as well as children's movement activities (Hammami et al., 2020). Another dangerous effect of this situation is the risk of deficits in executive function (EF), such as a decrease in the child's inhibitory ability to handle task-reluctant behaviour (Johnson et al., 2020), decreased mental flexibility in creativity and problem solving due to limited interaction with the environment outside the home

(Filippetti& Krumm, 2020). Working memory deficits, which impact pre-schoolers in particular, have been related to recurring difficulties with math, reading, and science in primary school (Morgan et al., 2019).

Early childhood as a digital native's generation competing in social life faces one of the obstacles to achieving 21st-century skills is anti-social behaviour includes a variety of social behaviours that are not approved, such as a set of behaviours that involve property destruction, violations of social norms and other insults and violations of basic rights. The current phenomenon shows that children's stimulation of EF has not been widely used, while anti-social behaviour is related to inhibitory control ability, mental flexibility, or brain working memory. Although there is a proven positive relationship between social skills and EF, intervention programmes in social competence rarely include EF as a key component in early childhood learning (Benavides-Nieto et al., 2017; Howard & Melhuish, 2017). Evidence on the EF contribution to school readiness is also increasing. Educators and parents need to consider ways in which this information will be optimized for early identification and intervention purposes, making it necessary to develop various intervention approaches that are used to improve executive functioning throughout the early-childhood period (Romero-López et al., 2018; Willoughby et al., 2017).

Several studies reported that working memory, inhibition, and mental flexibility development in children are related to physical activity. According to the findings, the potential benefits of physical activity with broader stimulation have both psychosocial and neurocognitive outcomes (Cameron et al., 2013; Kirpich& Diamond, 2019; Willoughby et al., 2018). Several studies reported that body-movement activity opportunities should fit into the child's learning environment, as positive associations have been found between motoric activity and indicators of skill and inhibition, mental flexibility, and working memory (Diamond, 2012; Mulvey et al., 2018; Paschen et al., 2019; Patten &Bodden, 2019). Moreno et al., (2011) mentioned that only children in the music group showed an increase in performance with 90% of the sample also developing in executive functions. In terms of promoting brain plasticity, dance instruction outperforms repetitive physical exercise (Rehfeld et al., 2018), learning dance shapes the perception of action and neural implementation in the child's brain (Gilbert, 2019; Kirsch et al., 2018), brain training with dancing and familiar music improves children's cognitive abilities (Karpati et al., 2015; Olga et al., 2018; Poikonen et al., 2018; Sawami et al., 2018).

Research on interventions on working memory (WM), inhibitory control (IC), and mental flexibility (MF) development in children has not been done much by using dance. Many people regard dancing as a separate art form from other aspects of development; however, existing perceptions still rank academic-related stimulation that can improve WM, IC, and MF in children. This study acts as a complement to other similar studies in bridging the problem gap about the impact of dancing on WM, IC, and MF of children at home, specifically, attempting to offer research results related to WM, IC, and MF in children and their stimulation through dance.

Theoretical Perspective

Children Executive Function

The first main point of executive function is working memory, which involves holding information in mind and mentally working with it (E. E. Smith &Jonides, 1999). Working memory is critical for understanding everything that unfolds over time since it constantly requires remembering what happened before and relating it to what happens in the future. The reasoning would not be possible without working memory. Working memory is essential for the ability to recognize connections between seemingly unrelated things or to separate elements from an integrated whole, such as creativity, which involves dismantling and recombining elements in novel ways. Working memory also makes it possible to carry conceptual knowledge, perceptions to support decisions, and to consider in making plans and decisions (Diamond, 2014). Working memory, selective attention, and focused attention seem similar because they belong to the neural base. The prefrontal parietal system (PPS) aids working memory by allowing children to selectively focus on the information in mind selectively, discard irrelevant thoughts, and overlap substantially. Children who use PPS pay attention to stimuli in their environment and emit unconnected stimuli. Simulations have shown that developmental enhancements in working memory can aid in selective attention skills development (Wais et al., 2010).

Inhibition control (IC) involves the ability to control a person's attention, behaviour, thoughts, or emotions to override strong internal tendencies or external lures, and instead do what is more necessary (Diamond, 2014). Without IC, a person will be controlled by impulses, past patterns of thinking or acting (conditioned responses), and/or stimuli in the environmental stimuli that draw a person in various ways. Thus, IC makes it possible for people to change and to choose how to react and how to behave, and not to behave recklessly and save one from fooling oneself (Reck & Hund, 2011).

Self-control is an aspect of IC that involves control over one's behaviour and control over one's emotions to control one's behaviour. Self-control is about

resisting temptation and not acting impulsively (Diamond, 2014). Related to the last aspect of self-control, delaying gratification, according to Mischel et al. (1989), is to make yourself forget the temporary pleasures for a bigger reward later (Louie & Glimcher, 2010). When you make an impulsive decision, it is because you are unable to wait. On laboratory tasks, children are frequently rushed to respond and thus make the mistake of giving inaccurate responses. IC skills help children wait to give the best response that improves their performance and keeps them from rushing and failing (Schmitt et al., 2015).

Being able to alter perspectives spatially is one aspect of mental flexibility. For example, what if someone sees it from a different direction, or interpersonal, or can someone look at something from another person's point of view? (Blair, Clancy & Diamond, 2008). Mental flexibility grows on inhibition control and working memory. Another aspect of mental flexibility involves changing the way of thinking outside the box. For example, if one way of solving the problem does not work, one can find a new way to find a solution or understand something that has not been considered before. Set shifting, also known as Mental flexibility, refers to the ability to switch between tasks, strategies, or mental devices (Moriguchi et al., 2016).

Dance for Children

A bulk of research suggests that working memory, inhibition, and mental flexibility of children's executive functioning skills and constructs of school readiness are essential to early learning and long-term academic achievements. This review focuses only on executive function and related constructs, but also motor skills with a focus on visuomotor integration (coordination of movement and visual perception by the brain), as a basis for learning, and describes how these skills develop in children in a two-way and synergistic (Best et al., 2011; McClelland & Cameron, 2019). Executive Function refers to the cognitive processes necessary for goal-directed brain and behaviour, which develop throughout childhood and adolescence. Best et al. (2011) has shown that intensive aerobic exercise can enhance children's executive function. Another study addressed this evidence as well as the possible mechanisms underlying the relationship between exercise and executive functioning (EmamiKashfi et al., 2019; Mulvey et al., 2018; Patten &Bodden, 2019). Gross motor skills interventions improved preschool children's executive functioning as well as can help children with their learning difficulties.

Dancing for early childhood has many benefits over regular physical activity (Fouracre& Hons, 2010). Heterogeneous literature and research have shown that dance has physical, cognitive, and psychosocial benefits for children (Mancini et al., 2018). Dance training to familiar music improves cognitive abilities because it can relieve stress (Sawami et al., 2018). Authors (Chatzihidiroglou et al., 2018) compared an experimental group of preschool children (n = 22; mean age = 5 years, eight months) who followed an 8-week dance program with a control group (n = 20; age average = 5 years, five months). The dancing group outperformed the control group in terms of pre-test to post-test improvements in synchronization and balance. Dance training also shapes the perceptions of actions and behavioural performance of participants on the motor and visual tasks to increase during the training period (Kirsch et al., 2018). Considering sensor motor synchronisation importance and balance for next child development and performance of sports and daily activities, these results suggest that dancing is well included in the early childhood curriculum. When children watch performing arts, a vast and complex network of brain processes emerges (Poikonen et al., 2018). Dancing compared to conventional fitness activities leads to a greater volume increase in more areas of the brain, including the cingulate cortex, insula, corpus callosum, and sensorimotor cortex (Rehfeld et al., 2018). Karpati et al. (2015) demonstrated that short-term dance training influenced brain activity in observing the action and simulating tissue. Therefore, it is essential to perform movements in dance activities in front of the children, as well as providing ideas for forming new movements and building creativity.

Research Question

This study aims to find the impact of dancing/listening to music on children's executive function at home by addressing the following research questions: (1) what are the participants' perceptions of WM, IC, and MF of children and their stimulation? (2) How do the participants develop working memory, inhibition, and mental flexibility of children at home? (3) Do the participants involve dance and music in the way of developing WM, IC, and MF of children?

Methodology

This study used the interpretive paradigm with a qualitative case study method (Creswell, 2012).

Participants

The researcher deliberately selects individuals who have a better understanding of the research problem. Each participant is an early-childhood parent in the South Tangerang area. Participants are seven parents aged between 28 and 35 who showed interest in participating to this study and had children aged 5-8 years. Two of the parent group graduated from secondary school while the rest graduated from university. Some participants are

colleagues who already of a trusting relationship with the researcher, making it easier for researchers to communicate effectively and have a professional working relationship. This sample size fulfilled the before-mentioned criteria for being interviewed for this study. The necessary steps are taken to make sure that people are not easily identified by their responses (Lodico et al., 2010).

Data Collection and Instrument

The questionnaire for the semi-structured interview comes from a measurement instrument that has been validated because it adopted The BRIEF-P (Behaviour Rating Inventory of Executive Functioning–Preschool) instrument (Ezpeleta et al., 2015; Gioia et al., 2013). It has 63 executive function items referring to behaviour in the past six months reflecting the extent to which the behaviour was a problem. Interview data were collected through 54 questions, 30 questions on the dimensions of working memory, 11 questions on the dimensions of inhibition, seven questions on the dimensions of MF, and six questions about the role of parents in developing WM, IC, and MF of children. Within 45-60 minutes, I openly presented queries to parents starting with five administrative questions. Due to the Covid-19 pandemic, arrangements for a 45-60-minute open question and answer session were made online. Its purpose is to allow interviewees to choose locations and ways to make sure convenience and transparency.

Ethical considerations and procedures

Before starting the interview, consent was obtained from the participants. Further steps such as explaining the research, identifying risks, maintaining confidentiality, and providing informed consent were taken before the interview began. Participants in this research are constantly exposed to minimal risk. All demographic information was removed from the data collected, and a pseudonym was assigned. Participants were told that the study was completely voluntary, and withdrawals could occur at any time. Participants were given some protection during the interview, starting with their identities kept secret.

The transcript of the interview was compared with the audio recording for accuracy. At the end of each interview, researchers emailed a copy of the transcription results to participants to verify their responses. Participants were also asked to check the appropriateness of the findings in their setting. The researcher extended an open invitation to the participants to discuss the findings following the interview. Researchers verify that correct information is recorded on interview forms, which are then processed by Google's documentation. Audio recordings were played back within 24 hours after each interview to compare with typed data. Participants will have access to the last publication of the study (Patton, 2002).

Data Analysis

Typological analysis (Ayres &Knaff, 2008, p. 900) begins by identifying a research group organising framework, a series ranging from children's working memory to mental flexibility, based on the main ideas presented earlier in the section on all research variables in the background section research. Furthermore, the researchers established initial source groups to aid in the identification of sources of similarity and variation. Researchers listened to the seven audio recordings and copied them into a Microsoft Word document. Each transcription was governed by three research questions. The next step is to read systematically each transcript several times looking for repeated ideas and phrases that can form patterns in the data. Interviews that last 50 minutes are very insightful. A detailed process is used to analyse data to describe, compare, and interpret participants' reactions and responses (Fink, 2016).

All information relates to the research question and is aligned to explore the development of working memory, inhibition, and mental flexibility of children at home. To clarify and ensure the accuracy of the data collected, member verification and peer-debriefing were utilised. Researchers also document information that is not in line with general themes. Researchers do not force the code to fall into certain categories. With peer-debriefing, researchers and external sources communicate to note discrepancies that do not support the patterns and themes that stem from analysing for interviews and observations. However, the participants had responses that were quite similar in those few different cases were found members can check what they stated during the interview during member checking. Once the procedure is finished, there will be no further editing or interviewing. Researchers use numerous sources or collection methods to compare the collected data with each other as a triangulation measure. Researchers searched all data collected including interview notes and transcripts for evidence to support initial findings. Researchers make sure that they have rich and descriptive records to do transferability. Themes are generated from data sets by reviewing matrices and connecting within and between focus groups and categories. To acquire a better understanding of the data, this study draws on relevant theoretical ideas and literature on which as a basis for the research.

Results and Discussion

The results reveal how researchers construct a research typology based on experiences and

perceptions of parents in developing working memory, inhibition, and mental flexibility of children at home. Interviews were used to support the findings and to develop three categories that informed the typology creation of this study. After reviewing all data sources, the researcher identified data categories from which three typologies emerged (see Table 1).

Each typology was further explained, and distinctive comments were provided for supporting the findings. Representative quotes from the interviews have been reproduced to show the following three typologies (Table 2 shows the participant numbering codes).

Importance to develop children's working memory through different new strategies

Parental strategies that reduced working memory deficits, as found by working memory identification criteria in children, show that parents' strategies tend to carry out instructions that suppress children, especially parents with college graduate status. Some parents devise ways for improving their children's working memory. These are some of the comments given by the parents about their strategy:

> *I am an impatient person, so I make a schedule for my child, if the child is not able to do their job properly, I am disappointed. My strategy is so that children can be smart in memorizing and so on, I limit the use of gadgets, only Saturdays and Sundays (P5)*

> *I don't have a specific strategy. I am always confused and overwhelmed to educate my children at home; especially this pandemic problem makes office work and guiding children at home clash and chaotic (P1)*

> *My strategy in guiding children, especially to improve memorization and/or do assignments, I imitated my mother's strategy because she was a teacher. I apply the schedule for the child to work on assignments, by agreement (P7)*

> *If I am a relaxed person, the children are relaxed too, I have a strategy that might be quite strange, and I like it when children do the physical activity first before doing tasks that will occupy their focus, such as playing a train. Past. I also gave an example to the children doing assignments while listening to music (P2)*

This finding is sorted to answer research questions according to the type of ideal typology found in the study of parents' perceptions of their children's development of working memory, inhibition, and mental flexibility (executive function), and stimulation. Most of the parents interviewed showed difficulties in stimulating the three dimensions of executive function, which include working memory, inhibition, and mental flexibility of children. Parents use strategies and interventions that are not based on a knowledge base. This is a significant finding, indicating that parents require intervention programs that are well structured and easy to understand. The research that explores the relationships in typically developing

Table 1

Results of Qualitative Information Transformation (Typology Analysis)

Dimension of executive function	Data description	Typology
Working memory 1. Attention, memory 2. Task Initiation 3. self-monitoring, time management 4. Goal setting, decision making, Planning 5. Organisation	Parental strategies reduce working memory deficits 1. Different parenting styles 2. Repetition during learning activities 3. The active involvement of children in doing tasks 4. Build discipline and independence 5. Instruction to meet learning objectives and completion of assignments 6. Dance practice helps strengthen memory	It is important to develop children's working memory through different new strategies
Inhibition 1. Control emotions 2. Impulses	Familiar Approach to Inhibition development 1. Build relationships 2. Positive reinforcement 3. Creating a model of self-regulation 4. Consequences 5. Contact with children and the child's immediate environment 6. Dancing strengthens children's patience	Positive reinforcement is the strongest factor in inhibition development
Mental flexibility 1. Adaptability	Providing opportunities for creation and expression 1. An active learning environment to keep children on task 2. Be consistent with the expected behaviour 3. Music and dance open the minds and hearts of children	Dancing to music supports the development of mental flexibility and the development of thinking

Table 2

Participant Name Code, Number, and Location

Central Jakarta	South Tangerang	Bandung
P (1)	P2, P3, P4, P5, P6(5)	P7 (1)

children between the family environment, parenting strategies, and executive functions, suggests the importance value of a supportive family environment and parenting practices training (Schroeder & Kelley, 2010).

Various parenting styles emerged in the findings of this study when identifying the criteria for the task initiation ability in children. Some of the parental comments' excerpts are as follows:

> *Because I go to college, I also work, I tend to be ignorant of the child's ability to do their work when I finish, thank God, that's okay, I'm tired of my assignments, so is my partner (P1)*

> *I'm ignorant because I'm tired of work and taking care of the house but I'm still trying to watch my child's progress. Especially if there is already a message from the teacher, I will try to guide my child if I need it (P3)*

> *In my opinion, the child must discipline. It's okay to cry a little to get used to it, sometimes I am a bit over the top when I demand that my child gets praise from the teacher or other people. I ask my children to study hard (P5)*

This parenting style is different because of the various backgrounds of the parents. According to interview transcripts, parental workload and stress levels are additional factors that influence this difference. Children with lower executive functioning were found to have higher salivary cortisol levels, and higher parenting stress was reported by their parents (Wagner et al., 2016). Finding approaches to boost parental capability in nurturing is a crucial strategy to improve school preparation. Repetition during learning activities these findings emerged when researchers asked about the child's memory skills and attention abilities. Parents describe their support for their child for this ability:

> *I try to help my child to improve memory by repeating the materials he must master (P6)*

> *I think repetition is most important to help children have good memory skills. I also got rid of gadgets for fear that his concentration on the things he had to study would be disturbed (P4)*

> *To memorize something new for my child, I do it by repeating it until the child has a trained memory. I remember when I asked the child to repeat a new dance move on a gadget; I noticed that the child became easier to focus (P2)*

Repetition has indeed been proven in research to improve children's working memory, but it is recorded that what can be stored properly in memory is the repetition of fun activities. Best (2010) said that children's skills development happens more quickly when the components of a task are introduced clearly and repetitively, the retention and transfer of those skills must enhance when there is contextual interference, such as the boring activity.

The active involvement of children in doing tasks in this finding shows the child's ability in the criteria for goal setting, decision-making, planning:

> *For example, the child gets the task of making clay crafts on Tuesday and must send them on Friday. Going home from school on Tuesday, the child independently looks for materials that agree with the task orders, doing it step by step, because the clay must be shaped, dry, and then given a colour and the assignment is ready on time. The child often independently prepares all the needs of the task (P7)*

Evidence from a comprehensive literature analysis indicates that enhancing these three skills is crucial to helping young people handle obstacles better and avoiding or minimising externalisation and related issues. Moreover, strategies can strengthen these three strengths effectively and have been shown to yield behavioural changes of real-world significance (Modecki et al., 2017). Examples are given on how effective intervention is immediately more than one of these capabilities, such as various stimulations of teachers and parents to provide many opportunities for children to be more independent in designing, planning, and carrying out tasks.

The criteria indicated for self-monitoring ability, time management, and time management of children, which are significant for children's thinking development and behaviour, result in the development of discipline and independence. Parental strategies are quite diverse, along with the recorded opinions of the parents:

> *Incidentally, at home, there is a container for toys so every time he plays; he always tidies up according to his place. If there are items lying out-of-place, he will store them in their place (P7)*

> *I am grateful that his things are well-organized. The pencil, ruler, and eraser are in the pencil case. The book is neatly tucked into the bag so that he has no trouble finding his belongings. After school, keep a bag in its place (P7)*

> *I feel that my organizational skills are not good enough. Maybe children imitate their parents. Children are often late for school, often leave things behind, at times like this, I feel, I need professional help to build independence and discipline (P1)*

The results of the interviews show that many parents do not realise that this behaviour is a disruption in time management or children's discipline because of the results of parenting and modelling around the child. According to the findings of Stoeger and Ziegler's (2008) research, children should be taught time management skills and learning strategies as early as possible since they have an impact on children's success in a variety of fields. Instruction to meet learning objectives and completion of assignments: The following category findings are derived from the overall working memory function criteria, which

leads to the discovery of parents' demands for new strategies for enhancing working memory, inhibition, and mental flexibility. Seen in the results of the interview:

> *Study instruction for time discipline. Teach homework activities such as cleaning the bedroom, sweeping, mopping, helping mothers cook, cleaning the bathroom, wiping the glass of household chores in the child's capacity (P7)*

> *Accompany and motivate every child's activity, both in doing their work from school and their assignments at home. As well as providing facilities agree to the needs of learning activities (P4)*

> *I often give instructions so that children first separate themselves from their friends, so that they focus on doing assignments from school and household chores (P3)*

Effective parenting strategies can impact the neurocognitive growth of children. Parental instructions that tend to be comfortable for the child's ears and heart can build children's performance, as evidenced by the findings of the interview quotations, which show that some parents can discipline children and achieve learning goals through their instructions. Linear regression analysis of Spruijt et al. (2018) study showed that children of parents who were more supportive, less bothersome, and asked more open-ended questions performed better on task inhibition, working memory, and cognitive flexibility.

Dancing practice helps strengthen memory. This finding is the child's memory ability identification to memorise dance movements:

> *The dancing instructions from the gadget helped my child memorize dance moves faster. The child also memorized the song lyrics which I thought were quite difficult for me. If only there was a guide who made it easier for parents to practice dancing at home ... (P4)*

> *Children love to dance, they dare to appear in public with their dance creations, there was an impromptu invitation to fill the void, the children practiced at night, and the next day they appeared boldly (P2)*

> *I compare my son who likes to dance with better focus and catching power even though he dances that is less directed, but compared to his older brother who only likes music, and doesn't really like physical activity, his older brother is more introverted and stiffer, also has difficulty remembering the words he is going to show (P6)*

Some parents claim to comprehend their child's brain stimulation by moving and playing music; however, dancing is quite difficult for most parents. Parents stated that dancing was unusual in an ordinary family because if it was done in the house, it is indicated that the family was indeed an artist. Therefore, most parents do stimulation for working memory, inhibition, and mental flexibility development in children through other strategies. It is vital to share knowledge about dance through various programs that educate parents so that parents are aware of the need to include dancing activities for young children at home. It is because dance develops new cells and connections in the brain; it helps children deal with stress that can interfere with learning, while also motivating, learning to dance is a way of knowing, thinking, translating, interpreting, and creating thoughts (Nim, 2017).

However, some findings sufficiently strengthen the theory of dance for early childhood from one of the participants. The participant (P2) said that she had liked music since she was a little girl, she also liked dancing, but her parents' thought dancing was a bad job for girls. Her parents looked down on dancing a little because they were worried that their child would get used to it into adulthood. This participant shifted their love of dancing to rhythmic gymnastics activities. She has been accustomed to listening to music since she was pregnant, and as a consequence, the children at the age of five months have liked music, and moved, swaying happily when listening to music. The results of the interviews about the child's working memory, inhibition, and mental flexibility also looked good. Recent research has shown that parental behaviour can influence the executive function (EF) development during childhood. The association between parental cognitive behaviour and executive function was modulated by the child's age; smaller children had stronger effect sizes. A naturally occurring influence exists between the behaviour of the parents and the child's future executive functioning. An important note is that early childhood can be a critical period in which the cognitive behaviour (executive functioning) of the parents is especially influential (Valcan et al., 2018).

Positive reinforcement as the strongest factor of development inhibition

The habitual approach to inhibition development is quite difficult to record from the results of the interviews; parents admitted most that the difficulty in this inhibition criterion is more towards getting used to the value of the child's resistance strength in completing the task, or the child's strength to withstand temptations that divert his focus. Instilling a positive attitude in children requires building relationships. This is recorded in several answers from parents:

> *Doing tasks with cooperation, 50% help first, and then he does the task (P5)*

> *Children can control impulses because since childhood. They have learnt to express feelings, find solutions, so they never get frustrated, can overcome themselves, sometimes they discuss together to solve problems (P2)*

Regarding the average of the findings on positive reinforcement of children's inhibitory ability, parents give the following support:

> *When a child has problems with things, he doesn't like, I give reinforcement through exemplary stories from religion (P6)*

> *Usually, I encourage him when he breaks down to do tasks that he thinks are boring, sometimes because he is tempted to play with gadgets (P1)*

> *... Sometimes he confided in himself but after being given reinforcement, he was enthusiastic again with the efforts he built from within ... (P2)*

The answer to research question number two, after looking at the findings of how parents develop children's executive function at home, reveals that their place is the same as the perception and understanding of parents in developing working memory, inhibition, and mental flexibility of children. Parents are confused regarding the interventions needed to improve the children's cognitive function. This is unfortunate because the person closest to the child is the best model in improving the child's executive function (Fay-Stammbach et al., 2014).

Making a model of self-regulation found in the results of the interview is one of the positive reinforcement approaches in building children's inhibition, some parents shared their experiences:

> *Often the father gives an example to the child, how to be kind to bad shop customers, even though sometimes the child is not satisfied with his father and mother patience (P7)*

> *Sometimes I like to laugh at myself seeing children behave imitating my behaviour when doing college assignments, they are eager to imitate their mother (P2)*

The exercise of consequences for an offence is one of the findings in the criteria for developing inhibition in children. Few parents utilise the consequences of transgression to teach their children inhibition. However, there is one parental comment:

> *I use consequence instead of punishment when children violate boundaries; my experience shows that consequences are more effective in controlling children's behaviour than punishment (P6)*

Another finding in this inhibitory ability identification is the child's environment that parents have the main role in affecting children emotional. The following is a quote from the parents' opinion:

> *... I feel like moving to a new house because mixing with other adults in the house makes it difficult for me to educate my children, my child imitates the bad emotions of the people around him... (P4)*

> *I have a hard time overcoming quarrels between children, which sometimes lead to child impulsivity because they feel they are being treated unfairly (P1)*

> *...when a child gets used to being alone at home, the child becomes confused with close friends. He is confused about how to behave, especially in dealing with other children's behaviour that makes him uncomfortable... (P5)*

Dancing strengthens children's patience; this interesting finding was obtained when parents were asked about their experiences of dancing or experiences in music:

> *... I saw that when the children were taking dance lessons for performing arts at their school, I saw my child patiently listening to the teacher's instructions and patiently repeating all the dance moves that were learnt.*

> *. I didn't know if I could do it at home. (P5)*

> *I feel when my child is fussy and tends to throw tantrums; I invite my child to listen to music and dance. Like a panacea, the child immediately smiles and moves along, but unfortunately, I don't do this that often, and tend to forget (P7)*

Interviewed parents did not understand the power of music and physical activity of dancing, which was done easily at home, but parents tended to be insecure and found it difficult. On average, the best stimulation for working memory, inhibition, and mental flexibility is through stimulation related to academics and is done in school. During the Covid19 pandemic, parents must pay some attention to educating their children at home, which creates stress for certain parents. Parents need to understand that physical activity with children brings pleasure to the parent-child pair as long as the movement activity together involves music and joyful movements, as well as strengthening the relationship between parent and child (Filanowski et al., 2020).

Some parents believe that professional intervention is required in the development of children's working memory, inhibition, and mental flexibility. Parents hope that in this technological era, the source of knowledge is complete so that they can give directly in improving the EF of children. They understand the EF of children leads to cognitive behaviour that will succeed in school. Parents tend to be anxious about their children's school readiness (Fridani, 2020). Currently, few sources discuss interventions for early childhood executive functions, especially interventions through dance. A dance group study by Chatzihidiroglou et al. (2018) showed a better pre-test to post-test increase in motor sensor synchronisation and balance. These results suggest that dancing must include in the curriculum of early childhood at school and by parents at home.

Dancing to music as a support for developing mental flexibility and developing thinking

The findings of interviews with people about arts involvement in parenting demonstrate that children possess mental flexibility ability and cognitive

development. Providing opportunities for creation and expression is the finding of the results of interviews with the criteria for problem-solving abilities in children, but few parents do this:

> *... I find children always happy and have lots of ideas when I play their favourite songs (P2)*
>
> *I see children when they are dancing according to the dance on a gadget, they are easy to create new movements, and are interested in new things (P2)*
>
> *When relaxed, he can quickly solve difficult problems in his task (P4)*

An active learning environment to keep the child on the task of finding is based on the following parental comments:

> *At home, the learning environment is good because everyone is productive and has their own busy life, the children imitate to always complete tasks faster (P2)*

Consistent with the expected behaviour of parents requires the strength of parents as the main role model at home. Almost all the parents interviewed expressed it was difficult to do.

> *Difficult to consistently show good things in children (P1)*
>
> *Keep children in good behaviour, I need a lot of knowledge to do that (P5)*
>
> *Children behave consistently sweetly when parents promise the things they want (P2)*

For the last research question, dance is an intervention in the development of working memory, inhibition, and mental flexibility (executive function) in children. Based on this research on dance and brain function, the research findings on the perception and behaviour of one of the participants showed that dance affects working memory, inhibition, and mental flexibility (executive function) development in children. Participants (P2) described that the child's memory ability was better when the child enjoyed music and dancing because dance is a complex form of communicative movement with widespread processing in the brain that is internally differentiated (Nim, 2017). Research by Bugos and Demarie (2017) showed that musical activities integrated with dance movements contribute to cognitive development in areas such as inhibition. The participant (P2) stated that his son, who enjoys dance classes, has the character to endure the pleasure of the moment to complete a task, to control urges while being attacked by his younger siblings, and to wait patiently for things he has not accomplished. The findings as to the interview result show that dance leads to good mental flexibility, such as fast problem solving, adaptability, such as courageous behaviour on stage, flexibility in determining movements in dance when limited by time, also demonstrates the MF abilities that will become a good foundation when you grow up. According to Hanna in a literature study by Nim (2017), strong claims regarding the workings of the brain of dancing people indicate the influence of dance on brain regions involved in verbal and non-verbal communication; a dance develops new cells and connections in the brain; dance helps children deal with stress that can interfere with learning, while it can motivate learning and learning to dance is a way to know, think, translate, interpret, and create thoughts.

Conclusion

The study findings address three research questions by suggesting three ideal forms of typology analysis outcomes. Firstly, it is vital to improve children's working memory development through different new strategies, which indicates that parents expect the latest guidelines to become the new references related to dancing as a process development tool. Secondly, positive reinforcement is the strongest factor in inhibition development. This reflects that parent play an important role in children's inhibition development at home as a provision to face the challenges of the 21st century. As the main actor models with inhibitory abilities, parents play the role of dance instructors for children. Thirdly, dancing with music supports mental development and thinking development, which reflects that dancing is a tool for children to know, think, translate, interpret, and create thoughts. In conclusion, further research is needed to increase the adult's ability around children to regulate various learning stimuli and involve art in them to form working memory, inhibition, and ideal cognitive flexibility of children.

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iejee

International Electronic Journal of Elementary Education
December 2021, Volume 14, Issue 2, 147-161

Representations in the Learning of Sequences and Regularities by Third-Grade Portuguese Students

Ana Raquel Faria[a], Floriano Viseu[b], Alexandra Gomes[c], Ana Paula Aires[d]

Received : 5 August 2021
Revised : 22 December 2021
Accepted : 31 December 2021
DOI : 10.26822/iejee.2022.235

[a]Ana Raquel Faria, University of Minho, Braga, Portugal
E-mail: anafariayt@gmail.com

[b]**Corresponding Author:** Floriano Viseu, Department of Integrated Studies on Literacy, Didactics and Supervision, CIEd, University of Minho, Braga, Portugal.
E-mail: fviseu@ie.uminho.pt
ORCID: https://orcid.org/0000-0002-8221-6870

[c]Alexandra Gomes, Department of Integrated Studies on Literacy, Didactics and Supervision, CIEC, University of Minho, Braga, Portugal.
E-mail: magomes@ie.uminho.pt
ORCID: https://orcid.org/0000-0002-5208-570X

[d]Ana Paula Aires, University of Trás-os-Montes and Alto Douro, Portugal.
CIDTFF - Research Centre on Didactics and Technology in the Education of Trainers of University of Aveiro, Portugal.
E-mail: aaires@utad.pt
ORCID: https://orcid.org/0000-0001-8138-3776

Abstract

Due to their abstract nature, representation of mathematical concepts through different registers favors their understanding. In the case of "sequences and regularities", it becomes propitious the exploration of different registers of representation in the institution of topics, such as term, order, formation law, and generating expression. Considering these assumptions, a teaching experiment was performed to understand the contribution of multiple representations in the learning of "sequences and regularities" by 3rd-grade students. The study adopted a qualitative methodology and the findings of the study reveal that students initially presented a smaller variety of representations, which increased during the teaching experience. Students showed a greater preference for pictorial representations and made explicit connections between different representations throughout their resolutions. Pictorial representations and tables allowed close and distant generalizations, the determination of the formation law, and the generating expression. The greatest difficulties of the students resulted from the interpretation of the statements of the proposed tasks, which were also evident in the representation (natural language), showing a greater number of incorrect answers. This result shows that some students still have difficulties in justifying their reasoning, either in writing or orally.

Keywords:

Third-Grade Students, Difficulties, Teaching, and Learning Sequences and Regularities, Representations

Introduction

Mathematics is characterized by the abstract nature of the objects that constitute it. To a certain extent, mathematics serves as a justification for the difficulties that some students have in its learning. Such difficulties constitute an obstacle to understanding certain mathematical concepts (Canavarro & Pinto, 2012), which impel students to manifest an attitude of rejection to this discipline. One way to alleviate such difficulties emerges from exploring different representations of mathematical concepts. Representations are a configuration that translates something, such as an object, an idea, or a mathematical content (Goldin, 2008). Duval (2012) argues that the lack of understanding of representations necessarily causes a misunderstanding

of the mathematical content. This finding aroused our interest in exploring multiple representations in learning "Sequences and Regularities". The multiple representations of mathematical objects can help students give shape and visibility to their thoughts and communicate their ideas. An example of this can be seen in the content "Sequences and Regularities", which is favorable to the exploration of different registers of representation in the establishment of its specific topics, such as term, order, formation law, and generative expression. Considering such assumptions, this study aims to investigate the contribution of multiple representations in the learning of 'Sequences and Regularities' by students in the 3rd grade.

Sequences and Regularities in the First Years

The exploration of "sequences and regularities" is transversal to the different academic years, as suggested in the Curriculum Management Guidelines: "[the content 'sequences and regularities'] should be worked in every year of schooling to allow a progressive development of algebraic thinking in students, in particular the ability to generalize" (Ministry of Education and Science [MEC], 2016, p. 6). Consciously or unconsciously, the human being is constantly looking for new patterns (Baratta-Lorton, 2009). Several authors (Devlin, 2002; Orton, 1999; Sawyer, 1995; Steen, 1998), have defined mathematics as the "science of patterns", as when a pattern is identified, there will inevitably be the possibility of doing math. Vale and Pimentel (2010) explained that any interaction the mind makes with patterns establishes relationships, even in everyday activities such as reading and shopping. Establishing relationships is essential in the students' path to counteract the tendency of being "limited to remembering a set of facts, concepts and procedures in isolation" (Vale & Pimentel, 2010, p. 33).

According to Vale (2009), "sequences and regularities" enhance the ability to abstract and communicate using multiple representations. Moments when students are encouraged to communicate and share their ideas allow them to develop their reasoning (National Council of Teachers of Mathematics [NCTM], 2000). For Lannin et al. (2011), reasoning in mathematics is an evolutionary process that involves "conjecturing, generalizing, investigating why, and developing and evaluating arguments" (p. 13). According to some studies (Branco, 2008; Pimentel et al., 2010; Rivera & Becker, 2009) working with "sequences and regularities" enhances algebraic reasoning ability, an important aspect for learning Algebra, which "is very useful for the student in his/her everyday life and further studies" (Borralho et al., 2007, p. 193). Hence, all students should learn Algebra (NCTM, 2000; Kiziltoprak & Köse, 2017), as early algebraic thinking and working with patterns encourage students to identify relationships and make generalizations. Pimentel et al. (2010) and Ponte (2005) argued that it is necessary to formulate generalizations starting from sequences and regularities, from the first years of schooling, as generalizing sequences students develop their algebraic thinking (Radford, 2010). In the study of sequences, Ponte et al. (2009) reported that one of the biggest obstacles for students arises in studying repetitive pictorial sequences, which is due to a lack of understanding, as only after assimilating the sequence will they be able to generalize. The generalization difficulty in this type of sequence is due to the relationship between term and order. On the one hand, children at an early learning level do not understand that sequences can be extended in both directions (Warren, 2005). On the other hand, children with more advanced levels have difficulty in the symbolic writing of a generalization and the attribution of a meaning to the letters of a numerical expression framed in a functional context (Saraiva & Pereira, 2010). In exploring growing pictorial sequences, Lannin (2003) reported that several children only use the additive strategy in describing generalizations, revealing difficulty in using other strategies. This can be explained by the fact that students only focus on presented dataset and do not understand the relationship between the datasets (Warren, 2005). Rivera and Becker (2008) and Ponte and Velez (2011) advocated that students had difficulties in justifying their reasoning, either in writing or orally, and they failed to formulate a valid justification for the generalization. The exploration of "sequences and regularities" also enables students use of multiple representations, such as gestures, tables of values, letters, and natural language (Warren, 2009). They are the main instruments students use in the first years of schooling (Alvarenga & Vale, 2007; Pimentel et al., 2010).

Mathematical Representations

Mathematical representations translate mathematical objects as these "are not directly accessible to immediate intuitive perception or experience" (Duval, 2012, p. 268), unlike everyday palpable objects. As such, it is necessary to create representations that signify, produce, and resemble them so that it is possible to reason for them and "give visibility to what we think" (Canavarro & Pinto, 2012, p. 53). According to Duval (2012), there are several ways to represent mathematical objects: a number, a function, a vector, and figures. However, a mathematical representation only makes sense when observed in a certain context, with defined rules and meanings (Ponte & Velez, 2011). For example, thinking of the number 3, it could refer to the "three little pigs", or represent something immaterial like the cardinal of a set of three elements.

Goldin (2008) claimed that understanding a mathematical concept implies that the subject

can distinguish the mathematical objects from the representation that makes it accessible. If students confuse mathematical objects with the representation made of these same objects. In that case, this can lead to "a loss of understanding and acquired knowledge quickly becomes unusable throughout their learning context" (Duval, 2012, p. 268). Goldin (2008) distinguished two types of representations: external and internal. External representation is palpable and observable and can be found on paper, screens, or other support. They include mathematical symbols (symbolic writing); algebraic writing; pictorial representations (figures, images, and icons); objects, and verbal language (written). Goldin differentiated some external representations observed in a classroom context: mathematical symbols, verbal language, figures, and objects. As for internal representation, Goldin and Kaput (1996) considered cognitive constructions formed in students' minds. These are "mental images built on reality, referring to cognitive models, concepts or mental objects, and therefore not observable" (Almeida & Viseu, 2002, p. 195). Duval (2012) presented a similar thesis, distinguishing two types of representations: mental representations, where the subject uses a set of personal images that help give meaning to the mathematical objects in question; and semiotic representations, which are productions constituted using symbols belonging to a system of representations. It can, thus, be concluded that semiotic representations result from an exteriorization of mental representations. For Vygotsky (2008) and Piaget (1990), mental representations are an interiorization of what the subject assimilates and that depends on the interiorization of semiotic representations.

Ponte and Velez (2011) showed that, for a long time, only symbolic representations were worked in schools and, as emphasized by Dufour-Janvier et al. (1987), external representations are introduced in the school, "there appearing to be few opportunities for students to explore their numerical representations" (p. 119). According to NCTM (2000), children should learn conventional forms of representations, but they should also be guided to develop and create their representations that will support their learning.

The "iceberg model" developed by researchers at the Freudenthal Institute (Webb et al., 2008) is a metaphor illustrating the students' experience of the wide range of representations. At the top of the iceberg, there is a formal representation and at the submerged and broader part of it appear pre-formal and formal representations. Webb et al. (2008) emphasized three phases of learning: the informal phase, the pre-formal phase, and the formal phase. In the informal phase, the concepts are approached in a familiar context in a concrete way (with informal representations, such as figures, drawings, etc.). In the pre-formal phase, complexity increases, and representations appear more abstractly (for example, number lines). Finally, the formal phase implies that students resort to formal representations. When the students reach the formal stage, it does not mean that they will never resort to informal or pre-formal representations. Goldin (2000) and Webb et al. (2008) considered that students can resort to these representations again in moments of insecurity or confusion.

According to Duval (2012), "the use of many registers seems to be a necessary condition so that mathematical objects are not confused with their representations" (p. 270). The primary objective of representations is to give access to the represented object, which, for Duval (2012), brings together a set of necessary conditions promoting conceptual apprehension, implying the coordination of multiple representations. First, students must form an identifiable representation through the composition of a text, a drawing, a scheme, geometric figures, formulas, etc. Afterward, students should process, that is, transform a given representation into the same record in which it was initially created. This can be conceived through calculus, a way of handling symbolic expressions. Finally, students can perform a conversion, which means transforming this representation into a new one, keeping all or part of the content of the initial representation. It is important to emphasize that cognitive activities between conversion and treatment are distinct and independent, being two radically different types of semiotic representation transformation (Duval, 2012). A 2nd-grade student, for example, might look at a drawing with four circles and add those four circles to another three in a new drawing. The student will be able to get the sum of four and three without converting the drawing to another representation, such as for the numerals 4 and 3 or even for the symbolic writing of "4 + 3". However, students capable of converting the mentioned representations will show that they have mastered the mathematical content as they can apply it through multiple representations. The hypothesis underlying Duval's theory (2012) is that the complete understanding of a concept occurs in the coordination of at least two representation registers, and this manifestation occurs through cognitive conversion activity. The recommendations in the Curriculum Management Guidelines (MEC, 2016) are in line with Duval's theory, suggesting that the teacher should allow students to appropriately, consistently, and gradually use the "symbolic representation of data, ideas, concepts, and mathematical situations in various forms" (p. 16) and emphasize the importance of students being able to "pass information from one representation to another, to obtain different perspectives of the same situation" (p. 16). Carraher and Schliemann (2007) highlighted that working with "sequences and regularities" allows exploring

geometric and numerical representations, where the ordinal positions (order) are related to the number of elements in that position (term). Alvarenga and Vale (2007) reinforced that "students, from the early years of schooling, can and should be encouraged to observe patterns and represent both geometrically and numerically, starting the study of algebra in a strongly intuitive and informal way" (p. 2). Students must be aware that there are multiple representations of the same situation and must "be able to move from one (representation) to the other understanding that the rules are equivalent" (Vale & Pimentel, 2005, p. 15). In working with "sequences and regularities" this allows them to "see," that is, understand, the existing pattern or relationship (Orton, 1999), regardless of how it is presented to them.

Methodology

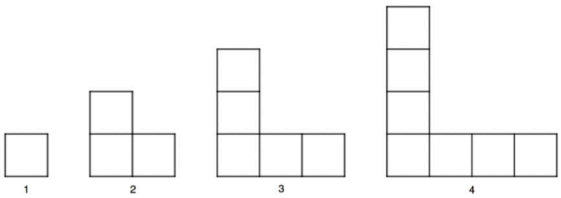
Considering the importance of representations in the learning of sequences and regularities, the study investigated the contribution of multiple representations in the learning of "sequences and regularities" in third-grade students. The study was conducted in the academic year of 2019–2020 in the context of the supervised teaching practice of the first author of this work. The study participants were 26 3rd-grade students, nine boys and 17 girls. All the participants are eight years old. More than half of the class (58.3%) indicated mathematics as the subject in which they had more difficulty; however, most students (66.7%) reported that they liked it. Regarding performance in mathematics, most students obtained "good" and "very good" levels and no student obtained insufficient level in their assessment at the end of each period of the school year. Given the nature of the objective outlined, this study adopted a qualitative and interpretive approach to understand the students' mathematical activities in solving the proposed tasks in the classroom context (Bogdan & Biklen, 1998). Twelve tasks were developed and explored in four classes to challenge students to develop their strategies, using their previous knowledge and multiple representations in the topic "sequences and regularities", with the students organized into 12 work pairs. Data were obtained from the students' resolutions and collected before their discussion in the class group. In this work, the study focused on the analysis of three tasks only. The analysis that results from the resolution of the tasks focuses on the following dimensions: (i) identification of numerical regularities; (ii) determination of the generating expression of a sequence; and (iii) transformation of representations. In each dimension, the types of representations used, and possible connections between the different representations are also analyzed. The strategies used by students in obtaining the following terms from the sequences are also analyzed. These strategies are classified using the typology of Ponte et al. (2009) as follows: (1) "representation and counting strategy", where students represent all the terms of the sequence until they determine the term that was asked of them; (2) "additive strategy", where students perceive the change that occurs from term to term and from there obtain the next term; (3) "whole object strategy", in which students, through one term, determine other multiple terms of that term; (4) "term decomposition strategy", where students decompose the term, thus realizing how it was constructed.

Presentation and Analysis of Results

Identification of Numerical Regularities

In determining the formation law of a sequence, the students started by solving Task 1, which asked them to identify the regularity that characterizes obtaining a given term from its predecessor and establish close generalizations.

Task 1. Look at the following sequence of figures. In each figure, each square is formed by four equal toothpicks.

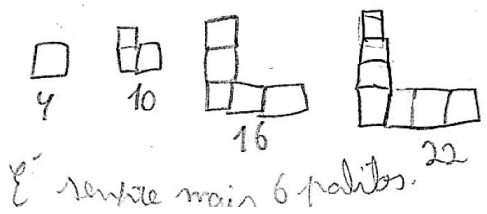


1. What happens to the number of toothpicks from one term to the next?
2. What is the formation law regarding the number of sticks in the sequence?
3. How many toothpicks are there in the order 6 figure? And in the order 8?

From the analysis of the answers given to each question, most of the students answered correctly in the first two questions. As for the first question, nine pairs correctly illustrated the formation law of the sequence, as exemplified by the answer given by pair P10, which represented each term and understood that six more toothpicks would be needed to form each subsequent figure (Figure 1).

Figure 1

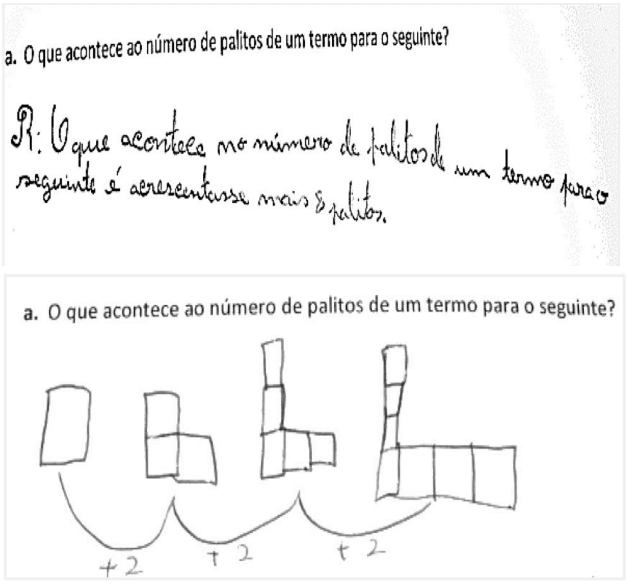
The Correct Answer of Pair P10 to Question 1 of Task 1 ["It's Always Six More Toothpicks"]



According to the resolutions of three pairs of students who answered incorrectly, two pairs miscounted the number of toothpicks to be added, and one pair considered the number of squares that increased from one figure to the next (Figure 2).

Figure 2

The Incorrect Response of Pairs P11 and P6 to Question 1 of Task 1

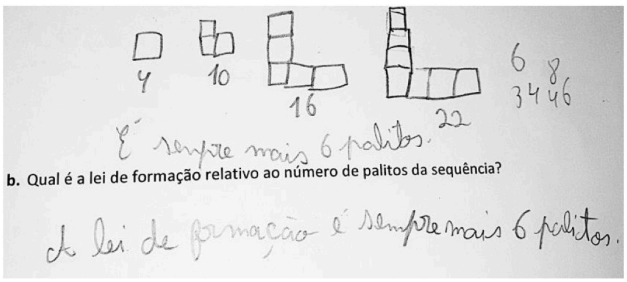


(Note: Pair P11's answer to Question 1 of Task 1: "What happens to the number of toothpicks from one term to the next is to add eight more toothpicks")

In the second question, nine out of 12 pairs of students answered correctly and reported that they related the formation law of a sequence to the phenomenon that occurs from one term to the next, successively, as illustrated by the response of pair P10 (Figure 3).

Figure 3

The Correct Answer of Pair P10 to Question 2 of Task 1

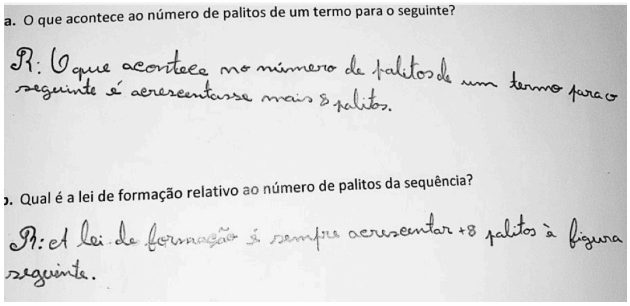


(Note: "The formation law is always more six toothpicks")

Two pairs gave partially correct answers as they made the correct association of the formation law to the phenomenon that happens next; however, as they incorrectly answered the previous question, the formation law presented does not correspond to the sequence under study, such as the response of the P11 pair suggests (Figure 4).

Figure 4

The Partially Correct Answer of Pair P11 to Question 2 of Task 1

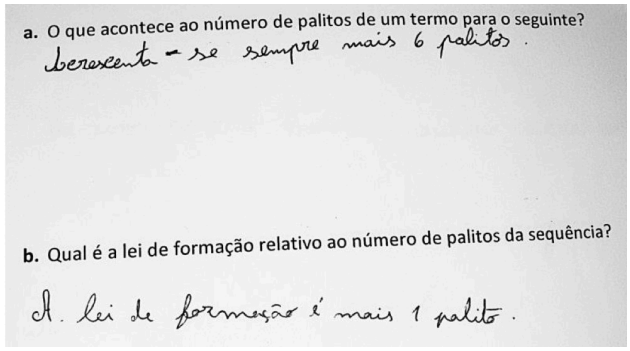


(Note: "The formation law always adds more eight toothpicks")

One of the pairs gave an incorrect answer. In the first question of the task, the pair understood what happens from one term to the next in the sequence; however, they could not relate this event as the formation law of the sequence, so they presented a different answer to the second question (Figure 5).

Figure 5

The Incorrect Response of Pair P2 to Question 2 of Task 1

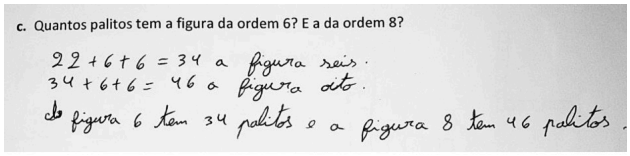


(Note: Pair P2's answer to Question 1 of Task 1: "add six more toothpicks.")] [Pair P2's answer to Question 2 of Task 1: "The formation law is more 1 toothpick")

Finally, in the third question, the students were asked to identify the terms of two distinct nonconsecutive orders. Three strategies used by the students to solve the problem stand out: the "term decomposition strategy," the "representation and counting strategy" and the "additive strategy." The "additive strategy" was presented by two pairs, who realized they had to successively add the formation law of the sequence (+6) to obtain the following terms. The P2 pair managed to achieve valid conclusions (Figure 6).

Figure 6

The Correct Answer of Pair P2 to Question 3 of Task 1

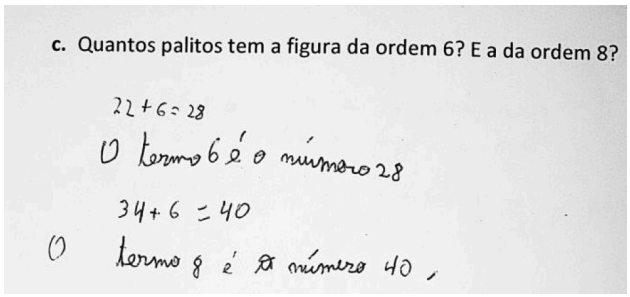


(Note: "Figure 6 has 34 toothpicks and Figure 8 has 46 toothpicks")

Pair P3 used this strategy and got a partially correct answer. This pair resorted to symbolic writing but could not visualize the sequence and realized that the orders requested were not consecutive nor immediately following those presented (Figure 7).

Figure 7

The Partially Correct Answer of Pair P3 to Question 3 of Task 1



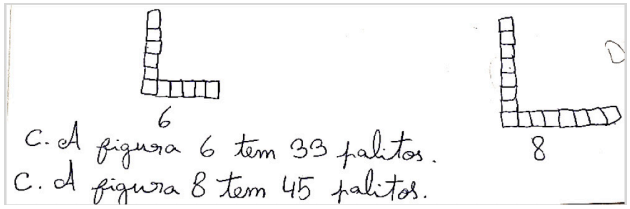
(Note: "The term 6 is the number 28. The term 8 is the number 40.")

As shown in Figure 7, the pair P3 added to the number of order fourth sticks (22) six units and assumed that the number of order sixth sticks would be 28. This shows that the representation used did not allow students to visualize the sequence and determine the following term (order 5 term) only. One can understand that in the second part of the task, in determining order 8, students started from the number of toothpicks they considered to be in figure 6 (28) and added six units, obtaining the order 7 term. To this result (34), they added another six units, reaching the order 8 term. Although the result is incorrect, students already showed a certain understanding of the formation law of the sequence. The choice of symbolic writing probably made it difficult to solve the task as it did not allow them to visualize the continuity of the sequence, as the degree of abstraction of students in this age group is still low.

As for solving strategies, it was observed that the "term decomposition strategy" was used by three pairs. Students represented, through pictorial representations, only the terms they intended to determine, which indicates that they understood how the figure was constructed. Students, through pictorial representation, were able to generalize a situation, realizing that the number of the figure is equal to the number of squares horizontally and the number of squares vertically; however, although pairs were able to represent the sequence correctly, they were not able to draw valid conclusions, probably due to little experience with the manipulation of pictorial representations. Students represented the terms correctly but were not able to accurately count the number of toothpicks in the figure. Figure 8, referring to the resolution of pair P9, depicts a counting error of one unit per figure, which translates into a partially correct answer.

Figure 8

The Partially Correct Answer of Pair P9 to Question 3 of Task 1

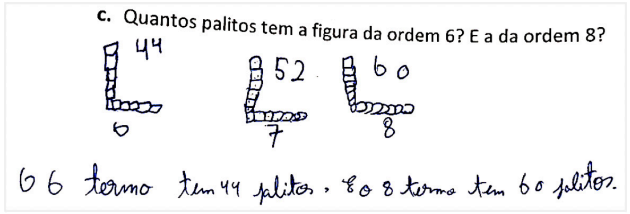


(Note: "Figure 6 has 33 toothpicks. Figure 8 has 45 toothpicks")

The use of the "representation and counting strategy" was also observed. It implies that students represent all the terms in the sequence until they obtain the desired term (Ponte et al., 2009). This strategy was used by a pair who incorrectly answer the question, and it may, once again, be a matter of lack of interpretation of the pictorial representation (Figure 9).

Figure 9

The Incorrect Response of Pair P4 to Question 3 of Task 1



(Note: "The term 6 has 44 toothpicks. And the term 8 has 60 toothpicks")

According to Figure 9, pair P4 correctly represented the terms, but the toothpick count is quite different from reality, with the order sixth term exceeding 10 units and the order eighth term exceeding 14 units.

Representations

In the analysis of the resolutions to the proposed questions, it is verified that the different pairs resorted to multiple representations (Table 1).

Table 1
Frequency of the Types of Records Used by Students in Task 1 (n=12)

	Response types															
	C					PC					I					
Question	PR	NL	S	SW	T	PR	NL	S	SW	T	PR	NL	S	SW	T	
1	3	6	0	0	0	0	0	0	0	0	0	2	1	0	0	
2	0	9	0	0	0	0	2	0	0	0	0	1	0	0	0	
3	1	1	0	1	0	2	1	0	1	0	2	2	0	0	0	
Total	4	16	0	1	0	2	3	0	1	0	2	5	1	0	0	

Note: PR: pictorial representation; NL: natural language; S: schemes; SW: symbolic writing; T: tables. C: Correct answer; PC: Partially correct answer; I: Incorrect answer.

Table 1 shows that students mostly used natural language. The use of this type of representation allowed half of the pairs to obtaining a correct answer to the first question of the task. The predominance of this representation may be because the task is presented through a pictorial sequence, and the students do not feel the need to proceed with the treatment of this representation. Students may have understood the question only by analyzing the pictorial sequence, presenting their answer in natural language, without explaining the reasoning that resulted in the same answer.

The pictorial representation, being an informal representation, despite being less used, resulted only in correct answers. This may mean that, as it is a more visual representation, it facilitated understanding, which is corroborated by Vale (2009), who argues that exploring generalization through different representations of visual support is essential for understanding mathematical topics under study.

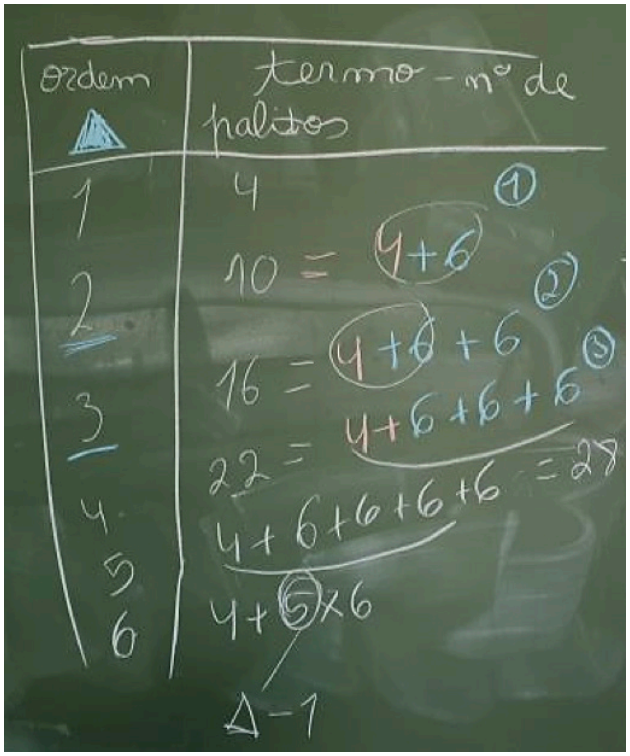
A pair of students chose to present their resolution with a pre-formal representation, the schema; however, this greater complexity in the representation may have led to confusion in the interpretation of the task, which led them to obtain an incorrect answer.

In the second question of the task, all pairs used natural language to present their answers, with nine pairs getting correct answers, in the third question, within the representations used, no representation stands out, as only three pairs managed to get a correct answer.

Connections between representations

A representation that was not used by any student was introduced in the discussion of resolutions in class. The aim was to offer new possibilities and develop the students' capacities in the treatment and conversion of representations. As the different representations previously used by the students were already registered on the board, (e.g., pictorial representations and symbolic writing), these same representations were used to build a table to organize the data (Figure 10).

Figure 10
Table Built in the Blackboard



This moment provided the class with the development of greater resourcefulness in the connections between multiple representations and allowed students to understand the mathematical content, even when represented in different ways.

A geometric figure (triangle) was assigned to the order to familiarize students with algebraic expressions. In determining the order sixth term, the numeral 5 of the symbolic expression in the table was converted using the following formula: ''Δ-1.'' The conversion of representations and their respective treatment, in working with ''sequences and regularities'' allow students to understand the mathematical objects under study and develop the capacity for generalization and abstraction (Vale, 2009).

Determining the Generating Expression of a Sequence

In determining the terms of a sequence defined by a formation law that allows obtaining each term from the previous ones, knowing the first terms, students solved Task 2.

Task 2. In a school canteen, four students can sit at a table. The tables are all the same. six students can seat, when two tables are combined.

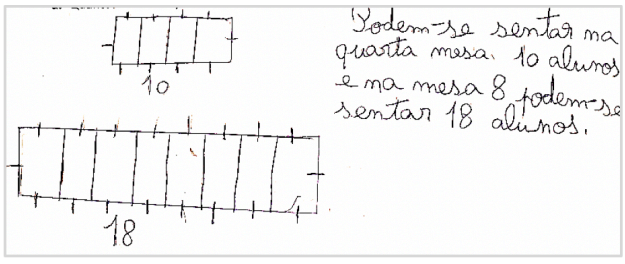
1. *How many students can sit at five and 10 tables? Justify your answer.*
2. *How many tables will be needed for 20 students to seat? Justify your answer.*
3. *Could there be a table with 31 students and all seats occupied?*

Only four of the 12 pairs transformed the presented representation into a new representation. Two pairs converted the statement to a pictorial representation, one pair to a schema and one pair to a table with symbolic writing, meaning that most pairs answered the questions in Task 2 correctly.

Ten pairs answered the first question correctly, while the other two gave a partially correct answer. However, different strategies emerged (Ponte et al., 2009). Eight of the 12 pairs developed the "term decomposition strategy." Although it is not explicit in their resolution, it is clear that students have decomposed the terms to understand that each one presents the same number of tables as the order to which it corresponds. In this case, when students draw the terms of the orders only, they aim to determine them with the number of tables corresponding to the desired order, as illustrated by the response of pair P5 (Figure 11).

Figure 11

The Correct Answer of Pair P5 to Question 1 of Task 2

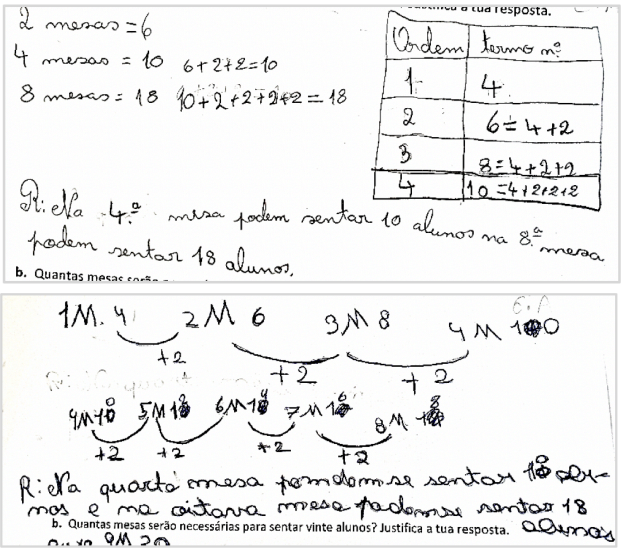


(Note: ["In the fourth table can seat 10 students, and in the table 8 can seat 18 students"])

The "additive strategy" was used by two pairs who obtained the correct answer by successively adding two to the previous term, as this is the formation law of this sequence, as illustrated by the answers of pairs P11 and P9 (Figure 12).

Figure 12

The Correct Answer of Pair P11 and Pair P9 to Question 1 of Task 2

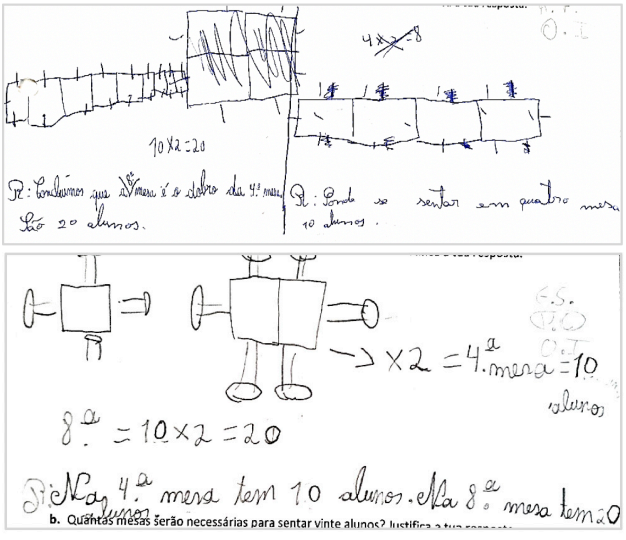


(Note: [Pair P11's answer to Question 1 of Task 2: "In the fourth table can seat 10 students, in the table 8 can seat 18 students."] [Pair P9's answer to Question 1 of Task 2: "In the fourth table can seat 10 students, and in eighth table can seat 18 students"]).

Finally, two pairs chose to resort to the "whole object strategy," which implies the determination of a term starting from a multiple term. However, this strategy is not feasible in this case, because, despite the number of tables doubling, the number of people seated does not correspond to the double, since two more places have to be considered at the head of the tables. Thus, students were able to answer the number of people who can sit at four tables correctly, but wrongly as to the number of people who can sit at eight tables, as illustrated by the responses of pairs P6 and P1 (Figure 13).

Figure 13

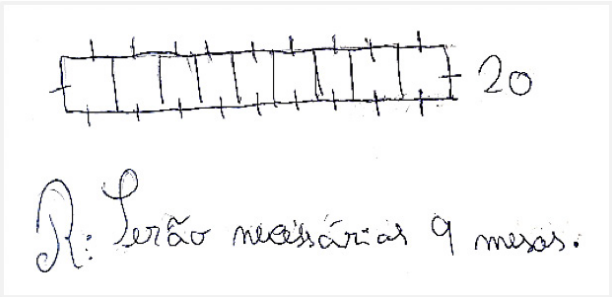
The Correct Answer of Pair P6 and Pair P1 to Question 1 of Task 2



(Note: [Pair P6's answer to Question 1 of Task 2: "We conclude that the eighth table is the double of the 4th. There are 20 students."] [Pair P6's answer to Question 1 of Task 2: "Can seat in four tables 10 students."] [Pair P1's answer to Question 1 of Task 2: "At the fourth table, there are 10 students. At the eighth table there are the double")

Nine pairs managed to determine the correct solution in the second question, and only three had an incorrect answer. Of the correct answers, seven pairs only drew the figure corresponding to the solution to the problem, so they may have obtained this result by trial and error, as illustrated in Figure 14.

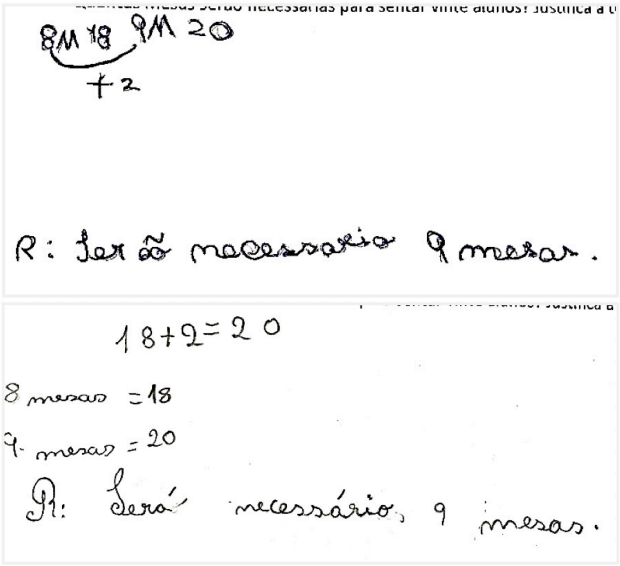
Figure 14
The Correct Answer of Pair P7 to Question 2 of Task 2



(Note: "Will be needed nine tables?")

Two other pairs obtained the correct answer through the "additive strategy", as to each term the formation law is added to obtain the next term (Figure 15).

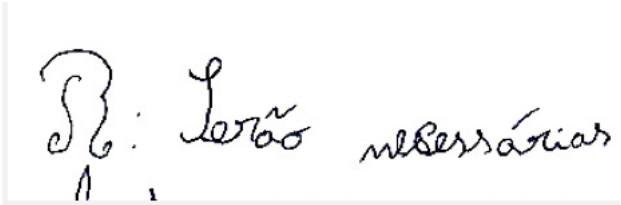
Figure 15
The Correct Answer of Pair P9 and Pair P11 to Question 2 of Task 2



(Note: Pair P9's answer to Question 2 of Task 2: "Will be needed nine tables"] [Pair P11's answer to Question 2 of Task 2: "Will be needed nine tables?")

Finally, two pairs had an incorrect answer, determining terms where the condition of sitting only 20 students is not verified, as shown in the answer of pair P7 (Figure 16).

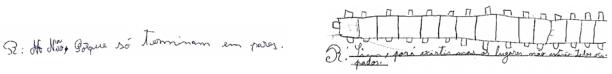
Figure 16
The Incorrect Answer of Pair P7 to Question 2 of Task 2



(Note: "Will be needed 10 tables to seat 20 students?")

In the third question, it is confirmed that 10 pairs answered the question correctly. Students found different conditions justifying it was not possible for 31 people to seat and occupy all seats. For example, pair P6 noticed that it was not possible because the terms are all equal, so 31 does not belong in the sequence, and pair P12 chose to design the tables, ending up verifying the impossibility of seating 31 people and having all seats occupied (Figure 17).

Figure 17
The correct Answer of Pair P6 and Pair P12 to Question 2 of Task 2



(Note: Pair P6's answer to Question 2 of Task 2: "No because they only end in even numbers"] [Pair P12's answer to Question 2 of Task 2: "Yes there may be but the seats are not occupied")

Representations

Multiple representations were used in solving the questions in Task 2, which prompts us to analyze which ones contributed the most for the students to solve the presented task (Table 2) effectively.

According to Table 2, it appears that most of the correct answers result from the pictorial representation.

Connection between representations

When discussing the resolutions of Task 2, the students were asked about the relationship between the term and the order of the sequence. This interaction resulted in a new representation: algebraic writing (Figure 18).

Table 2

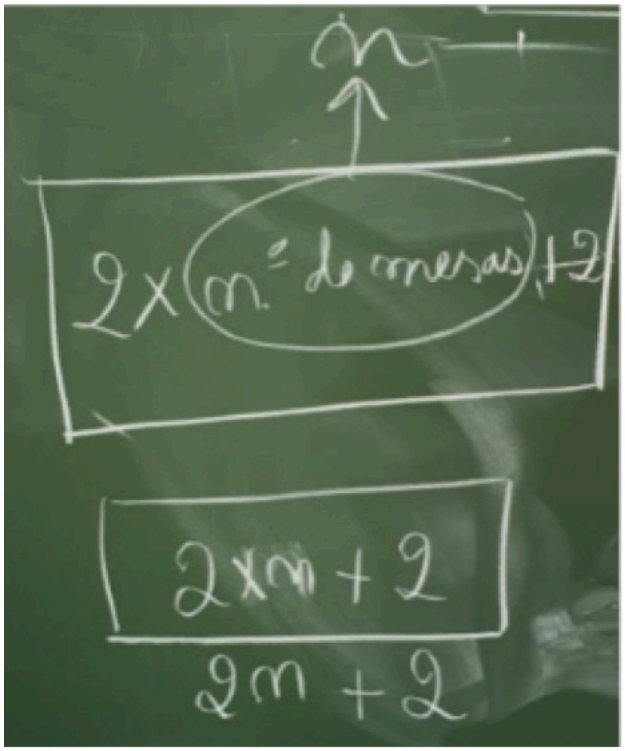
Frequency of the Types of Records Used by Students in Task 2 (n=12).

	Response types														
	C					PC					I				
Question	PR	NL	S	SW	T	PR	NL	S	SW	T	PR	NL	S	SW	T
1	8	0	1	1	1	1	0	0	1	0	0	0	0	0	0
2	7	0	1	1	0	0	0	0	0	0	2	0	0	1	0
3	5	6	1	0	0	0	0	0	0	0	0	0	0	0	0
Total	20	6	3	2	1	1	0	0	1	0	2	0	0	1	0

Note: PR: pictorial representation; NL: natural language; S: schemes; SW: symbolic writing; T: tables. C: Correct answer; PC: Partially correct answer; I: Incorrect answer.

Figure 18

Generating Expression of the Sequence That Translates the Number of Students Who can Sit at a Set of Tables

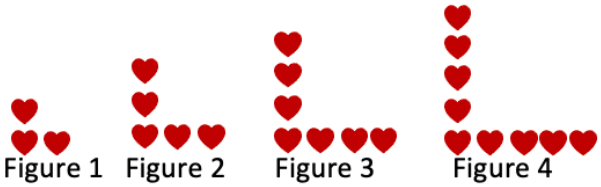


Although students are still at an embryonic stage in the development of their algebraic thinking, given the interest and resourcefulness shown by them in the proposed tasks, we think it is opportune to explore the representations that emerged to obtain the algebraic expression of the sequence, replacing the "number of tables" using the following formula: "*n*".

Transformation of Representations

To determine a formation law compatible with a partially known sequence and formulate it in symbolic language, students explored Task 3.

Task 3. Look at the following sequence of figures

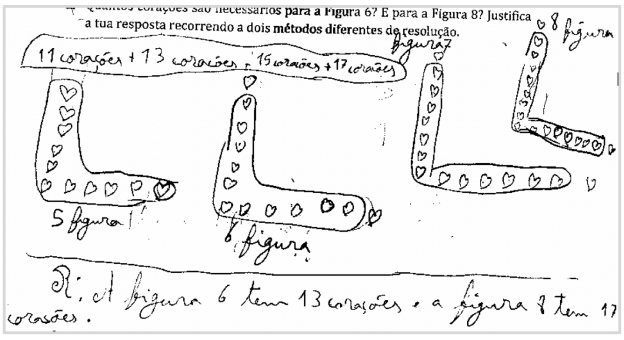


1. *How many hearts are needed for Figures 6 and8? Justify your answer using two different resolution methods.*
2. *Is there a picture with 100 hearts? Justify your answer.*
3. *Construct the generating expression of the terms of the sequence.*

Only a pair of students gave partially correct answers to the first question, while the rest answered correctly. Three pairs resorted to the "representation and counting strategy" to obtain the desired terms, as suggested by the resolution of pair P12 (Figure 19).

Figure 19

Correct Answer of Pair P12 to Question 1 of Task 3

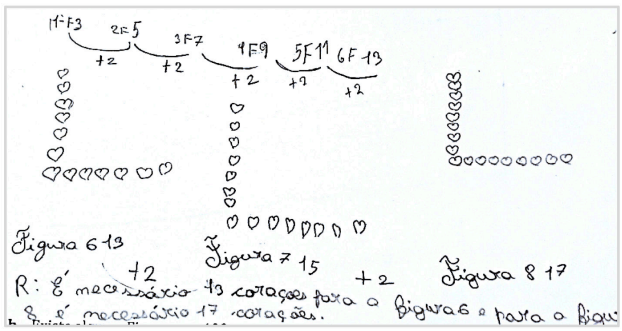


(Note: "Figure 6 has 13 hearts and Figure 8 has 17 hearts")

The "additive strategy" was applied by seven pairs, adding the formation law to each term to obtain the next term. Six pairs obtained the correct answer, as illustrated by the answer of pair P9 (Figure 20).

Figure 20

The correct Answer of Pair P9 to Question 1 of Task 3

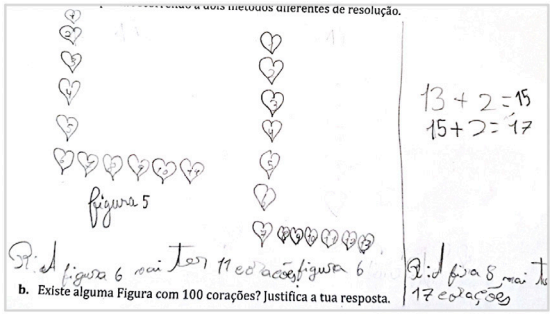


(Note: "It is necessary 13 for the figure 6 and for the figure 8 it is necessary 17")

However, pair P6, another pair that opted for this strategy, translated these representations into a partially correct answer, despite providing a correct pictorial representation and symbolic writing (Figure 21).

Figure 21

The Partially Correct Answer of Pair P6 to Question 1 of Task 3

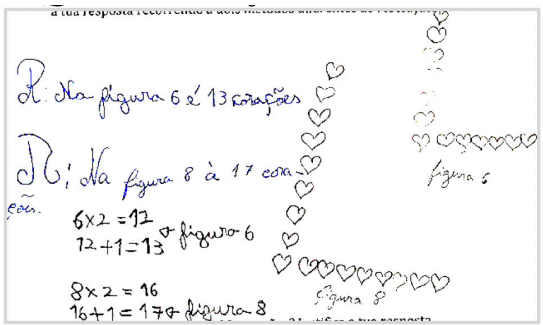


(Note: "Figure 6 will have 11 hearts. Figure 8 will have 17 hearts")

Finally, the correct answers include the "term decomposition strategy" used by three pairs. For example, P3 solved the question correctly by dividing the figure into three parts and realizing that the number of hearts is twice the number of the figure plus one (Figure 22).

Figure 22

The Correct Answer of Pair P3 to Question 1 of Task 3

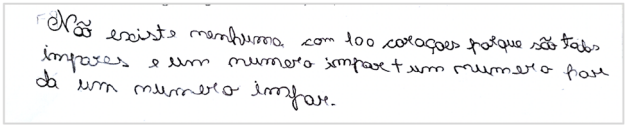


(Note: "In the figure 6 there are 13 hearts. In the figure 8, there are 17 hearts")

Nine of the 12 pairs answered the second question correctly, as suggested by the resolution of pair P5 (Figure 23).

Figure 23

The Correct Answer of Pair P5 to Question 2 of Task 3

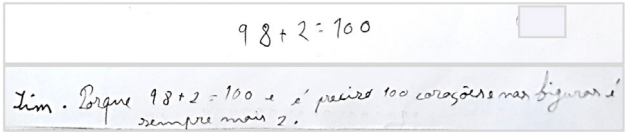


(Note: "There are none with 100 hearts because they are all odd, and an odd number + an even number gives an odd number")

Two pairs of students answered the question incorrectly, probably because they did not distinguish the characteristics of the sequence, as illustrated by the resolution of pair P12 (Figure 24).

Figure 24

The Incorrect Answer of Pair P12 to Question 2 of Task 3

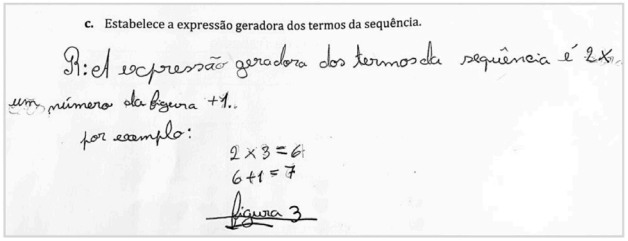


(Note: "Yes. Because 98+2=100 and we must have 100 hearts, and in the pictures, it is always +2")

In the last question, half of the pairs identified the generating expression obtaining a correct answer, as suggested by the resolution of pair P11 (Figure 25).

Figure 25

The Correct Answer of Pair P11 to Question 3 of Task 3

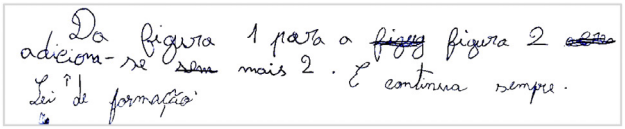


(Note: "The generating expression of the terms of the sequence is 2x a number in the figure +1. For example, 2×3=6;6+1=7")

Four of the remaining six couples did not give any response. Two pairs gave the wrong answer as they presented the formation law of the sequence instead of its generating expression, which were requested, as observed in the resolution of pair P8 (Figure 26).

Figure 26

The Incorrect Answer of Pair P8 to Question 3 of Task 3

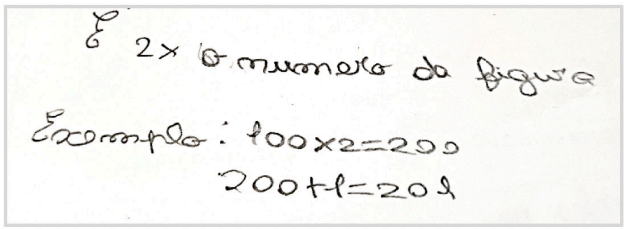


(Note: "From figure 1 to figure 2 add +2. And it always continues")

Also, in question 3, a pair of students gave partially correct answers. Although they presented an example in which they applied the generating expression, they were not able to identify its entirety (Figure 27).

Figure 27

The Partially Correct Answer of Pair P9 Pair to Question 3 of Task 3



(Note: It is 2x the number of the figure. Example: 100×2=200;200+1=201")

Representations

The analysis of students' responses to Task 3 identified which representations were used the most and which ones were used the most in correct answers (Table 3).

The first question asked students to present two different methods of resolution, which prompted them to use several representations in the same question. Of the pairs that with the correct answers, one pair only gave one representation, six pairs gave two representations, and four pairs gave three representations. As shown in Table 3, the students mainly used pictorial and table representations in solving the first question.

In the conversions between multiple representations, it was found that all pairs maintained the veracity of their solution, demonstrating a possible understanding of the mathematical objects, considering Duval's theory (2012) that a student able to coordinate two different representations would have achieved a complete understanding of the content under study.

In the second question, 11 pairs presented their answer in natural language, and nine of them answered correctly. As for the last question of the task, four correct answers, presented in symbolic writing, were obtained.

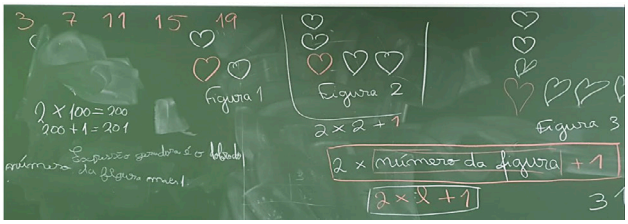
Connections between representations

In the first question, all pairs of students were able to convert representations without losing the "mathematical object" in question, revealing that they mastered in the mathematical contents. To understand the connections that students established between representations, a moment of discussion was created to discuss them.

As most of the students used pictorial representations, in the first moment, this representation was used to invite P8 to present their resolution on the board, which converted the pictorial representation into a table. A different reasoning was, then, explored using the pictorial representations used by pair P1 pair (Figure 28).

Figure 28

Exploitation of Item 1 by Pair P1



The discussion generated in the class group favored the determination of the generating expression (Figure 29).

Table 3

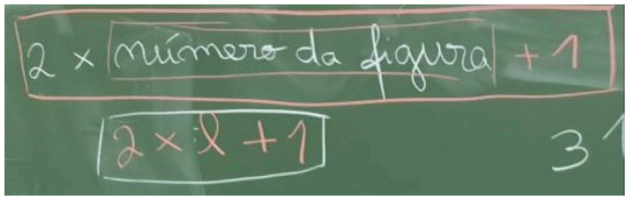
Frequency of the Types of Records Used by Students in Task 3 (n = 12).

	Response types														
	C					PC					I				
Question	PR	NL	S	SW	T	PR	NL	S	SW	T	PR	NL	S	SW	T
1	11	0	3	3	10	1	0	0	1	0	0	0	0	0	0
2	0	9	0	0	0	0	1	0	0	0	0	1	0	1	0
3	0	2	0	4	0	0	0	0	1	0	0	1	0	1	0
Total	11	11	3	7	10	1	1	0	2	0	0	2	0	2	0

Note: PR: pictorial representation; NL: natural language; S: schemes; SW: symbolic writing; T: tables. C: Correct answer; PC: Partially correct answer; I: Incorrect answer.

Figure 29

Sequence Generating Expression



To continue with the familiarization of algebraic expressions, ''figure number'' is replaced by ''l''. Although the expression was not formally presented as an algebraic expression, students understood its meaning as they participated in its construction.

Conclusions

From the analysis of students' resolution of the sequence of tasks presented in the teaching, we conclude from experience that the students preferred the pictorial representations, with one of the most used representations being natural language.

Initially, students mainly resorted to this representation, and there was no variety of registers. It was also found that most students were not able determine near and far generalizations at first.

During the teaching experience and using a greater variety of representations, students were observed to respond more assertively to questions about near and distant generalizations and questions involving the determination of the formation law and the generating expression. This result leads to the conclusion that the exploration and connections between different representations stimulate the improvement of students' ability to argue and reason as they discuss important mathematical ideas (Lannin, 2003; Viseu et al., 2021).

Although pictorial representations stand out for facilitating understanding, students also encountered other representations such as tables during the teaching experience.

However, this representation almost always appeared to support other representations, and students solved the tasks with another register and, then, made connections between the previously used representations and the table.

Regarding the exploration of multiple representations, different pairs were able to make connections between different representations, which indicates that they helped determine generalizations. Despite their age range, the students showed improvement in their algebraic thinking, namely in generalization.

In this process, pictorial representations were the most helpful representations in constructing meanings of the mathematical objects under study, allowing them to express their reasoning more confidently and clearly, as they provided visual support that attenuated the abstract nature of the mathematical concepts and gave them meaning (Ozsoy, 2018).

The first difficulty arose in the interpretation of the statement of tasks. Although students resorted to strategies, such as the ''representation and counting strategy'', which implies a representation of all terms of the sequence up to the desired term, they obtained the wrong solution to the question presented.

This result is in line with the findings of the study by Duval (2012), where the greatest difficulties in mathematical thinking arise from the lack of proper understanding of a mathematical representation, originating the incomprehension of the mathematical objects. While natural language was one of the most used representations by students and gave rise to the most correct answers, it was also the most frequent representation in the incorrect answers. The students who used this register to develop their resolution had difficulties and often failed to obtain a valid answer to the questions.

Students perceived their greatest difficulties as ''understanding the questions'' and ''understanding the texts''. Also, most students reported natural language as the representation they found most difficult to learn. Tables and drawings were the most highlighted representations as the tables provided faster, easier, and more specific reasoning, and the drawings helped them understand the concepts. Regardless of the representation, it was concluded that involving students, from the early years of schooling, in the translation of their mathematical thinking promotes learning with understanding of concepts, communication, and reasoning skills.

Acknowledgements

This work is also funded by CIEd – Research Centre on Education, Institute of Education, University of Minho, projects UIDB/01661/2020 and UIDP/01661/2020, through national funds of FCT/MCTES-PT; by CIEC - Research Center for Child Studies, Institute of Education, University of Minho, projects under the references UIDB/00317/2020 and UIDP/00317/2020; and by National Funds through FCT – Fundação para a Ciência e a Tecnologia, I. P. under the project UIDB/00194/2020.

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International Electronic Journal of Elementary Education
December 2021, Volume 14, Issue 2, 163-177

Improving the Reading and Writing Performance of a Student with Dyslexia: An Action Research Study

Yakup Balantekin*

Received : 31 May 2021
Revised : 15 November 2021
Accepted : 28 December
DOI : 10.26822/iejee.2022.236

*Correspondance Details: Yakup Balantekin, Primary Education Department, Uludag University, Bursa, Turkey
E-mail: yakupbalan@gmail.com
ORCID: https://orcid.org/0000-0002-8674-3598

Abstract

The aim of this study was to improve the reading and writing performance and reading motivation of a third grade primary school student who does not have any cognitive or physical disabilities. In the study conducted by the action research method, one of the qualitative research methods, the student's reading and writing performance and reading motivation were evaluated by scales. While fluent reading strategies were used to improve the student's reading performance, the strategy of identifying the main idea at the sentence level was used to improve his reading comprehension skills. On the other hand, the programmed instruction approach was adopted to improve the student's writing skills. At the end of the study, there was an improvement in the student's word recognition level, reading speed, comprehension percentage and reading motivation. While planning support programs for students with reading and writing problems, it is recommended that it is necessary to decide whether to develop both skills together or only one skill by considering the intensity of the students' needs and that reading books prepared for students should consist of stories short enough to end in one reading.

Keywords:

Reading; Comprehension; Reading Motivation; Writing; Legibility

Introduction

Reading and writing skills are required for individuals to be successful during their education and activities of daily living (Birgisdottir et al., 2020; Horowitz-Kraus et al., 2020). It can be said that literacy is a developmental stage of the individual since reading and writing are a prerequisite for learning both at school and throughout life (Lonigan et al., 2009), which has caused literacy to cease to be an exception and has transformed it into a requirement (Harmey, 2020).

Reading, which is referred to as the process of making sense out of the text (Fox & Alexander, 2011), allows individuals to get to know life, to find out and fulfill their needs, to have fun, and to enrich their lives in many areas (Jenkins & O'Connor, 2002; Tekşan & Yılmaz-Alkan, 2020). In addition to such a

decisive contribution of reading to the personal lives of individuals, it also has effects on social and economic development (Snow et al., 1998). The clues of whether a child will be successful in his/her education life and whether he/she will be able to contribute to society can be observed in his/her success in reading and writing (NAEYC, 1988). Therefore, it should not be forgotten that the support provided for individuals' reading skills also helps to improve their social life.

The reading act achieves its purposes by recognizing the words and knowing their meanings and grasping the information in the background of the text, and readers' sufficient knowledge of the alphabet, form, sound and spelling, phonological awareness, and fluent reading skills should be developed (Jenkins & O'Connor, 2002). In order to achieve this, phonology instruction is a necessary component of reading instruction (Saha et al., 2021), and phonological awareness, decoding and repetition have significant roles in the acquisition of reading skills (Wagner & Turgosen, 1987). The process of learning to read supported by phonological sensitivity supports the development of reading skills (Plaza & Kohen, 2003). To this end, Duke and Block (2012) recommend that all students, especially students in the risk group, should be provided with access to pre-school education within the context of reading skills in primary school for the development of their reading skills, that a conscious phonological awareness instruction in areas such as how many sounds the words consist of, which letter represents which sound, and decoding in the axis of vocabulary instruction. In addition, they state that it would be beneficial that vocabulary instruction should be carried out in grades at the primary school level, that the recognition of the concepts and language structures in a wide variety of areas should be ensured to improve reading comprehension skills, that readers should be able to use comprehension strategies in a planned and conscious manner so that they can understand the text, and that school administrations should conduct out-of-school activities for the development of students' reading skills.

Writing is another skill that is learned in the first years of life (Hartingsveldt et al., 2014). Writing requires intensive functioning of cognitive processes (Roitsch et al., 2020) and many competencies such as phonological awareness, spelling and writing rules, metacognitive skills, the ability to read and spell words accurately, and recognition of the meaning of words and the syntax of the language (Watson et al., 2016). Meeks, Madelaine and Stephenson (2020) emphasized the role of writing skill in the education and training environment by indicating that students with insufficient writing skills may face academic failure.

The acquisition of writing skills by students in a timely and effective manner will support their subsequent academic development (Barnett et al., 2020). However, some students may have problems in writing such as insufficient legibility, unwillingness to write, difficulty in writing, slow writing, and feeling uncomfortable while writing (Hartingsveldt et al., 2015). Under normal conditions, students who have the problems mentioned in the writing skill learned at school may need support throughout their lives (Barnett et al., 2020). Therefore, early identification of problems faced by students in writing and taking measures to solve these problems may prevent worse consequences in writing (Thomas et al., 2020). The fact that children realize that the sounds in the spoken language represent the letters used in writing from early childhood will enable them to be successful in their writing education (Laing & Espeland, 2005). Therefore, Bus et al. (1995) recommend that adults should read books to children so that they can be aware of the relationships between the sounds and letters.

The literacy skill supports individuals in fulfilling their lifelong changing needs and desires and in overcoming the difficulties they face in their lives (Eldering & Leseman, 1993), and constitutes the basis of all knowledge, skills and experiences of individuals. If students' literacy skills are not developed, students will face difficulties in other learning domains (Geske & Ozola, 2008). Since the formal education process is based on reading comprehension, it is a fact that reading difficulties will inevitably lead to educational difficulties (Hulme & Snowling, 2011; McQuillan, 2019). In particular, students leaving primary school without acquiring the literacy skills required for a higher education level (Torgesen, 2002) and students' academic failures due to inadequacies in literacy skills may lead to school dropouts (Meeks et al., 2020). Therefore, supporting students with the mentioned literacy problems in the earliest period will prevent the emergence of bigger problems such as school dropouts (Jenkins & O'Connor, 2002; Snow et al., 1998).

Since children do not have the same opportunities and facilities in their lives before they start primary school, some children cannot start primary school at a sufficient level of readiness, which prevents them from benefiting equally from reading and writing education in primary school. One of the main grounds of this study is to ensure that all children receive an equal education within the context of reading and writing. Although not being sufficiently ready to read and write is not a problem caused by children, its consequences primarily affect them. Since reading and writing performance is one of the prerequisites for academic achievement, and academic achievement also prevents children from dropping out of school, literacy support provided to a child will also ensure that the child will be protected from adverse environmental conditions and habits outside of school

by ensuring his/her presence in the educational environment for a longer period of time. The aim of this study, which is based on the importance of literacy in individual and social life, is to develop the literacy skills of a student whose reading and writing skills could not reach a sufficient level in the collective instruction conducted in the classroom, in accordance with the action plan. Since reading and writing have similar ways of presenting information, and cognitive processes, contexts and their development progress in parallel with each other, it is efficient to carry out their learning processes together (Fitzgerald & Shanahan, 2000). Furthermore, the support education to be provided for students in the risk group in terms of literacy performance should be more intense and detailed than the instruction activities applied in classrooms (Torgesen, 2004). Therefore, in the present study, the difficulties experienced by the student regarding reading and writing skills were discussed together, and more intense activities were carried out to improve both skills.

Method

Research Model

This study was conducted in accordance with the action research design, one of the qualitative research methods. This design is a reflective process that enables researchers and implementers to develop practical solutions to problems and allows questioning and discussion instead of theoretically dealing with the problems they detect in the learning environment (Ferrance, 2000). This design is based on a flexible approach that gives the researcher the opportunity to produce solutions, to make choices among them and to implement them (Burns, 2009). Due to the flexible structure, the solution process of the problem is planned, monitored and evaluated, and as a result of this, changes can be made in the action plan if needed (Tripp, 2005). In this study, the aim is to improve the reading and writing performance of a third grade student who needed support within the context of reading and writing skills in accordance with the specified characteristics of the action research.

Characteristics of the Participating Student

This study was conducted with a third grade primary school student who had no physical, mental or personal problems, and who was examined by the school counseling service and found to have no difference in terms of the competences in any area compared to his peers. The name of the student was kept confidential in accordance with the ethical rules, and the student was coded with the initial letter of his name, "F". "F" is nine years old, the second child and the only boy in the family, and is studying in a public primary school. He has been studying with the same teacher since the first year of primary school. His school is close to his home, and he goes to school accompanied by an adult and does not take the school bus. The mother of "F" is a housewife and his father works as a worker in the private sector. The house belongs to them but F does not have a private room. Nobody stays in the home except for the family members, and he lives with his paternal grandmother and grandfather in a two-story house with his nuclear family. Moreover, his maternal grandmother resides within walking distance of the student's house. Since the sister of "F" has a chronic illness, she regularly receives inpatient treatment with her mother at the hospital. Therefore, "F" sometimes stays with his maternal grandmother and sometimes with his paternal grandmother when his mother is in the hospital, which has significantly affected the learning process and school attendance of "F". "F" does not have any disorder but wears glasses due to amblyopia. It was determined based on the classroom teacher's observations that the student had problems in reading, comprehension and writing. While the observations indicating that the student had reading and comprehension problems were verified by the Informal Reading Inventory, which was adapted to Turkish by Akyol (2019), the writing problem was verified by the Multidimensional Legibility Scale developed by Yıldız and Ateş (2010). In the evaluation performed with a reading text at a lower level than the grade level of the student, it was determined that the student was literate at the *frustration* level and that his writing was at the *illegible* level. Permission to study with "F" was obtained from his family, and the materials such as the notebook and story book used during the study were provided by the researcher.

Data Collection Tools

The measurement tools used during the study process and the purposes for which these tools were used are explained below.

Informal Reading Inventory

This was prepared by Akyol (2019) to determine the reading levels of students by benefiting from Harris and Sipay (1990), Ekwall and Shanker (1998) and May (1986). Students' word recognition and comprehension percentages can be calculated by means of this inventory and the accompanying tables. Three levels, namely *Independent Level,* which is defined as the student's ability to read and understand the text without any support, *Instructional Level*, which is defined as the student's ability to read and understand the text as desired by receiving support from a teacher or an adult, and *Frustration Level*, which is defined as the student's understanding of very little of what he reads and making a lot of reading errors, were determined to make sense of the percentages. Due to these categories, the level at which primary

and secondary school students are readers can be determined.

The student's correct reading rate per minute was calculated based on the *formula of the number of words read correctly/the total number of words in the text x 60* recommended by Akyol and Yıldız (2010).

Multidimensional Legibility Scale

This scale is used to evaluate the legibility of the text and was developed by Yıldız and Ateş (2010). In this scale prepared based on the analytical evaluation approach, legibility is evaluated with five factors, namely slope, space, size, form and line tracking. Each factor is evaluated as completely sufficient (3), partially sufficient (2) and insufficient (1). The slope factor was excluded from the measurement since the use of vertical basic letters is recommended in the Ministry of National Education [MoNE, (2019a)] Turkish Course Curriculum. Under these conditions, the lowest and highest scores obtained from the scale are 4 and 12, respectively. Writing with a total score of 4-6.7 is considered as *illegible*, writing with a total score of 6.8-9.5 is considered as *moderately legible*, and writing with a total score of 9.6-12 is considered as legible. With this measurement tool, the student's legibility level was determined, and at the end of the action research, the change in the student's legibility level was determined.

Motivations for Reading Questionnaire

This scale, developed by Wigfield and Guthrie (1997) and later revised by Wang and Guthrie (2004), was adapted to Turkish by Yıldız (2010). The construct validity of the scale was tested by confirmatory factor analysis, it was determined that the correlation coefficients between the factors and their items varied between .41 and .73 and that the chi-square fit index (χ 2 df = 2.51) was at an acceptable level. The scale consists of two main factors: the Intrinsic Motivation Factor consisting of the sub-factors of interest and curiosity, and the Extrinsic Motivation Factor consisting of the sub-factors of recognition, social, competition and harmony. The reliability study of the scale was conducted by the internal consistency coefficient and test-retest method. The Cronbach alpha internal consistency coefficient was calculated as α =.59 for the curiosity sub-factor, α =.68 for the interest sub-factor, α =.52 for the recognition sub-factor, α =.62 for the social sub-factor, α =.62 for the competition sub-factor, α =.54 for the harmony sub-factor, α =.68 for the Intrinsic Motivation Factor, α =.82 for the Extrinsic Motivation factor, and α =.86 for the whole scale. The consistency of the scale over time was calculated by the test-retest method with 71 students three weeks after the main implementation, and it was determined that there was a moderate and high level of correlation between the factors depending on the consistency coefficients (between the values r = .65 and r =. 810) between the two implementations. The scale was prepared as a four-point Likert-type scale, which is scored as 1 point for Very Different From Me, 2 points for A Little Different From Me, 3 points for A Little Like Me and 4 points for A Lot Like Me, and consists of 21 items. The lowest and highest scores that can be obtained from the scale are 21 and 84, respectively. With this scale, the change in the student's reading motivation level was determined by measuring it at the beginning and at the end of the action research.

Analysis of Data

The student's word recognition percentage and comprehension percentage were calculated using the Informal Reading Inventory. The student read the text aloud and his reading was recorded. The number of words that the student misread was determined by listening to the recordings. The student's word recognition percentage was determined by matching the number of misread words and the total word count of the text on the row column axis in the inventory table. The student's comprehension percentage was calculated by the answers given to the open-ended questions. In cases where open-ended questions are used, it is recommended that the questions should require simple and deep comprehension. In this study, the student's comprehension level was determined by five questions, consisting of three questions requiring simple comprehension and two questions requiring deep comprehension. While simple comprehension questions were scored as two points for full answering, one for half answering, and zero point for non-answering, deep comprehension questions were scored as three points for full and effective answering, two points for expressing more than half of the expected answer, one point for half answering, and zero point for non-answering. The student's comprehension percentage was calculated by dividing the score that the student got from the answers given to the questions by the full score that would be obtained if all the questions were answered correctly and completely. This result was placed in the relevant table of the inventory and the student's comprehension level was determined. The word recognition percentage and the comprehension percentage calculated in this way were interpreted in the table containing the three literacy levels (independent, instructional, frustration), and the student's general literacy level was revealed. The mentioned measurement and analysis processes were carried out separately for five reading texts.

The Motivations for Reading Questionnaire was applied before and after the action plan. The pre-and post-measurement results of the student were compared specifically for the sub-factors of

recognition, social, competition, and harmony of the extrinsic motivation dimension constituting the scale, and the interest and curiosity sub-factors of the intrinsic motivation dimension. With this comparison, the effect of the action plan on the student's reading motivation was determined.

Multidimensional legibility scale was applied before and after the action plan to determine the change in the student's legibility level. Scoring was done separately for the space, size, form and line tracking factors of the scale. Based on the pre- and post-measurement scores, the change in the student's legibility level was interpreted.

Preparation and implementation of the Action Plan

Before the action plan was prepared, the execution processes and the recommendations sections of the studies in the literature on improving students' reading comprehension and writing skills (Aktaş & Çankal, 2019; Akyol & Çoban Soral, 2020; Akyol & Ketenoğlu Kayabaşı, 2018; Akyol & Kodan, 2016; Akyol & Sever, 2019; Akyol & Yıldız, 2010; Dağ, 2010; Duran & Karataş, 2019; Dündar & Akyol, 2014; Kurtdede Fidan & Akyol, 2011; Kuşdemir et al., 2018; Yangın & Sidekli 2011; Yıldız, 2013) were examined. These studies were used in the preparation of the action plan, and it was concluded that the plan should be kept to as long as possible. Therefore, no time limit was imposed for the action plan, and the plan was implemented until the student moved up to the next level from the levels predicted in the measurement tools in terms of reading, comprehension and legibility. Therefore, measurement and evaluation were performed periodically to evaluate the student's performance. The action plan was planned as two days a week and three course hours in a day. The courses were applied at 40-minute intervals and with 5-10 minutes of listening time between each course in the home environment. Except for the measurements made before the implementation, the entire action plan continued for 18 weeks. Three course hours per week were allocated for reading and writing studies for 10 weeks, and four hours of writing studies and two hours of reading studies were performed in the last 8 weeks.

The reading books used in the reading activities during the action plan consisted of story books chosen the student in the bookstore. During the selection of the book, the student was guided to ensure that the book was suitable for his level, that it should not be too thick, that it should be illustrated and that the font size should be large. Among the strategies recommended by Akyol (2019), repetitive reading, paired reading and choral reading strategies were used to improve the student's reading fluency. During the reading, the student was briefly reminded of the chapter read in the previous implementation and the comprehension process was supported. Therefore, the books were read only during the implementation process, and the student was asked not to read these books at other times.

Hulme and Snowling (2011) indicate that although some students are proficient in oral reading, they may have problems in reading comprehension, and that their success in oral reading may prevent teachers from understanding that they have problems in comprehension. No situation similar to the mentioned problem was encountered during this study. In the interim evaluations made during the action plan process, although there was an improvement in the student's reading fluency, since the same level of improvement was not observed in his comprehension level, comprehension development work was performed from the eleventh week onwards to increase the student's comprehension level. To this end, The strategy of identifying the main idea at the sentence level, which was designed by Pollac et al. (2021) to improve the reading comprehension skills of students with comprehension difficulties, was used. This strategy is based on the principle of finding the main idea by analyzing the sentences that make up the text one by one and understanding the whole text. This strategy is applied in three stages, namely (i) determining "Who?" or "What?", (ii) determining two important words, and (iii) writing the main idea. In the first stage, the student determines the subject of each sentence with the questions "Who?" or "What?". In this stage, the teacher supports the student on how to find the subject of the sentence with the help of sentences that he has planned previously. In the second stage, the student determines two important words for each sentence. With this practice, the student learns to distinguish the important words that will enable him to understand the sentence from other words. In this stage, the teacher makes the student distinguish the important words in the sentence by thinking out loud. In the third stage, the information obtained in the first and second stages is combined and the main idea of the whole text is found. The third stage consists of three steps in itself. In the first step, the most common answers to the questions "Who?" and what?" in the first stage are determined in the whole text; in the second step, five words in the whole text that best explain the subjects of the sentences are selected among the two important words selected for each sentence in the first stage; and in the third step, the main idea sentence is formed by combining the subject and five important words. In this process, the teacher supports the student in finding the additional words that will be required to form the main idea sentence in accordance with the grammar rules. A total of eight reading texts were studied with this strategy.

In the writing activities, the principles of programmed instruction recommended by Skinner for individual

instruction (Senemoğlu, 2005) were adopted. Mager (2014) indicated that programmed instruction allows the arrangement of the learning environment in accordance with the needs of the students in instruction carried out individually instead of in groups. The writing studies were carried out in accordance with the steps of programmed instruction: small steps, clear response, immediate feedback and self-pacing. First, the needs of the student were determined, the letters were divided into units according to ease of writing, immediate feedback was given to the student in the activities, the action plan was not limited to a period of time so that that the activities would be suitable for the student's learning speed, and the activities were continued until the legibility reached the next level. Due to reasons arising from the student's inability to hold the pencil correctly during the writing activities, writing was initiated with line exercises because of his inability to draw the general form of the letters. Vertical, curved, horizontal and round line exercises were performed. The line exercises were also continued during the writing of the letters. The letters were divided into categories according to the number of moves needed for the writing of the letters, and whether they would consist of vertical, horizontal and round lines. In small letters, there are five (c, ı, l, o, s) letters written with one move, eighteen (a, b, ç, d, e, f, g, h, i, j, n, p, r, ş, t, u, v, y) letters written with two moves, five (ğ, k, m, ö, z) letters written with three moves, and one (ü) letter written with four moves. In capital letters, there are five (C, I, J, O, S) letters written with one move, ten (Ç, D, G, İ, L, P, Ş, T, U, V) letters written with two moves, eleven (A, B, F, H, Ğ, K, N, Ö, R, Y, Z) letters written with three moves, and three (E, M, Ü) letters written with four moves. While the letters were being ordered, priority was given to the letters that supported each other's writing. For instance, the letter "I" supports the writing of the letter "F", and the letter "F" supports the writing of the letter "E". Similarly, the letter "P" supports the writing of the letter "B", the letter "n" supports the writing of the letter "m", the letter "v" supports the writing of the letter "Y", and the letter "u" supports the writing of the letter "y". These conveniences were also taken into consideration in the writing order of the letters. Priority was given to the letters consisting of vertical and horizontal lines, and during the writing of these letters, line exercises were performed to prepare for the writing of letters consisting of curved and rounded lines. While only line exercises and letter writing activities were performed in the first nine weeks, only letter writing and writing of words and sentences containing the letters learnt were performed from the tenth week to the fifteenth week, and dictation practice was performed from the sixteenth week onwards. While only a notebook consisting of four lines and three spaces was used during the first nine weeks, both a notebook consisting of four lines and three spaces and a lined notebook were used after the tenth week.

Since the action research was conducted by the researcher, support was received from a lecturer who had experience in action research and from a classroom teacher in order to avoid bias. The lecturer examined the plan before the implementation of the action plan and suggested that the student should choose the reading books. Furthermore, he also indicated that four hours should be allocated to the writing exercises, that were applied three hours a week during the implementation of the plan, after the 10th week. The classroom teacher determined the student's reading errors while using the Informal Reading Inventory, scored the student's answers to the open-ended questions, and evaluated the legibility of the student's writing with the Multidimensional Legibility Scale. During the implementation of the action plan, since the desired improvement in the student's comprehension level was not achieved despite the improvement in the student's reading performance, the strategy of identifying the main idea at the sentence level was added to the plan from the 11th week.

Results

The results of the measurement procedures performed before the implementation of the action plan until its completion are respectively presented in Table 1.

Table 1.
Data on the measurement and evaluation process performed in the action plan process

Reading text	Number of words	Number of reading errors	Word recognition level	Reading time	Reading speed (words per minute)	Comprehension percentage
Daisy and Poppy	159	24	E*	188 sec	51	16%
Efe Goes to the Theater	116	11	E	125 sec	54	33%
The Orange Tabby and her Kittens	166	10	94%	121 sec	56	50%
The Miser's Cats	155	6	96%	157 sec	58	67%
My friend Papi	181	5	97%	145 sec	58	75%

** In the Informal Reading Inventory, the abbreviation E is interpreted as a word recognition percentage of less than 91% in texts consisting of 156-160 and 116-120 words.*

It is recommended by Akyol (2019) that texts to be used to determine the reading and comprehension level of students should be selected from a lower level than the student's grade level and that the word count of the texts should be in the range of 100-200 words for third graders. Therefore, the reading texts were taken from the second grade Turkish course book and arranged by considering the word number criterion in such a way that the content integrity would not be impaired. When Table 1 is examined, it is observed that the student's number of reading errors, which was 24 before the action plan was applied, decreased to 5, that his word recognition percentage, which was at the frustration level, increased to 97%, that his reading speed, which was 51 words per minute, increased to 58 words per minute, and that his comprehension level, which was 16% increased to 75% by the end of the implementation. "F", whose general literacy level was at the frustration level with his word recognition (E) and comprehension level (16%) before the implementation, increased to the instructional level with his word recognition (97%) and comprehension level (75%) after the implementation.

The first and final measurement scores for reading motivation, which was applied to determine the effect of the action plan on the student's reading motivation, are presented in Table 2.

Table 2.
First and Final Measurement Scores of the Motivations for Reading Questionnaire

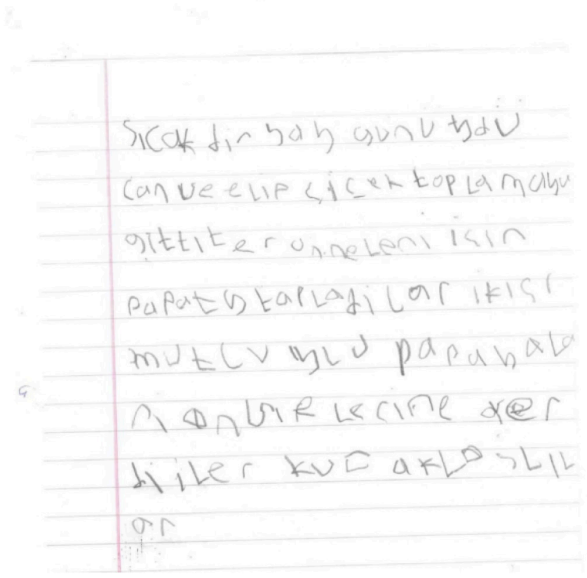
Factors	Sub-Factors	First Measurement	Final Measurement
Extrinsic Motivation	Recognition	5	7
	Social	6	8
	Competition	7	10
	Harmony	6	8
	Extrinsic Motivation Total Score	24	33
Intrinsic Motivation	Interest	6	12
	Curiosity	4	8
	Intrinsic Motivation Total Score	10	20
	Grand Total Score	34	53

When Table 2 is examined, it is observed that while the students' extrinsic motivation score was 24 and 33 before and after the action plan, respectively, his intrinsic motivation score was 10 and 20 before and after the action plan, respectively, and his total reading motivation score was 34 and 53 before and after the action plan, respectively.

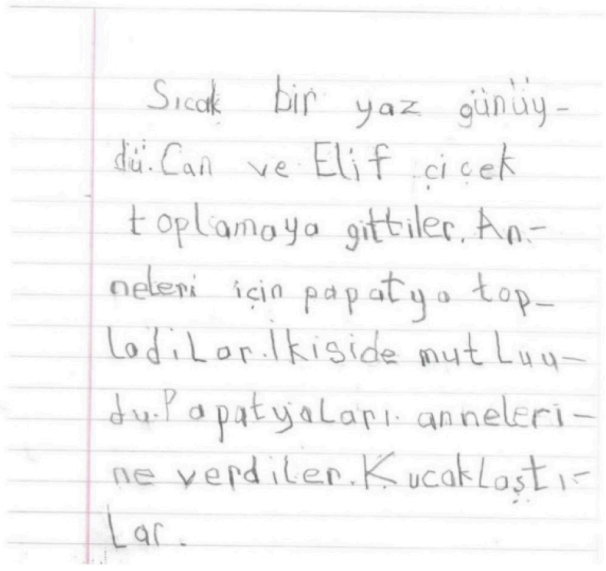
Examples of the student's writing before and after the implementation are presented in Figure 1 to reveal the effect of the action plan on the student's legibility.

Figure 1.
Text samples

First implementation



Final implementation



Transcription
It was a hot summer day. Can and Elif went to pick flowers. They picked daisies for their mother. Both of them were happy. They gave the daisies to their mother. They hugged each other.

It was calculated that the first test score and the final test score of the Multidimensional Legibility Scale were 5 (space = 1; size = 1; form = 1; line tracking = 2) and 8 (space = 2; size = 2; form = 2; line tracking = 2), respectively. Based on these scores, while the student's legibility level was illegible before the action plan, it was determined to be moderately legible after the action plan.

Discussion

In this study aimed at improving the reading, comprehension and legibility of a third grade primary school student, practices were performed to reduce the student's reading errors and increase his legibility. Therefore, reading and writing practices were carried out together. In terms of reading errors, it was determined that the student frequently failed to say the last letters and syllables of words, and that after reading the root of the word, he made mistakes in reading the whole word by guessing the affixes without reading them. In the reading activities performed with the student before the action plan, it was observed that the student made the mistake of skipping lines while reading texts written with a single line spacing. Therefore, attention was paid to ensure that the line spacing of the selected story books would be wide. Furthermore, the reading texts used for evaluation were prepared in one-and-a-half line spacing. Easterbrooks and Lederberg (2021) indicate that students' probability of comprehending the text will decrease when they read without paying attention to punctuation, stress and intonation. Reading exercises were carried out together due to reasons such as the student's failure to pay attention to the punctuation marks, recognize the line he skipped, and correct the words that he misread. In the study conducted by Kanık Uysal and Akyol (2019), it was observed that the participating student made the same mistakes, and a reading program to be carried out with the student was prepared. The fact that the student who was supported performed reading under the supervision of the researcher ensured the elimination of reading errors in a shorter period of time.

It was observed that the reading performance of the student gradually increased from the first pages to the next pages while the story books were read. During the book reading activities performed with the student, the student had difficulty in reading words he encountered for the first time. However, when the number of pages read in the book increased, he could read more comfortably the words he previously had difficulty with. Since some words are frequently repeated in books due to the subjects of the books, there was a noticeable improvement in both the word reading performance and general reading fluency of the student as the number of pages he read increased. It was observed that there was a slight decrease in this performance when a new book began to be read, whereas there was an improvement again as the pages progressed. The fact that students make simple mistakes while reading may cause them to read less by reducing their desire to read (Torgesen, 2004). This may cause students to make more mistakes in more difficult texts they will encounter, which may also affect the reading performance of students in a cycle. In the study conducted by Kaşkaya (2016) in which it was aimed to improve the reading fluency of students with instruction supported by the neurological-impress method (NIM), activities were organized before reading in order to transform the words in the text into acquired words, and it was ensured that the student became familiar with the words. Therefore, if books consisting of short and limited words are preferred for students with poor reading skills, it can be ensured that the student achieves the pleasure of reading an entire book by preventing him/her from abandoning the book halfway through. Insufficient vocabulary may cause students to have difficulty in reading words that they have not encountered previously while reading, which will make it difficult to use these words in their writing (Hebert et al., 2021). The new words that students learn during reading activities will support their writing skills as well as their reading skills.

Since the individual must pay attention to the text intensively and consistently for reading comprehension, reading anxiety negatively affects his/her reading comprehension (Macdonald et al., 2021). The student said, "I get bored while studying, but I never get bored when I study with you". Similarly, the student's mother revealed the student's affective approach to the study by stating "On the days when he is to study with you, he prepares his equipment early and waits for you". Reading requires attention and emotional integration (Jakovljević et al., 2021). It is considered that the student's positive approach to the implementation was affected by the fact that he was just accompanied and chose the books himself while buying them. It was observed that for the student, going to buy a book after the end of each book was a reinforcer for the student. It is also considered that the student's review of the books, prediction of the content by interpreting the visuals, and choosing the books himself increased his motivation. Tezel et al. (2019) indicate that children's choice of books that they will read and prioritization of the topics that children love and care about in choosing the books will support their reading habits.

While students with underdeveloped reading skills mostly maintain reading by reading slowly with hesitation and receiving support for correction from another person (Knight-McKenna, 2009), individuals with developed skills read words in an automated way, and the words must have been engraved in the brain beforehand for this (Jenkins & O'Connor, 2002). According to Çaycı and Demir (2010), the word repetition method is useful for fluent reading of words that hinder the reading fluency of students who read the words that they know fluently but sometimes hesitate, and that the student has difficulty in recognizing while reading the text. Therefore, the words that the student had difficulty in reading, and that he repeated and misread during the story book reading activities were detected during reading,

and then, these words were written on cards and speed reading exercises were performed. With the word repetition method applied by Sağlam et al. (2020), the reading fluency of students was supported and positive results were obtained. In the studies conducted by Uzunkol (2013) and Yılmaz (2008), it was concluded that the word repetition technique increased students' reading fluency.

Since the academic success of students during the education and training process depends on reading performance, academic failure due to reading inadequacy may negatively affect students' motivation for learning, for the course and for school (Torppa et al., 2019). Moreover, since students' experience of difficulties in reading may cause them to face some social and emotional problems, these difficulties should be identified and eliminated as early as possible (Jakovljević et al., 2021). A delay in providing support to students in this context may lead to an increase in performance difference between them and their peers within the context of literacy and may cause problems to become permanent, which may prevent the support programs that are provided from achieving their goals. A third grade primary school student was supported in this study. This grade level is considered to be late for students who need support. According to Torgesen (2004), a significant number of the students who still have reading problems towards the end of primary school show indications that they experienced these problems during pre-school education and in the first year of primary school. Foorman et al. (1988) stated that instruction should be provided to students who are at risk of failing to acquire reading skills. Hulme and Snowling (2011) went one step further and stated that teaching children to read correctly, fluently and with adequate comprehension is one of the main goals of early education. These determinations confirm that supporting students simultaneously with the formal education process from the pre-school period onwards will contribute to their social and emotional development. From this point of view, it can be stated that it is a wrong decision to wait until the third grade so that students who are in the third grade of primary school and have insufficient literacy skills in Turkey can benefit from the support provided by the MoNE (2019b) through the Remedial Education Program in Primary Schools.

Reading is a complex skill that requires precise coordination of the eyes to efficiently track the lines of a text as well as the interaction of cognitive processes to understand the content (Guimarães et al., 2020). In this study conducted with "F", regarding the student's reading errors, it was observed that he frequently skipped the lines, and wide line spacing and 14 font size were preferred to prevent this. When the effects of the types of reading errors on comprehension are considered, it can be said that line skipping is an error type that further prevents comprehension. Onursoy et al. (2010) indicated that with regard to eye movements, readers focus more on images than texts while reading, and they recommended that short texts should be preferred more than long texts by placing the visuals in appropriate places in the page layout. In the preparation of book designs in accordance with the reading practices of students with problems in line tracking due to eye movement deficiency, the recommended page layout for the development of these skills and the use of these books in support programs may be a solution to the line tracking problem.

The student's proper grip of the pencil and the sitting position are important factors to ensure legible writing (Hartingsveldt et al., 2015). Moreover, the development of the inner muscles of the hand is also a determinant of legibility (Reis, 1989). In the pre-implementation performed with the student, it was observed that the student could not hold the pencil correctly. The student held the pencil at its midpoint, which prevented him from grasping and controlling the pencil. When the student was asked why he held the pencil at its midpoint, he said "I cannot see the writing I write when I hold it closer to the end point.". It was found out that the student had this problem because he could not adjust the degree of tilt while holding the pencil. It was observed that the student's writing was more obscure since he could not apply pressure on the pencil with his current pencil grip, and that his pencil control skill was insufficient between two lines due to the failure to grasp the pencil well. The pencil grip with wrist slightly bent, holding the pencil with the index finger and thumb, and supporting the pencil with the middle finger recommended by Graham and Miller (1980) and Yıldız et al. (2015) was adopted as the student's technique for holding the pencil. In order to achieve this, the student was warned by the researcher, and the correct pencil grip was shown. However, no change was achieved because the student's pencil grip had turned into a habit. Therefore, apparatuses that enable students to hold the pencil correctly were used, and thus, the student's pencil grip could be changed. Since writing skill has an important place in the life of the individual, it is necessary to find solutions to the problems that the child will have in this field in the early period (Hartingsveldt et al., 2015). Most children become acquainted with the pencil in a home environment. If parents consciously monitor their children's pencil grip and prevent their incorrect pencil grip, this may prevent the occurrence of this problem in the education and training environment by preventing it from becoming a habit.

"F" developed his own style regarding the writing of each letter while writing. The general tendency of the student in writing letters was to write each letter

in a single move and without raising his hand. For instance, while writing the letter "A", he drew the "/" line from bottom to top and then drew the "\" line and completed the writing of the letter in a single move by drawing a curved line from the lowest point of this line to the midpoint of the previous line. While writing the letter "t", he immediately drew the "-" line while drawing a line from top to bottom and then completed the writing of the letter by completing the line he drew from top to bottom. When the student was asked why he wrote each letter at once without raising his hand, he replied "I want to finish the writing quickly". Furthermore, when the student was asked about his opinions on his own writing, it was observed that the letters were not written properly and that he was not aware that his writing crossed the lines. All of this was interpreted as the fact that the student did not like writing very much, perceived writing as a task and wanted to finish it as soon as possible, and that spelling mistakes had become a non-disturbing permanent habit for the student. Orhan (2017) indicates that reward is an effective factor in the formation and change of habits. When "F" wrote letters in his own style and did not make an effort to make his writing legible, the act of writing was completed in a short time and "F" got rid of a boring action for himself. In brief, the act of writing with this form of writing lasted a short time, which may probably have been perceived as a reward by the student. Therefore, it was aimed to prevent the student from getting bored by taking frequent breaks during the writing activities. However, it was concluded that a longer-term and planned study was needed to change the student's approach to writing.

While writing, the student wrote the letters quickly and attempted to complete the writing task as soon as possible. In particular, he prevented the legibility of the letters by moving the pencil in various directions at the end of the last line while drawing the lines that made up the letter. For instance, the letter "L" is written vertically with the line "I" in the first move and horizontally with the line "_" in the second move. The student disrupted the aesthetics of this letter by moving the pencil up or down at the end of the horizontal line. He did this while writing every letter. The student was made to write the letters gradually in order to solve this problem. For instance, the letter "L" is written in two moves. Before the first move, the lines were drawn by discussing with the student where the pencil would be placed, the slope rate of the line and in which direction to draw, and after drawing this, the second move was made and the writing of the letter was completed. In this process, it was observed that the student did not take into account the directions provided while drawing the lines that made up the letters and drew the lines as he desired. For instance, it was stated by the researcher that he did not put the pencil in the correct place while writing the letter "A", and although the student was asked to stop, the student completed the writing of the letter. Due to the frequent occurrence of this situation, in the interview held with the student's mother, she stated that the student showed this behavior when he did not want to write. In the interview held with the student, he said "I am hot and sweaty while writing and I have difficulty in breathing.". When he was asked about the reason for this, he said "I do not like to write; when I was writing in the first grade, my mother was putting pressure on me, holding my hand and writing, and my hand was sweating and painful". Putman and Walker (2010) indicate that children's behaviors are indicators of their motivation and that students should be provided with motivational opportunities during reading and writing education. Deniz and Demir (2020) indicate that writing motivation affects writing performance and emphasize that the intrinsic motivations of students support the writing skill more, and that therefore, environmental conditions should be regulated appropriately and external factors should not be exaggerated. Therefore, a break was given when the student was bored during the writing activities, the use of colored pencils during the line exercises was provided, and when the student created the correct form of the letter during the letter writing exercises, the writing of that letter was terminated.

Recommendations for Researchers, Educators, Parents and Policy Makers

(i) Reading books prepared for students that consist of stories ending in one reading will make it easier for students to understand what they read. (ii) It is possible to conduct studies that will reveal the order of letters in accordance with the principle of 'from easy to difficult' in order to improve the legibility of students who have acquired the reading and writing skills but have problems in legibility. (iii)Students with legibility problems should be supported at the earliest possible period before gaining the habit of writing. (iv) Students' acquaintance with the pencil in early childhood should not be left to chance, and parents should make their children acquire the correct pencil holding habit by consciously monitoring their child's pencil holding process. (v) Students' opinions should be considered when parents buy books for their children and classroom teachers build the classroom library in order to increase children's desire for reading. (vi) While planning support programs for students with reading and writing problems, it should be decided whether to develop both skills together or only one skill by considering the intensity of the students' needs. The aim of developing only one skill for students who need serious support can enable the limited time in the action plan to be used more efficiently. (vii) Longitudinal studies can be conducted to reveal whether students whose reading and writing skills are supported can maintain the reading and writing level that they reach.

Limitations

The most important limitations of this study are the aim of improving the reading and writing skills together for the student with severe reading and writing problems, and the inadequacy of motivational variables related to the mentioned language skills. It is inevitable that students who still have reading and writing difficulties in primary school will have negative affective attitudes towards these skills, despite the progress of their grade level. Unless these feelings change, it is difficult to achieve permanent improvements in skills. Therefore, if the researcher were to do the same study with the participating student again, he would prefer to conduct the study by preparing an action plan that was planned on only one skill and supported by intensive motivational elements.

Declaration of Commitment to the Ethical Rules

Approval was received for this study from the family of the participating student and Türkiye/Bursa Uludağ University Research and Publication Ethics Committee. Scientific research ethics were observed during the study.

Declaration of Interest Statement

The author has no conflict of interest with any institution or person regarding this paper.

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APPENDIX Action Plan

	Day 1		Day 2	
	READING (2 course hours)	WRITING (1 course hour)	READING (1 course hour)	WRITING (2 course hours)
Week 1	Reading the book entitled The Red Spotted Caterpillar	Pencil holding practice Line exercises	Reading the book entitled The Red Spotted Caterpillar	Pencil holding practice Line exercises
Week 2	Reading the book entitled Akkuzu, Karakuzu and the Crows	Pencil holding practice Line exercises	Reading the book entitled Akkuzu, Karakuzu and the Crows	Pencil holding practice Line exercises
Week 3	Reading the book entitled The Little Sparrow	Pencil holding practice Line exercises	Reading the book entitled The Little Sparrow	Pencil holding practice Line exercises
Week 4	Reading the book entitled The Little Sparrow	Writing the letters I, İ, ı, i Line exercises	Reading the book entitled Uzun Köprü Statue of Liberty	Writing the letters L, F Line exercises
Week 5	Reading the book entitled Uzun Köprü Statue of Liberty	Writing the letter E Line exercises	Reading the book entitled Uzun Köprü Statue of Liberty	Writing the letters E and T Line exercises
Week 6	Reading the book entitled Prince Yusuf	Writing the letter H Line exercises	Reading the book entitled Prince Yusuf	Writing the letters H and l Line exercises
Week 7	Reading the book entitled Prince Yusuf	Writing the letter N	Reading the book entitled Sun Girl	Writing the letters N, M and t
Week 8	Reading the book entitled The Sun Girl	Writing the letters V and v	Reading the book entitled The Sun Girl	Writing the letters Y, Z and z
Week 9	Reading the book entitled Gülperi	Writing the letters K and k	Reading the book entitled Gülperi	Writing the letters A, a and d.
Week 10	Reading the book entitled The Black Snake	Writing the letters g and ğ. Writing words and sentences consisting of the letters learned.	Reading the book entitled The Black Snake	Writing the letters P, B and p. Writing words and sentences consisting of the letters learned.
	READING (1 course hour)	WRITING (2 course hours)	READING (1 course hour)	WRITING (2 course hours)
Week 11	Comprehension studies with the sentence analysis method. (The Old Woman)	Writing the letters B, R and b. Writing words and sentences consisting of the letters learned.	Reading the book entitled Pinocchio	Writing the letters U,Ü, u, ü and y
Week 12	Comprehension studies with the sentence analysis method. (The Untidy Crow)	Writing the letters r, n and m	Reading the book entitled Pinocchio	Writing the letters J and j. Writing words and sentences consisting of the letters learned.
Week 13	Comprehension studies with the sentence analysis method. (The Little Penguin)	Writing the letters D, d and h.	Reading the book entitled Pinocchio	Writing the letters C, Ç, c and ç. Writing words and sentences consisting of the letters learned.
Week 14	Comprehension studies with the sentence analysis method. (The Good Citizen)	Writing the letters G and Ğ. Writing words and sentences consisting of the letters learned.	Reading the book entitled Pinocchio	Writing the letters O, Ö, o and ö
Week 15	Comprehension studies with the sentence analysis method. (What is Money?)	Writing the letters S, Ş, s, and ş .	Reading the book entitled Rüzgaroğlu	Writing the letters e and f. Writing words and sentences consisting of the letters learned.
Week 16	Comprehension studies with the sentence analysis method. (What Should You Eat?)	Sentence writing exercises through dictation.	Reading the book entitled Rüzgaroğlu	Sentence writing exercises through dictation.
Week 17	Comprehension studies with the sentence analysis method (Well done)	Sentence writing exercises through dictation.	Reading the book entitled Rüzgaroğlu	Sentence writing exercises through dictation.
Week 18	Comprehension studies with the sentence analysis method (The Red Balloon)	Sentence writing exercises through dictation.	Reading the book entitled Rüzgaroğlu	Sentence writing exercises through dictation.

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International Electronic Journal of Elementary Education
December 2021, Volume 14, Issue 2, 179-194

TIMSS International Benchmarks of Eighth Graders in Mathematics: A Correspondence Analysis Study

İlhan Koyuncu*

Received : 21 October 2021
Revised : 27 December 2021
Accepted : 30 December 2021
DOI : 10.26822/iejee.2022.237

*Correspondance Details: İlhan Koyuncu, Adiyaman University, Department of Educational Sciences, Turkey, Adıyaman, Turkey.
E-mail: ilhankync@gmail.com
ORCID: https://orcid.org/0000-0002-0009-5279,

Abstract

The aim of this study is to investigate the relationship between a variety of non-cognitive factors and the mathematics performance levels of eighth grade students in the Trends in International Mathematics and Science Study (TIMSS). The sample group consists of 4077 Turkish students who took part in TIMSS 2019. Data were collected using the student background scales in the student questionnaire and achievements tests by TIMSS practitioners. It was interpreted through correspondence analysis as an exploratory and multivariate statistical technique. Results indicated a significant correspondence between students' achievement and attitudes towards mathematics, instructional structure, school climate, and home educational resources. High-achieving students were found to express more positive attitudes, attach higher instructional clarity to mathematics lessons, encounter less disorderly behavior during mathematics lessons, and have more home educational resources. Regarding school climate, high-achieving students had less sense of school belonging than low-achieving students. As for school discipline and safety, high-achieving students faced more bullying than intermediate-level students. Results suggest that students with low mathematics achievement should be supported in terms of both educational resources and non-cognitive factors.

Keywords:

Educational Resources, TIMSS, School Climate, Correspondence Analysis, Bullying

Introduction

Mathematical knowledge covers a set of skills ranging from such basic operations as counting and calculating in everyday life to complex operations in engineering, economics, architecture, medicine, health care, etc. More or less mathematical knowledge is needed in all areas of life. Learning mathematics helps develop problem-solving skills and deal with challenges in life (Lindquist et al., 2017). The acquisition of mathematical knowledge and skills is affected by a number of factors, e.g., socioeconomic status (Akyüz, 2014; Dahl & Lochner, 2012; Sirin, 2005), school resources (Hanushek & Wößmann, 2017; Lee & Zuze, 2011; Visser et al.,

2015), school climate (Cohen et al., 2009; Konishi et al., 2010; Lubienski et al., 2008; Mohammadpour, 2012), teacher quality and experience (Akiba et al., 2007; Baumert et al., 2010; Burroughs et al., 2019; Goe, 2007; Gustafsson & Nilson, 2016; Harris & Sass, 2011; Hill et al., 2005), instructional clarity (Boston, 2012; Ferguson, 2012; Nilsen et al., 2016; Schlesinger et al., 2018; Scherer & Nilsen, 2016), classroom climate (Cornelius-White, 2007; Marzano et al., 2003; Nilsen et al., 2016), attitude and intrinsic motivation (Akyüz, 2014; Becker et al., 2010; Marsh & Craven, 2006; Pajares & Miller, 1994; Vansteenkiste et al., 2008; Xiao & Sun, 2021), as well as self-concept and self-confidence (Kaskens et al., 2020; Marsh & Craven, 2006; Möller et al., 2009). Since this study aims to investigate the relationship between the students' mathematics achievement in TIMSS 2019 and various non-cognitive student background variables, the factors associated with school success were discussed under separate subheadings in line with home, school, classroom contexts and attitudes towards mathematics as included in the TIMSS 2019 Context Questionnaire Framework (Mullis & Martin, 2017).

Home Contexts

Concerning the home context, students' mathematics achievement may be associated with a range of factors, i.e. parents' education level, economic status, and home educational resources. Primarily, parental socioeconomic status (SES) has a crucial role in mathematics performance (Akyüz, 2014; Dahl & Lochner, 2012; Schreiber, 2002; Sirin, 2005; Visser et al., 2015). In a meta-analytic review, Sirin (2005) found a stronger relation between SES and mathematics achievement in comparison to other courses. Similarly, Jordan et al. (2006) found that SES is significantly associated with children's development and mathematics performance. On the other hand, parents with lower level of education are known to have considerable difficulty supporting their children's mathematics learning (Sari & Hunt, 2020). After children start primary school, however, the impact of intelligence decreases and social background (SES) becomes increasingly important.

Home environments that parents provide for their children can contribute considerably to the latter's mathematical development. Home educational resources refer to tangible and intangible assets in a home, i.e. parental education levels, parental involvement in homework, and language use at home (Juan & Visser, 2017). The relevant studies indicate that home educational resources are predictive of mathematics performance (Chiu & Xihua, 2008; Lacour & Tissington, 2011; Mohammadpour, 2012; Ölçüoğlu & Çetin, 2016; Sarı et al., 2017; Oral & McGivney, 2013; Visser et al., 2015). LeFevre et al. (2009) found that mathematics performance in the early school years is predicted positively by the frequency with which children were engaged in numeracy-related home activities (e.g., playing games involving counting, talking about numbers, using calendars, playing with calculators). Furthermore, "number talk" or the extent of mathematical language and applications at home were found to be closely associated with children's mathematics achievement (Levine et al., 2010; Ramani et al., 2015). Lehrl et al. (2020) followed 554 three-year-old children up to the age of 13 in home learning environments. Their results showed that book exposure and the quality of mathematics-related verbal interactions predicted mathematical outcomes in secondary school and that the effects were mediated through early language and arithmetic skills.

School Contexts

Concerning the school-level variables (school resources, school climate, teacher quality and experience, safety and security etc.) it can be argued that worse learning environments have a negative impact on student achievement, whereas favorable perceptions of safety and learning environments have a positive impact on mathematics achievement (Kwong & Davis, 2015). Teacher-student behaviors and mathematics achievement are affected by the safety and order of school environment, the importance attached to success at school, and the overall condition of the school (Sarı et al., 2017; Visser et al., 2015). It is seen that students who attend schools having a favorable climate achieve higher scores in mathematics (Lubienski et al., 2008; Mohammadpour, 2012). According to Fan and Williams (2018), student self-efficacy and intrinsic motivation play a mediating role in linking the perceptions of school climate with reading and mathematics achievement. Besides, students' perceptions of school climate are significantly related to achievement outcomes, and perceptions of school climate regarding teacher-student relations are significantly related to the variables of self-efficacy and intrinsic motivation. Akyüz (2014) found that student bullying and school climate of discipline and safety are significant predictors of mathematics achievement in Turkey and Finland. Students' exposure to bullying at school negatively affects their sense of school belonging (Duggins et al., 2016; Arslan, 2021). According to Arslan (2021), school bullying has a significant and negative predictive effect on youth internalizing-externalizing behaviors and school success, while school belonging mitigates the adverse impact of bullying on youth mental health and achievement.

As TIMSS 2011 international results show, successful schools are likely to have better working conditions, better facilities, and more instructional materials, e.g., books and computers (Mullis et al., 2012). Furthermore, poorly resourced schools have teachers with poor qualifications, while better-resourced schools are able to attract teachers with higher qualifications (Visser et al., 2015). Yet, there is evidence that students

from disadvantaged backgrounds may have higher achievement if they attend schools where the majority of students are from advantaged backgrounds (Mullis & Martin, 2017).

Classroom Contexts

In classroom contexts, a variety of factors including teacher quality, instructional effectiveness and clarity, and suitability of classroom environment have direct or indirect impacts on students' mathematics achievement. A great deal of studies highlighted the key role of teacher quality in mathematics achievement (Akiba et al., 2007; Baumert et al., 2010; Goe, 2007; Gustafsson & Nilson, 2016; Hill et al., 2005). Burroughs et al. (2019) specified key teaching factors associated with higher mathematics achievement as follows: teacher experience, teacher professional knowledge (measured by education and self-reported preparation to teach mathematics), and teacher provision of opportunity to learn (measured by time on mathematics and content coverage). Gustafsson & Nilson (2016) found that teachers' attained level of education had effects on mathematics achievement. They identified quite substantial effects of professional development on student achievement as well. Teacher self-efficacy, as assessed by self-reports of preparedness for teaching in different domains, showed a weakly positive, but insignificant relation to student achievement.

Students' Attitudes toward Mathematics

Mathematics achievement is related to children's beliefs about mathematics (Marsh & Craven, 2006; Pajares & Miller, 1994). Xiao and Sun (2021) concluded that the group of students with the lowest mathematics anxiety and the highest motivation levels showed the highest mathematics achievement and levels of persistence, and that the groups with high mathematics interest, mathematics self-concept, and instrumental motivation showed the most frequent mathematics-related behaviours (participation in mathematical activities). An overall positive relationship is found between mathematics self-concept and mathematics achievement (Kaskens et al., 2020; Möller et al., 2009). Akyüz (2014) found that mathematics self-confidence has positive and significant effects on student achievement. The overall relationship between attitude and achievement is based on the assumption that the better a student's attitude towards a subject or task, the higher the level of achievement or performance (Schreiber, 2002). Attitude towards mathematics was the most effective factor predicting mathematics achievement of both Turkish and Korean students in TIMSS 2011 (Topçu et al., 2016). On the other hand, in a study by Geesa et al. (2019), an interesting pattern emerged referring to the conclusion that as Turkish students' mathematics achievement scores were lower than students from South Korea and the United States, their attitudes towards mathematics were higher.

Importance of the Study

In this study, students with different proficiency levels are compared over a variety of factors associated with mathematics achievement. This allows to investigate the results separately and comparatively for each competence level. Correspondence analysis, a multivariate analysis technique used, helps to achieve the purpose and highlights the importance of the current study. In addition, an investigation on Turkey, a country placed at the intermediate benchmark in TIMSS 2019 with a remarkable rising trend in recent years (MONE, 2020), is likely to offer substantial information about the relationship between achievement levels and student characteristics in an intermediate-level developing country. Since Turkey's first participation to TIMSS, its eighth grade mathematics achievement score has risen from 429 to 496, reaching the intermediate benchmark in TIMSS 2019. The rate of Turkish high-achieving students increased, while the rate of Turkish low-achieving students decreased (MONE, 2020). Turkey recorded the highest score upswing between 2015 and 2019, increasing its achievement score in almost all regions. Moreover, in the Turkish case, both male and female students increased their scores with no significant difference between the genders (MONE, 2020). TIMSS and similar international large-scale assessments have indirect influence on education reforms in Turkey (Parlak et al., 2020). Considering the impact of TIMSS and similar assessments on education policies in Turkey, this study is expected to provide educators with important feedback.

Aim of the Study

The aim of this research is to investigate the relationship between student performance in TIMSS 2019 and the scales regarding home, school, and classroom contexts, as well as attitudes towards mathematics given in the student questionnaire. To this end, answers were sought to the following questions:

What kind of correspondence is found between the eighth grade students' mathematics achievement in TIMSS 2019 and the scale scores regarding

1. *attitudes towards mathematics (confident in mathematics, like learning mathematics, and value mathematics)?*
2. *instructional clarity in mathematics lessons in association with mathematics education and curriculum, as well as disorderly behaviors during mathematics lessons in the classroom context?*
3. *home educational resources in the home context?*
4. *student bullying and sense of school belonging in the school context?*

Method

Research Design

This is a survey-type research study that describes quantitatively the background variables and performance levels of Turkish students who participated in TIMSS 2019. It is also a correlational research study as it examines the correspondence between a set of non-cognitive variables and performance levels of students. Survey studies identify the characteristics of participants by the data collected through questionnaires or interviews, whereas correlational studies investigate the relationship between two or more variables (Büyüköztürk et al., 2016).

Participants

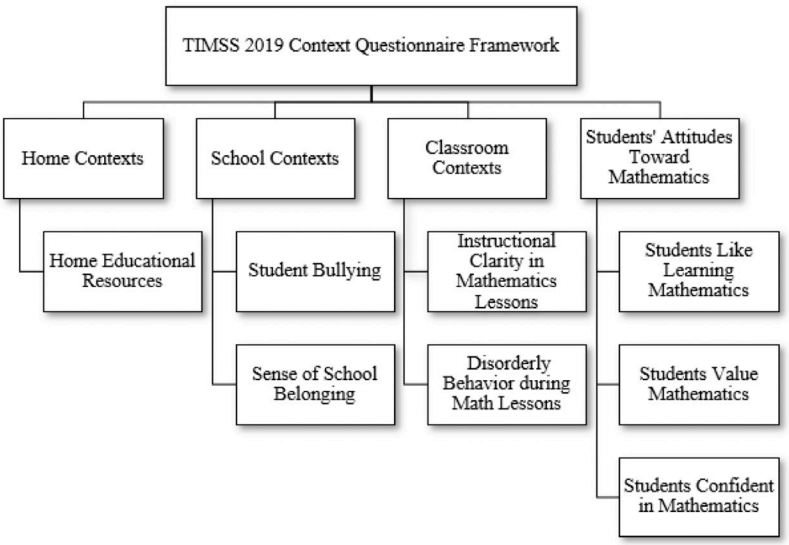
The participants consist of 4077 eighth grade students who took part in TIMSS 2019 from Turkey. They were selected by TIMSS practitioners through purposive and stratified sampling. Of the participating students, 2012 (49.4%) were female, and 2045 (50.2%) were male. There is no data on the gender of 20 (0.5%) students. The students' ages range from 13 to 18, with an average of 14 years. In terms of achievement levels, 820 (20.1%) of the students were at Level 1, 1058 (26%) at Level 2, 979 (24%) at Level 3, and 786 (19,3%) at Level 4, and 434 (10.6%) at Level 5.

Data Collection Tools

Research data were collected through the TIMSS 2019 achievement tests and the scales within the student questionnaire. TIMSS has been conducted by the International Association for the Evaluation of Educational Achievement (IEA) every four years since 1995. It is a large-scale study in which the effectiveness of education systems in more than 60 countries is examined and compared with other countries (Mullis & Martin, 2017). Fourth and eighth grade students' performance in science and mathematics is assessed on an international scale. In TIMSS, detailed data are collected by using cognitive tests in mathematics and science, in addition to a range of scales in student, teacher, school and home contexts. A well-structured assessment process is completed through a detailed assessment framework (see Mullis & Martin, 2017) on student achievement in mathematics and science and a technical report (see Martin et al., 2020) is presented. Achievement in these domains is described at four proficiency levels as international benchmarks: low, intermediate, high and advanced. Regarding the eighth grade mathematics performance, students at the low benchmark (400-475) have basic mathematical knowledge; those at the intermediate benchmark (475-550) can apply basic mathematical knowledge in simple situations; those at the high benchmark (550-625) can apply mathematical knowledge to more complex situations, and those at the advanced benchmark (625 and above) are expected to reason, solve equations, and make generalizations in a variety of problem situations (see Mullis et al., 2020). In the present study, student performances were assessed at five proficiency levels, since a considerable percentage of students (approximately 20%) scored below 400 which is the lower bound of the low benchmark.

TIMSS mathematics achievement test covers the topics of numbers (30%), algebra (30%), geometry (20%), data and probability (20%), as well as the cognitive domains of knowing (35%), applying (40%) and reasoning (25%) (Mullis, & Martin, 2017). Achievement scores are calculated via item response theory via parameter estimations for the responses to each subtest (Martin et al., 2020). The framework of the scales used in the current study and included in the TIMSS 2019 student questionnaire is presented in Figure 1.

Figure 1.
Framework of the scales used in the study (Mullis & Martin, 2017)



According to Figure 1, the scales of confidence in mathematics, liking learning mathematics and valuing mathematics are related to attitudes towards mathematics. The scales of instructional clarity in mathematics lessons and disorderly behaviors during mathematics lessons are taken into consideration in the classroom context. Moreover, while student bullying and sense of school belonging were handled in the school context, home educational resources scale were assessed in the home context (Mullis, & Martin, 2017). The student questionnaire also includes three-category versions of those variables along with their continuous formats. The Cronbach's alpha reliability coefficients of the scales for the Turkish sample were calculated as 0.64 for home educational resources (3 items); 0.87 for disorderly behaviors during mathematics lessons (6 items); 0.85 for instructional clarity in mathematics lessons (7 items); 0.76 for sense of school belonging (5 items); 0.84 for student bullying (14 items); 0.89 for students confident in mathematics (9 items); 0.92 for students like learning mathematics (9 items); and 0.88 for students value mathematics (9 items) (Martin et al., 2020). The scales and datasets of the TIMSS 2019 are presented by Fishbein et al. (2021), and all the relevant international results can be accessed from Mullis et al. (2020).

Data Analysis

A simple correspondence analysis was used to interpret the data. It is an explanatory technique that statistically and graphically explores the correspondence in cross tabulations consisting of two or more variables (Alpar, 2020). It is a non-parametric method and does not require any assumptions except for the absence of empty cells in frequency tables. This multivariate technique is a generalized version of scatterplots which represent data in a plane with vertical and horizontal coordinates. Based on Hirschfeld's (1935) work in algebra, this technique deals with the geometric representation of distances (usually Euclidean) between profiles in rows and columns of a cross tabulation in a two-dimensional plane (Greenacre, 2017). In order to test column-row dependence, first of all, the $\chi 2$ value for test of independence is computed. Dividing the obtained $\chi 2$ value by row and column totals leads to total inertia values, i.e. the weighted average of the squares of distances from the center of profiles. A significant value of $\chi 2$ indicates a significant interaction or dependence between rows and columns in the cross tabulation (Greenacre, & Hastie, 1987). The correspondence analysis performed within the scope of the present study covers a summary table including the values of $\chi 2$ and its significance, as well as the biplot graphs with row and column profiles. Moreover, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were also reported.

In the study, IEA IDBAnalyzer software was used to obtain SPSS syntaxes to evaluate the frequency (correspondence) tables required for the correspondence analysis. This software allows to obtain the necessary statistics by using five plausible values for the mathematics field in the TIMSS data and the student weights together. Thus, within the scope of this study, all plausible values and student weights were used together to obtain the frequency tables. After obtaining these tables, it was observed that there were not any empty cells in the frequency tables. Moreover, univariate and multivariate outliers were handled by weighting columns and rows with the frequency of the observations. Finally, a series of correspondence analysis were performed for each of research problems. All analyses were carried out by using SPSS software.

Results

The summary results of the simple correspondence analysis investigating the relationship between students' mathematics performance levels and the background variables are presented in Table 1.

As seen in Table 1, a significant correspondence was found between all categories of variables and performance levels ($p < .001$). Two dimensions were elicited from all variables. The inertia values for singular values show that two dimensions explain 100% of the total variance. The eigenvalues for each variables show the correspondence between the actual graph and the resulting graph (Aksu & Coskun, 2020). Total eigenvalues showed moderate or higher correspondence for home educational resources (.571) and students confident in mathematics (.659). These values were low for all other variables. The correlation between dimensions was moderate ($.30 \leq r \leq .70$) for the variables of home educational resources and confidence in mathematics, though it was low ($-.30 \leq r \leq .30$) for other variables. For the attitude towards mathematics scales, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 2.

Although the values of contributions of each subcategory to the dimensions were given in Table 2 in detail, biplot graphs are highly practical tools to see visually the positions of the row and column points. These graphs make it possible to examine the relationship between the categories of students' background variables and performance levels. Figure 2 incorporates the biplots showing the correspondence between the scores of attitudes toward mathematics (students confident in mathematics, students like learning mathematics, students value mathematics) and performance levels.

Figure 2 shows that students at Level 1 somewhat like learning mathematics, those at Levels 2 and 3 do not like learning mathematics, and those at Levels 4 and 5 like learning mathematics very much. Likewise, students at Level 1 do not value mathematics, those at Levels 2 and 3 somewhat value mathematics, and those at Levels 4 and 5 strongly value mathematics. Students at Levels 1, 2 and 3 are not confident in mathematics, whereas those at Level 4 are somewhat confident in mathematics, and those at Level 5 are very confident in mathematics.

For the scales in the classroom context, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 3.

Figure 3 indicates that students at Level 1 encounter disorderly behaviors during some mathematics lessons, whereas those at Level 2 observe such behaviors during most lessons, and those at Levels 3, 4 and 5 during a few or no lessons. Instructional clarity in mathematics lessons was low and moderate according to students at Level 1 and Level 2. Students at Levels 3, 4, and 5 reported high instructional clarity in mathematics lessons.

For home educational resources, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 4.

Table 1.
Analysis summary

						Proportion of Inertia		Confidence Singular Value	
									Correlation
Scale	Dimension	Singular Value	Inertia	Chi Square	Sig.	Accounted For	Cumulative	Std. Deviation	2
Home educational resources	1	.412	.170			.870	.870	.014	.596
	2	.159	.025			.130	1.000	.017	
	Total	.571	.195	790.112	.000*	1.000	1.000		
Sense of school belonging	1	.078	.006			.858	.858	.016	-.045
	2	.032	.001			.142	1.000	.016	
	Total	.110	.007	28.681	.000*	1.000	1.000		
Student bullying	1	.115	.013			.922	.922	.016	.101
	2	.033	.001			.078	1.000	.016	
	Total	.148	.014	57.991	.000*	1.000	1.000		
Students like learning mathematics	1	.302	.091			.962	.962	.015	.011
	2	.060	.004			.038	1.000	.017	
	Total	.362	.095	376.024	.000*	1.000	1.000		
Instructional clarity in mathematics lessons	1	.189	.036			.980	.980	.015	-.006
	2	.027	.001			.020	1.000	.016	
	Total	.216	.036	147.245	.000*	1.000	1.000		
Disorderly behaviour during mathematics lessons	1	.087	.008			.905	.905	.015	-.002
	2	.028	.001			.095	1.000	.016	
	Total	.115	.008	34.130	.000*	1.000	1.000		
Students confident in mathematics	1	.530	.281			.944	.944	.013	.346
	2	.129	.017			.056	1.000	.018	
	Total	.659	.298	1193.978	.000*	1.000	1.000		
Students value mathematics	1	.224	.050			.989	.989	.015	.015
	2	.024	.001			.011	1.000	.013	
	Total	.248	.051	202.977	.000*	1.000	1.000		

** Significant at the level of .001 (8 degrees of freedom).*

Table 2.
Overview of row and column profiles for attitude scales

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Students Like Learning Mathematics Lessons	Row Points[a]	Very Much	.298	.786	.108	.053	.643	.059	.996	.004	1.000
		Somewhat	.406	-.176	-.284	.006	.044	.551	.650	.350	1.000
		Do Not Like	.296	-.552	.279	.027	.314	.390	.950	.050	1.000
		Active Total	1.000			.086	1.000	1.000			
	Column Points[a]	Level 1	.206	-.456	-.406	.014	.149	.573	.859	.141	1.000
		Level 2	.245	-.414	.267	.013	.146	.294	.921	.079	1.000
		Level 3	.246	-.134	.145	.002	.015	.087	.804	.196	1.000
		Level 4	.191	.527	-.115	.015	.184	.043	.990	.010	1.000
		Level 5	.112	1.135	.041	.042	.505	.003	1.000	.000	1.000
		Active Total	1.000			.086	1.000	1.000			
Students Value Mathematics	Row Points[a]	Strongly	.475	.471	.039	.023	.478	.046	1.000	.000	1.000
		Somewhat	.405	-.322	-.124	.009	.191	.404	.990	.010	1.000
		Do Not Value	.120	-.781	.265	.016	.331	.549	.992	.008	1.000
		Active Total	1.000			.049	1.000	1.000			
	Column Points[a]	Level 1	.207	-.509	.055	.012	.242	.041	.999	.001	1.000
		Level 2	.244	-.344	-.083	.006	.131	.111	.996	.004	1.000
		Level 3	.247	-.025	.107	.000	.001	.186	.440	.560	1.000
		Level 4	.191	.488	-.191	.010	.206	.454	.990	.010	1.000
		Level 5	.112	.910	.168	.021	.421	.208	.998	.002	1.000
		Active Total	1.000			.049	1.000	1.000			
Student Confident in Mathematics	Row Points[a]	Very	.151	1.467	-.399	.171	.631	.218	.984	.016	1.000
		Somewhat	.343	.218	.448	.016	.032	.625	.527	.473	1.000
		Not Confident	.506	-.587	-.185	.092	.338	.157	.979	.021	1.000
		Active Total	1.000			.278	1.000	1.000			
	Column Points[a]	Level 1	.207	-.619	-.110	.041	.154	.023	.993	.007	1.000
		Level 2	.244	-.522	-.209	.035	.129	.096	.967	.033	1.000
		Level 3	.246	-.190	.143	.005	.017	.046	.892	.108	1.000
		Level 4	.191	.656	.538	.048	.159	.502	.874	.126	1.000
		Level 5	.112	1.577	-.572	.148	.541	.334	.973	.027	1.000
		Active Total	1.000			.278	1.000	1.000			

a. Symmetrical normalization

Figure 2.
Attitude scales

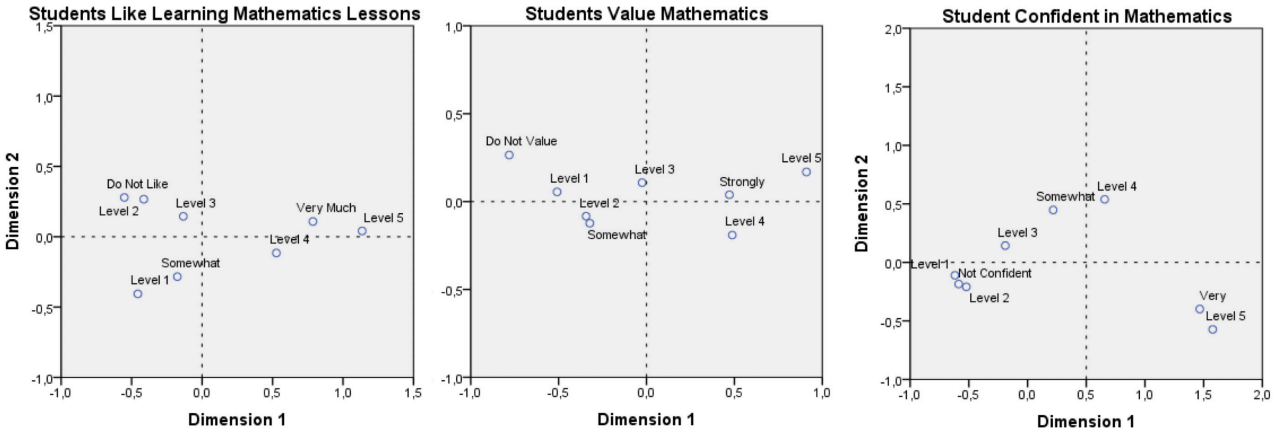


Table 3.

Overview of row and column profiles for the scales in the classroom context

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Disorderly Behavior during Math Lessons	Row Points[a]	Few or No Lessons	.233	.530	.012	.006	.765	.002	1.000	.000	1.000
		Some Lessons	.654	-.154	-.069	.001	.182	.164	.957	.043	1.000
		Most Lessons	.113	-.199	.376	.001	.052	.834	.555	.445	1.000
		Active Total	1.000			.008	1.000	1.000			
	Column Points[a]	Level 1	.207	-.484	-.064	.004	.567	.044	.996	.004	1.000
		Level 2	.245	-.117	.162	.000	.039	.335	.699	.301	1.000
		Level 3	.246	.147	-.168	.001	.062	.362	.774	.226	1.000
		Level 4	.190	.312	-.041	.002	.216	.017	.996	.004	1.000
		Level 5	.112	.296	.203	.001	.115	.241	.904	.096	1.000
		Active Total	1.000			.008	1.000	1.000			
Instructional Clarity in Mathematics Lessons	Row Points[a]	High	.671	.295	.016	.011	.318	.011	1.000	.000	1.000
		Moderate	.268	-.533	-.136	.014	.417	.315	.994	.006	1.000
		Low	.061	-.891	.416	.009	.265	.674	.982	.018	1.000
		Active Total	1.000			.034	1.000	1.000			
	Column Points[a]	Level 1	.207	-.676	.012	.017	.515	.002	1.000	.000	1.000
		Level 2	.244	-.182	-.126	.002	.044	.249	.960	.040	1.000
		Level 3	.247	.138	.180	.001	.026	.509	.873	.127	1.000
		Level 4	.190	.440	.023	.007	.201	.006	1.000	.000	1.000
		Level 5	.112	.591	-.181	.007	.214	.234	.992	.008	1.000
		Active Total	1.000			.034	1.000	1.000			

a. Symmetrical normalization

Figure 3.

Mathematics curriculum and instruction

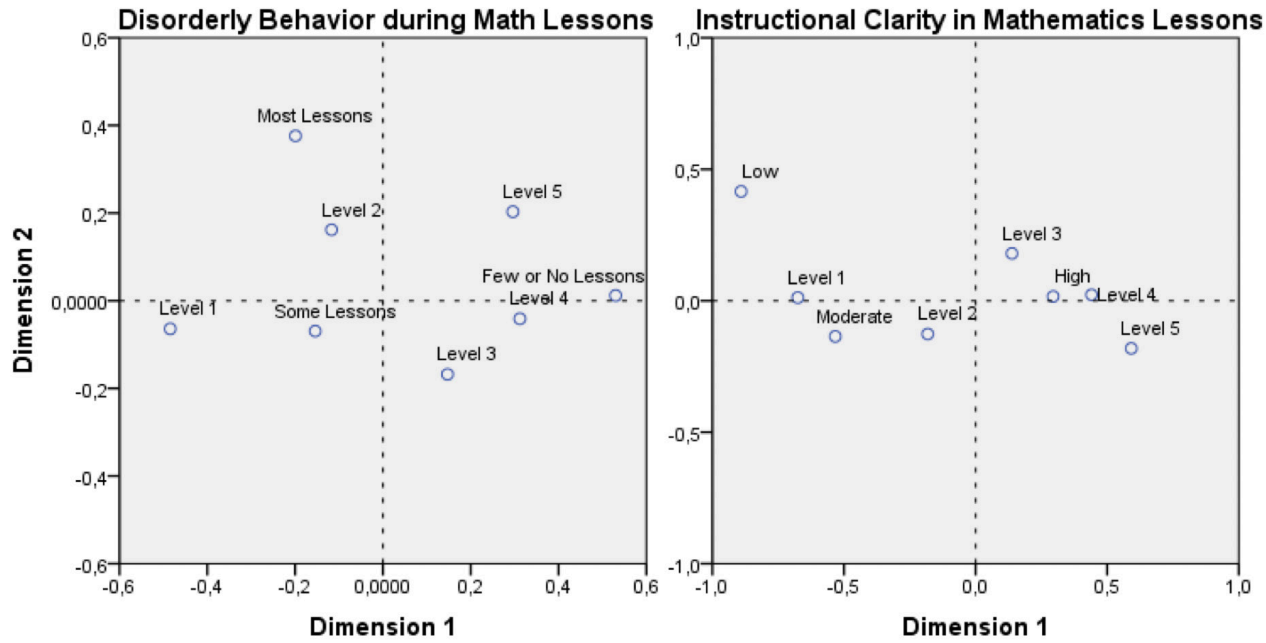


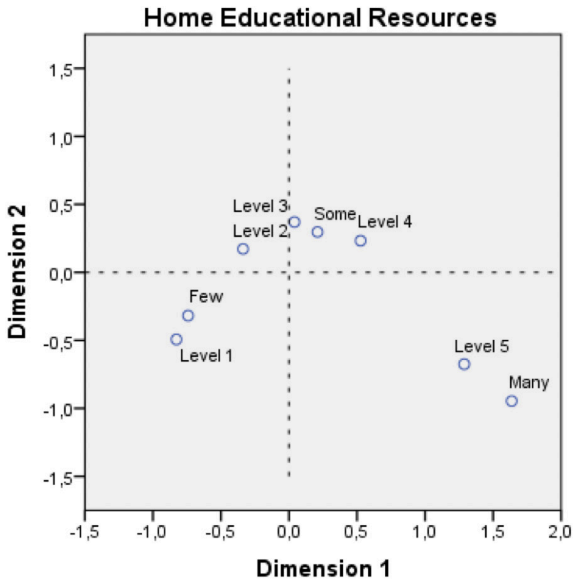
Table 4.
Overview of row and column profiles for home educational resources

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Home Educational Resources	Row Points[a]	Many	.074	1.636	-.946	.091	.488	.437	.889	.111	1.000
		Some	.594	.210	.297	.019	.064	.342	.572	.428	1.000
		Few	.332	-.742	-.318	.080	.448	.220	.936	.064	1.000
		Active Total	1.000			.190	1.000	1.000			
	Column Points[a]	Level 1	.207	-.827	-.493	.065	.347	.330	.883	.117	1.000
		Level 2	.245	-.338	.172	.012	.068	.047	.912	.088	1.000
		Level 3	.246	.040	.370	.005	.001	.221	.030	.970	1.000
		Level 4	.190	.526	.233	.023	.129	.068	.932	.068	1.000
		Level 5	.112	1.288	-.675	.083	.454	.334	.907	.093	1.000
		Active Total	1.000			.190	1.000	1.000			

a. Symmetrical normalization

Although the values of contributions of each subcategory to the dimensions were given in Table 4 in detail, biplot graphs are highly practical tools to see visually the positions of the row and column points. Figure 4 includes the biplots showing the correspondence between performance levels and the scale scores regarding home educational resources in the home context.

Figure 4.
Home educational resources



According to Figure 4, students having few resources are placed at Level 1, those having some resources at Levels 2, 3 and 4, and those having many resources at Level 5.

For the scales in the school context, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 5.

The contributions of each subcategory to the dimensions were interpreted through the biplot graphs. The biplots showing the correspondence between performance levels and the scale scores regarding student bullying and sense of school belonging in the school context are presented in Figure 5.

Figure 5 shows that students at Levels 1 and 2 have some sense, those at Level 3 and Level 4 have high sense, and those at Level 5 have little sense of school belonging. It is seen that students at Level 1 face bullying averagely once a week or once a month, those at Level 2 once a month, whereas those at Levels 3, 4 and 5 never or almost never face bullying.

Discussion

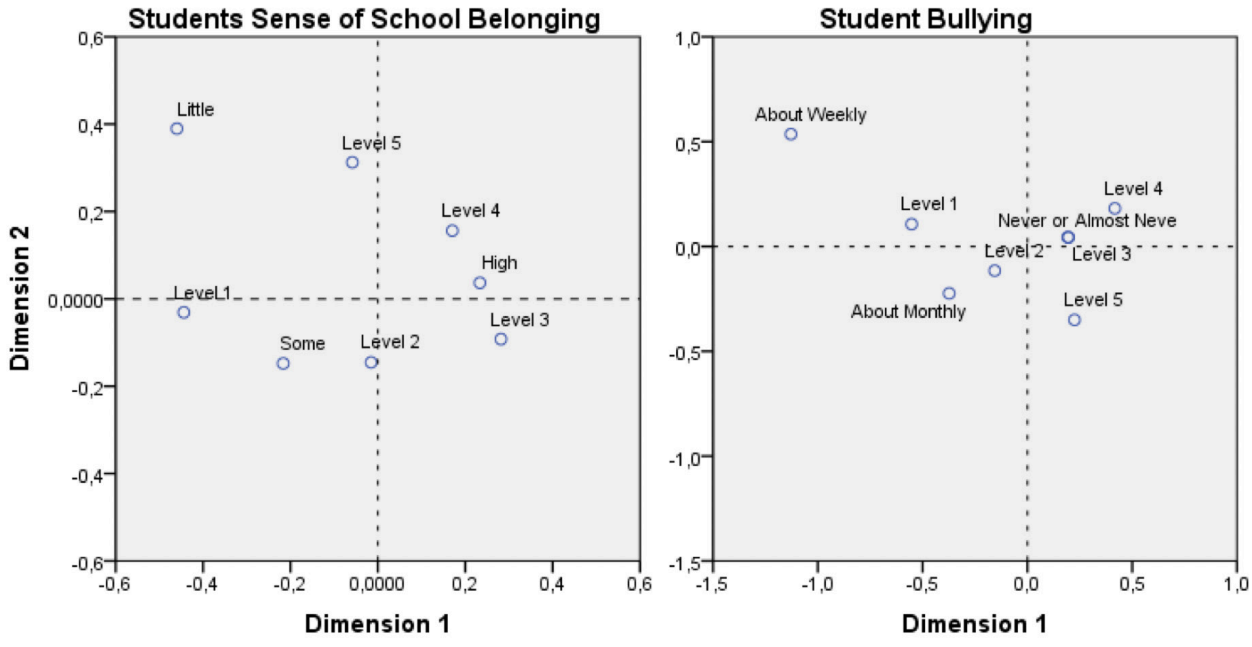
In this study, the relationship between students' performance levels in mathematics and background variables regarding classroom, home and school contexts was investigated through correspondence

Table 5.
Overview of row and column profiles for the scales in the school context

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Student Bullying	Row Points[a]	Never or Almost Never	.713	.196	.043	.003	.235	.052	.989	.011	1.000
		About Monthly	.243	-.373	-.224	.004	.289	.468	.926	.074	1.000
		About Weekly	.044	-1.128	.536	.007	.476	.481	.952	.048	1.000
		Active Total	1.000			.014	1.000	1.000			
	Column Points[a]	Level 1	.206	-.552	.106	.007	.538	.090	.992	.008	1.000
		Level 2	.245	-.156	-.115	.001	.051	.125	.892	.108	1.000
		Level 3	.247	.193	.044	.001	.079	.018	.988	.012	1.000
		Level 4	.190	.417	.181	.004	.284	.241	.959	.041	1.000
		Level 5	.112	.225	-.350	.001	.048	.526	.648	.352	1.000
		Active Total	1.000			.014	1.000	1.000			
Students Sense of School Belonging	Row Points[a]	High	.531	.234	.037	.002	.438	.031	.991	.009	1.000
		Some	.376	-.217	-.148	.001	.266	.357	.860	.140	1.000
		Little	.093	-.460	.390	.002	.296	.612	.800	.200	1.000
		Active Total	1.000			.005	1.000	1.000			
	Column Points[a]	Level 1	.206	-.444	-.031	.003	.614	.009	.998	.002	1.000
		Level 2	.245	-.016	-.145	.000	.001	.225	.032	.968	1.000
		Level 3	.247	.282	-.092	.001	.296	.091	.964	.036	1.000
		Level 4	.190	.170	.156	.000	.083	.202	.774	.226	1.000
		Level 5	.112	-.058	.313	.000	.006	.474	.091	.909	1.000
		Active Total	1.000			.005	1.000	1.000			

a. Symmetrical normalization

Figure 5.
Scales in the school context



analysis. Research results indicate a significant relationship between performance levels and attitudes towards mathematics, instructional structure, school climate, and home educational resources. The results are discussed in detail below for each of research problem separately.

First of all, according to the study results, low-achieving students had lower levels of confidence in mathematics, and they slightly like and value mathematics. In parallel, it was found that high-achieving students had higher levels of positive attitudes. Other studies also show that students' beliefs about mathematics support their mathematics achievement (Pajares & Miller, 1994; Xiao & Sun 2021). For example, Şahin and Boztunç Öztürk (2018) found that liking mathematics is positively related to mathematics achievement. Positive beliefs are expected to lead students to set aside more time, put more effort, and succeed in mathematics. On the contrary, relevant false beliefs and negative experiences can cause mathematics anxiety over time (Ashcraft & Krause, 2007; Li et al., 2021). For example, Fırat and Erdem (2019) found that the fourth grade students with difficulties in learning mathematics had mathematics anxiety and prejudices towards mathematics, even though they had not experienced difficulty in affective domain during the first grade. A negative relationship is found between mathematics achievement and anxiety (Barroso et al., 2021; Casanova et al., 2021). We therefore argue that early diagnosis and intervention are crucial to prevent false beliefs in mathematics from turning into mathematics anxiety. Early anxieties may snowball and eventually lead students to avoid mathematics classes and mathematics-related career choices (Ramirez et al., 2013).

Second, while low-achieving students found instructional clarity in mathematics lessons low, high-achieving ones found it high. The relationship between the quality of mathematics instruction (clarity and supportive climate) and mathematics achievement was highlighted by several studies (Boston, 2012; Schlesinger et al., 2018; Scherer & Nilsen, 2016). According to Nilsen et al. (2016), the quality of mathematics instruction depends on (a) supportive climate, (b) instructional clarity, (c) cognitive activation, and (d) classroom management. They relate these dimensions to teacher qualities (education, preparation, experience, etc.). In this respect, it is possible to argue that teacher qualities are of importance for the clarity of mathematics. Higher achievement among students from socioeconomically advantageous schools can be explained in part by the fact that such schools have better quality teachers (Mullis & Martin, 2017). Ersan and Rodriguez (2020) found that associations between instructional quality and mathematics scores were significant even after controlling for the impact of SES. From this point of view, we can underscore the unique impact of mathematical clarity on achievement. Another result found in the present study supporting this claim was the fact that low-achieving students faced disorderly behaviors during mathematics lessons more often than high-achieving students as for the classroom climate.

Third, home educational resources are associated with student achievement in TIMSS. Accordingly, low-achieving students reported to have insufficient home educational resources, whereas high-achieving students had sufficient resources. Previous studies also indicated that home educational resources and attitudes towards mathematics both positively and significantly predict student achievement (Geesa et al., 2019; Özkan, 2018). For instance, Özkan (2018) found that students from the top five countries in mathematics achievement have more home educational resources and opportunities than Turkish students. Even among the top five countries, the average achievement of students with more home educational resources and opportunities was found higher than that of students with less resources and opportunities. Some empirical studies show that students who receive more support from their parents have higher mathematics achievement and more favorable attitudes towards mathematics than students who receive less support (Cai et al., 1999). This can be explained by parental socioeconomic status and education level (Sari & Hunt, 2020; Sirin, 2005). Studies have found a significant relationship between parental education level and children's mathematics achievement (Kaleli-Yılmaz, & Hanci, 2016). For instance, the education level of students' mother and if students come from a home with many books have a clear influence on students' mathematics performance (Wiberg, 2019). Parents' mathematical activities at home (Levine et al., 2010; Lehrl et al., 2020) and their attitudes towards mathematics (Mohr-Schroeder et al., 2017; Sheldon & Epstein, 2005) can contribute to children's mathematical skills and attitudes towards mathematics. According to Soni and Kumari (2017), parents' mathematics anxiety and attitude act as precursors to their children's mathematics anxiety and attitude and further influence the mathematics achievement of their children.

Fourth, in terms of school climate, an interesting result regarding the Turkish sample in TIMSS is that high-achieving students had less sense of school belonging than low-achieving students. In their meta-analytic review, Korpershoek et al. (2020) found a small positive relationship between achievement levels and school belonging. In another study using data from Turkey as well, Korean students who reported that they liked school, felt safe, and had sense of school belonging were more successful in science and mathematics. On the contrary, when Turkish students' sense of school

belonging increased, their science and mathematics achievement decreased (Topçu et al., 2016). As a matter of fact, a number of studies found a significant relationship between sense of school belonging and mathematics achievement (Hughes et al., 2015; Smith et al., 2021). Sense of school belonging is important for students' academic achievement, well-being and mental health (Allen et al., 2018; Arslan, 2021). Moreover, according to Korpershoek et al. (2020), sense of school belonging negatively predicts absence and dropout rates. This finding needs to be investigated in the context of Turkish education system. Ahmadi et al. (2020) showed that student-level variables, such as socioeconomic status, parental involvement, and peer support are related to sense of school belonging. In addition, school-level variables including sense of fairness and teacher-student relations could explain the variance in school belonging. Therefore, the contradictory result in the present study can be attributed to several reasons. First of all, it can be explained by the fact that successful students are disliked and excluded by their peers in school environments. It is known that children who excel in mathematics and other fields are not accepted by typically developing peers and are even exposed to peer bullying (Peterson & Ray, 2006). Concerning the school discipline and safety, a finding of the current study is that high-achieving students face more bullying compared to intermediate-level students. The fact that these students encounter bullying averagely once a month may have harmed their sense of school belonging. Secondly, teacher quality may be another reason (Kiefer et al., 2015). Teachers need to have further professional and pedagogical knowledge in order to support successful students educationally, socially and emotionally inside and outside the classroom. Teachers' deficiencies in these fields and inability to develop bilateral relations with students may weaken students' sense of school belonging (Ibrahim & El Zaatari, 2020).

Conclusion

In conclusion, there are strong associations between students' achievement levels and their attitudes towards mathematics, approaches to mathematics instruction, possession of sufficient educational resources, as well as perceptions of school climate and discipline. Overall, it is seen that low-achieving students have a negative attitude towards mathematics, find the mathematics instruction unclear and the classroom environment unfavorable, and their educational resources are insufficient. This situation indicates that students' failure in mathematics is closely related to not only insufficient resources, but also negative attitudes and approaches.

Limitations and Suggestions

This study has some limitations due to its quantitative nature. First, it is limited to the variables included in the TIMSS student questionnaire and used in the study. Future studies can investigate the relationship between student achievement and teacher- and school-level variables. Second, the scales in TIMSS consist of students' self-reported information. The results are therefore limited to student statements. Third, this study is limited to the sample of Turkish eighth grade students. The results of this study can be repeated and compared with similar conditions for other grade levels and for different countries. Fourth, the technique of correspondence analysis was used in this study. Future studies can investigate the relationship between student achievement and TIMSS scales via different analysis techniques. Finally, there are more low-achieving Turkish students in the TIMSS. This situation should be taken into consideration in the evaluation of the results of this study and in future studies.

Acknowledgements

The datasets used and/or analyzed during the current study are available from the corresponding author and TIMSS 2019 database. The author declares that there are no competing interests. This study was not funded.

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