South African Journal of Childhood Education
ISSN: (Online) 2223-7682, (Print) 2223-7674

The notions of floating and sinking: Exploring the conceptual knowledge of Grade R teachers

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Dates:
Received: 12 July 2023
Accepted: 08 Nov. 2023
Published: 31 Jan. 2024

How to cite this article:
Maraisane, M.J.L., Jita, L.C. & Jita, T., 2024, 'The notions of floating and sinking: Exploring the conceptual knowledge of Grade R teachers', *South African Journal of Childhood Education* 14(1), a1407. https://doi.org/10.4102/sajce.v14i1.1407

Background: Preschool teachers play a key role in early scientific education, and their understanding and ability to communicate scientific concepts are crucial. Researchers have extensively studied their grasp of basic scientific concepts, but their understanding of important concepts related to buoyancy, such as floating and sinking, remains relatively underexplored at this level.

Aim: This study sought to investigate Grade R teachers' understanding of buoyancy principles by focusing on the concepts of floating and sinking.

Setting: The study was conducted in Maseru, Lesotho with four Grade R teachers in their schools.

Methods: This study employed a qualitative research approach characterised by a case-study design within an interpretive paradigm. Thematic data analysis was used, drawing from semi-structured interviews with four purposefully selected Grade R teachers.

Results: The study found that Grade R teachers have a partial grasp of floating and sinking concepts. While they can describe these principles at a basic level, their ability to explain the reasons behind objects floating or sinking is limited.

Conclusion: The incomplete understanding of the floating and sinking concepts among Grade R teachers could negatively impact students' knowledge of science. Therefore, it is advisable to implement an in-service science content-focused programme to empower and equip teachers with the necessary knowledge and skills.

Contribution: This study contributes to the limited literature on understanding basic scientific concepts such as floating and sinking in early childhood education. Neglecting these concepts may impede students' learning if not properly addressed.

Keywords: content knowledge; early childhood; floating and sinking concepts; Foundation Phase; Grade R teacher; science learning; teachers' knowledge.

Introduction

Comprehension of scientific concepts plays a pivotal role in effective science teaching, as demonstrated in studies by Harrell et al. (2022) and Leuchter et al. (2020), and it correlates with enhanced student performance (Essa & Burnham 2019). Hence, teachers, serving as facilitators of students' knowledge acquisition, play a critical role in dispelling scientifically inaccurate information, drawing upon their content knowledge (Bonner, Diehl & Trachtman 2020). When taught proficiently, floating and sinking concepts can captivate young children's imagination and curiosity. This engagement sets a positive tone for their future exploration of science and learning in general (Essa & Burnham 2019). However, Andersson and Gullberg (2014) identified that preschool students often harbour misconceptions about the principles of floating and sinking. This is largely attributed to the limited support they receive from their teachers, which is influenced by the teachers' content knowledge.

Explaining the concepts of floating and sinking, which are based on the everyday experiences of learners, presents a challenging teaching task. Even in higher grade levels, teaching these concepts is known to be challenging (Kariotoglou & Psillos 2019). These concepts are found in the curriculum guide for Reception Grade, commonly referred to as Grade R (Lesotho Ministry of Education and Training [MoET] 2021). Learners often become confused if teachers cannot provide a clear scientific explanation of the relationship between the densities of objects and fluids (Zoupidis et al. 2021).

Furthermore, understanding the concepts of floating and sinking is closely linked to grasping the principles of density and buoyant force (Harrell et al. 2022). One of the most prevalent misconceptions is that objects sink because of their weight and float because they are light in weight (Zoupidis et al. 2021). For example, learners in the Foundation Phase (grades R to 3) might wrongly assume that a small piece of iron will float, while a large piece of wood will sink, which contradicts scientific principles (Qonita et al. 2019). To determine whether an object will float or sink, Radovanović, Sliško and Ilić (2019) recommend comparing the mass or volume of the object with that of the liquid. Concepts such as floating and sinking in early science education provide children with age-appropriate content and processes that lay a solid foundation for understanding science.

Numerous difficulties have been identified in the instruction of science content, potentially stemming from teachers' constrained comprehension of the subject matter and scientific procedural abilities. In Hong Kong, a study by Wan, Jiang and Zhan (2021) revealed that pre-service teachers lacked confidence in introducing science, technology, engineering and mathematics (STEM) concepts to young learners. Meanwhile, in the United States, Gerde et al. (2018) determined that early childhood teachers' self-assurance in teaching science had an impact on their limited involvement in science-related activities compared to mathematics and literacy. A South African investigation conducted by Kazeni (2021) focused on early primary school educators and found that these teachers had limited scientific knowledge and skills, leading to a negative perception of teaching science in the early grades. Additionally, Kennedy (2019) expresses concern that preschool teachers struggle to execute elementary steps in constructing science lessons because of their restricted knowledge of the subject matter.

Several researchers have delved into the teaching of concepts related to buoyancy, such as floating and sinking, in early childhood education. In many of these studies, the primary objective has been to unravel the intricate challenges and issues associated with conveying these concepts. To illustrate, Wei and Karpudewan (2018) discovered that Grade 1 teachers employed inappropriate strategies in an attempt to help students comprehend the concepts of sinking and floating by using social and emotional learning techniques. Moreover, Larsen, Venkadasalam and Ganea (2019) note that 5-year-old children often develop misconceptions when they lack the prerequisite knowledge before receiving explanations about floating and sinking concepts. In their study, Qonita et al. (2019) reach the conclusion that teachers possessed an inadequate understanding of these concepts, as they were unable to demonstrate the scientific procedural skills necessary for helping 5–6-year-old children construct knowledge related to these concepts.

In contrast, Zoupidis et al. (2021) observed substantial success in teaching the concepts of floating and sinking to Grade 5 students by employing a didactic transformation approach. Ibarra and Galindo (2022) discovered that 6-year-old children were able to elucidate the scientific processes involved when they used social interaction to construct their understanding of floating and sinking through the precursor model. Additionally, Leuchter et al. (2020) identified the use of scaffolding strategies by Swiss preschool teachers to facilitate the learning of content related to floating and sinking. It is worth noting that these studies do not provide insights into the teachers' comprehension of the concepts of floating and sinking.

Building on prior research focused on the investigation of science teaching and knowledge (Kazeni 2021; Kennedy 2019; Wan et al. 2021; Zoupidis et al. 2021), there is a noticeable gap concerning the examination of teachers' comprehension of the principles of floating and sinking. Existing studies have provided limited insights into the understanding of these concepts among Grade R teachers, particularly within the context of Lesotho. Consequently, this study aimed to address the following research question: What knowledge do Grade R teachers possess on the notions of floating and sinking? As a result, the primary aim of this study was to unpack the knowledge of Grade R teachers concerning the concept of floating and sinking. This aim was considered crucial, because it shed light on the importance of content knowledge in the teaching of science, particularly in the early stages of education.

The rationale behind conducting this study was to investigate how Grade R teachers comprehend the challenging concepts of floating and sinking. Teaching these concepts effectively requires teachers to have a solid grasp of the fundamentals and the ability to develop strategies for conveying this content to learners. Teachers' understanding of the science concepts in the curriculum significantly impacts learners' learning.

Literature review

In this section, we delve into previously published literature that offers insights into the conceptualisation of floating and sinking concepts. This exploration aims to provide a comprehensive view of how content knowledge is acquired and how science concepts are learned. We draw from a range of authoritative sources, including peer-reviewed journals and academic books, to shed light on this subject.

Defining the concepts of floating and sinking

The concepts of floating and sinking are commonly introduced in early-grade science activities. These concepts are intricately connected to the factors of density and buoyancy (Qonita et al. 2019). In essence, when objects either sink or float, their behaviour is governed by the interplay of buoyant force and density. As validated by Wei and Karpudewan (2018), the principles related to sinking and floating are fundamentally tied to the density of materials and other factors such as buoyancy. Therefore, as per the findings of Harrell et al. (2022), the phenomena of floating and sinking serve as visible manifestations of the dynamic relationship between the buoyant force and the weight of the object. In simpler terms, the weight of an object is counteracted directly by the buoyant force, and this equilibrium determines its position within a fluid medium. Qonita et al. (2019) clarify that buoyancy, being an upward force, determines whether objects will float, sink or remain stationary in a fluid medium. This means that an object will sink if its weight exceeds the buoyant force, float if its weight is less than the buoyant force and stay in place if its weight equals the buoyant force.

Research suggests that young learners and their educators often associate the buoyancy of objects with either their weight or size. According to this perspective, small and lightweight items are thought to float, while large and heavy ones are believed to sink (Harrell et al. 2022; Hsin & Wu 2011; Zoupidis et al. 2021). Similarly, Larsen et al. (2019) discovered that young learners tend to simplify the concepts of floating and sinking by focusing on a single dimension, either the size or weight of an object, to explain its buoyant behaviour. Moreover, Zoupidis et al. (2021) elaborate on another common misconception related to the shape of objects, where items resembling boats or ships are presumed to float. Additionally, learners often factor in the perceived heaviness or lightness of an object in determining whether it will sink or float. These misconceptions demonstrate that children form inaccurate beliefs about floating and sinking concepts, sometimes as early as preschool, because of their reliance on simplistic and irrational explanations.

The acquisition of science knowledge by teachers

Teachers use various channels to gain content knowledge, including systematic, craft and prescriptive knowledge. Courses offered at universities or colleges contribute to the systematic acquisition of knowledge by teachers, as observed by Sorge et al. (2019). Furthermore, as highlighted by Hirsch, Lloyd and Kennedy (2019), professional development workshops also play a significant role in teachers' acquisition of systematic knowledge. Consequently, education programmes, whether in-service or pre-service, are designed to enhance both teachers' content knowledge and their pedagogical skills, as emphasised by Barenthien et al. (2020). These programmes provide systematic knowledge that is structured to serve as a guide for the work of trainees. This means that preschool educators who have completed their studies in high school or a college of education will be equipped to impart the content they acquired during their training.

Systematic knowledge is acquired as educators engage with content and students in their daily teaching activities. Teffo (2020) supports this view by noting that knowledge evolves through hands-on experience gained from regular interactions with the subject matter and students. In essence, teachers' accumulated knowledge, stemming from their practical experiences, significantly shapes their overall knowledge acquisition. However, Graham et al. (2020) contend that the quality of teaching cannot rely solely on teachers' experiential knowledge.

Moreover, teachers gain knowledge through prescriptive documents. Neuman and Danielson (2021) define prescriptive knowledge as information obtained from mandated sources such as policies and curriculum guidelines. Kennedy (2019) further elaborates that this type of knowledge is presented in a manner that implies authority, ensuring that prescribed rules, procedures and policies are adhered to. Neuman and Danielson (2021) propose that students taught by instructors well versed in curriculum content are more likely to excel academically. Nevertheless, Hill and Charalambous (2012) caution that these materials may sometimes be insufficient in addressing students' inquiries comprehensively.

Science process skills when acquiring science concepts

Educators who possess a sound understanding of science content play a pivotal role in fostering a scientific mindset among their students through the cultivation of science process skills (Naudé & Meier 2020). According to Yildiz and Yildiz (2021), the development of these process skills commences in early infancy. During this phase, children exhibit innate curiosity and a penchant for exploring their surroundings in pursuit of answers to their questions. Consequently, teachers must ensure that learners engage in activities such as 'making observations, asking questions, using tools to collect, analyse, and interpret data, drawing tentative conclusions, and sharing information and communicating scientific results' (Naudé & Meier 2020:82). These practices are instrumental in nurturing learners' scientific abilities. For example, when introducing the concepts of floating and sinking, teachers can encourage students to categorise objects based on their floating or sinking attributes, without immediately requiring them to demonstrate which objects would float or sink. In the process of classification, students would naturally need to observe, make inferences and draw conclusions (Stears, James & Beni 2019). Furthermore, as noted by Yildiz and Yildiz (2021), fundamental science skills that can be cultivated in young learners encompass observing, predicting, classifying, measuring, communicating and inferring. However, Stears et al. (2019) raise the concern that early primary school teachers often lack proficiency in science process skills, which, in turn, limits their ability to effectively convey scientific content.

Teachers play a crucial role in facilitating their students' comprehension of content by employing strategies and skills that leverage their existing knowledge as a foundation for acquiring new insights (Palaiologou 2019). As underscored by Stears et al. (2019), this support is instrumental in prompting learners to employ scientific skills, enabling them to observe and understand, for instance, why objects either float or sink in water. In line with this perspective, Yildiz and Yildiz (2021) stress the importance of not underestimating skills such as counting, estimating, recording, collaboration, problem-solving and generalisation. These skills are deemed significant components in the effective teaching and learning of science concepts.

Theoretical framework

In this study, we gauged teachers' comprehension of the concepts of floating and sinking using the Content Knowledge for Teaching (CKT) framework, a model introduced by Ball, Thames and Phelps (2008), built upon Shulman's (1986) foundational work in teacher knowledge. The CKT framework operates on the premise that educators must possess content knowledge that is not only profound but also accessible to their students (Etkina et al. 2018). Within the context of this study, teachers' proficiency in grasping the concepts of floating and sinking becomes evident when they can effectively elucidate not only what causes objects to float or sink but also why they behave in this manner. Moreover, it is vital for them to be able to employ this knowledge to facilitate their students' understanding of these concepts.

The CKT framework consists of two primary domains: subject matter knowledge (i.e. content knowledge or CK) and pedagogical content knowledge (PCK). The former encompasses three subdomains: common content knowledge (CCK), specialised content knowledge (SCK) and horizon content knowledge (HCK). The latter domain comprises knowledge of content and students, knowledge of content and teaching and knowledge of the curriculum (Ball et al. 2008). For our study, we found it suitable to focus on content knowledge, as we sought to delve into teachers' scientific understanding of the concepts of floating and sinking. Consequently, we adopted two subdomains of CK, namely CCK and SCK. Common content knowledge pertains to the kind of knowledge that is common to various professionals and is typically acquired through general schooling experiences (Ball et al. 2008). For example, it encompasses the basic understanding that some objects float in water, while others do not. Specialised content knowledge, on the other hand, delves into the specific knowledge required for teaching practice that is not necessarily essential in other professions. This involves a teacher's ability to utilise their acquired CCK to help students comprehend the underlying reasons why certain objects may not behave as expected when floating or sinking.

Methods

This study employed a qualitative approach, specifically utilising a case-study design, to delve into the comprehension of Grade R teachers regarding the concepts of floating and sinking. In this context, we assessed the understanding of four teachers by requesting them to provide explanations for what constitutes floating and sinking, the reasons behind objects floating or sinking and the scientific processes they employ to facilitate students' grasp of this subject matter. This research design aligns with the interpretive paradigm, as the data were collected from four Grade R teachers situated in their respective schools (Thanh & Thanh 2015). Consequently, this design was chosen to interpret and gain insight into their comprehension of the concepts of floating and sinking, as well as their background knowledge for teaching these concepts.

This study focused on Grade R teachers who had completed their early childhood education certification. We purposefully selected four participants for this research based on specific attributes that rendered them suitable for generating the desired data, following the recommendations of Cohen, Manion and Morrison (2018). At the time of study, these teachers were actively engaged in teaching Grade R classes located in the township of Maseru, Lesotho. The participants exhibited a range of experiences, with teaching tenures spanning from 5 to 8 years. The significance of this experience is underscored by Teffo (2020), as it equips teachers with the necessary content knowledge. All participants shared the same qualifications and were exclusively female. Their early childhood education certificates, obtained from teacher colleges, provided them with the requisite curriculum content knowledge for effective teaching, in accordance with the findings of Barenthien et al. (2020). It is noteworthy that they also instructed the life skills subject, which includes the concepts of floating and sinking.

We obtained rich and comprehensive data by inviting participants to articulate their comprehension of the concepts of floating and sinking. These insights were gathered through semi-structured interviews, which proved to be an effective approach for acquiring detailed information about the subject under investigation. The one-on-one interview format facilitated in-depth probing and elaboration on the information sought, allowing for a deeper exploration of the participants' perspectives. To ensure the accuracy and thoroughness of the data-collection process, we secured permission to audio-record the interviews, as recommended by Creswell and Creswell (2018). This approach was adopted to capture every nuance and detail of the participants' views.

The analysis of the data commenced with a comprehensive review of the audio-recorded interviews. Initially, we familiarised ourselves with the data by both listening to the audio recordings and reviewing the written notes, in line with the guidance of Coolican (2017), who emphasises the importance of gaining a thorough understanding of participants' statements. Subsequently, the data were transcribed to facilitate a thematic analysis, which adopted an inductive approach. We engaged in multiple readings of the data, observing the emergence of recurring themes across all the participants. These themes were organised based on their conceptual similarities, and each cluster of themes was assigned a distinct code. This manual coding process involved working through transcripts using highlighters and pens. Following this initial coding process, the codes were structured into coherent themes that directly addressed the research question. These themes were reviewed, refined and meticulously examined to ensure that they aligned with the aim of this study. This process ultimately culminated in a descriptive and narrative synthesis of the data, allowing for the drawing of informed conclusions and interpretations. It is important to note that because of the small-scale nature of this case study, the findings may not be broadly generalisable beyond the specific context under investigation.

Silverman (2011) aptly reminds us that when conducting research, we are essentially stepping into the personal space of the individuals we engage with. As a result, building trust is paramount, and respecting their rights, needs, desires and values becomes an ethical imperative. Consequently, ethical considerations were carefully addressed prior to the commencement of data collection.

To begin, we diligently sought ethical clearance from the University of the Free State Ethics Committee, with the assigned reference number UFS-HSD2017/1015. Subsequently, we sought approval from the MoET and the school principals to conduct our study within their educational institutions. Lastly, participants were invited to engage in the study on a voluntary basis, with assurances provided regarding their anonymity, confidentiality and the right to withdraw from the study at any time of their choosing. To further protect the participants' information, pseudonyms (namely Kat, Tsepo, Potso and Lefu) were employed in this study.

Ethical considerations

Ethical clearance to conduct this study was obtained from the Lesotho Ministry of Education and Training (MoET) (No. UFS-HSD2017/1015).

Results

The findings of this study were structured based on teachers' comprehension of the concepts of floating and sinking within the CKT framework, as elucidated by Ball et al. (2008).

Sources and methods of acquiring knowledge on floating and sinking concepts among Grade R teachers

During the interviews, participants were queried about their educational background and how they had come to acquire knowledge in the realm of science content. This line of questioning is consistent with the existing literature, which underscores that teachers accumulate knowledge through various avenues (Barenthien et al. 2020; Hirsch et al. 2019; Sorge et al. 2019). In addition to the assumption that participants had received instruction in science concepts during their teacher training, it was also presumed that they might have been exposed to these concepts during their secondary or high school education or through their everyday experiences in teaching the subject to their students.

As such, participants were invited to elucidate how their experiences in teacher training or high school had prepared them for teaching the concepts of floating and sinking. Among the participants, only Kat had a background in biology, chemistry and physics, as indicated by her statement, 'I did biology, chemistry and physics'. In contrast, the other three participants, Tsepo, Potso and Lefu, acknowledged that they had not previously studied physics or chemistry. This distinction is evident in the following statements:

> 'I did biology in high school. The other ones [*referring to chemistry and physics*] I did not do. I did them in a secondary school, as they were called combined sciences.' (Tsepo)
>
> 'What can I say? In science, we were doing … I can't remember, we were doing human and social biology.' (Potso)
>
> 'I did biology.' (Lefu)

The quotes presented earlier suggest that the participants in this study had completed the biology coursework during their high school education, implying that their grasp of physics concepts pertaining to the topic of floating and sinking may be limited. Tsepo revealed that she had studied chemistry and physics as part of combined sciences in secondary school, which suggests that she possessed some science knowledge acquired during her secondary and high school years. Moreover, the participants were asked to elaborate on how their college education had familiarised them with the concepts of floating and sinking. They highlighted that their college experiences had significantly equipped them with effective methods and strategies for teaching. This finding correlates with Ball et al.'s (2008) CCK, which suggests that Grade R teachers should possess knowledge related to floating and sinking. Upon further exploration, the following was expressed:

> 'I can make an introduction that includes questions; a question can be, "Who has ever swum?" Then from the swimming, I will relate floating and sinking, because the learner will say, "I swam in the swimming pool." Then I will ask, "What happens when you swim?" The learner will say, "I float on top of the water".' (Lefu)

The quotation above underscores the Lefu acknowledgement that the knowledge gained during her college education has proven invaluable in devising effective strategies for addressing the topic. This perspective aligns with the findings of other participants in the study. It also corresponds with the insights presented in the works of Barenthien et al. (2020) and Sorge et al. (2019), which emphasise the significant role of college-structured courses in enhancing teachers' knowledge. However, it is worth noting that, during their high school education, three out of the four participants did not engage with physics, which might have provided them with a more comprehensive understanding of the concepts of floating and sinking. Although the participants considered their college exposure to be beneficial, it equipped them primarily with pedagogical methods and teaching strategies, contributing less to their content knowledge in physics.

Teachers' perceptions on how they conceptualise floating and sinking concepts

Participants were invited to elucidate their understanding of the concepts of floating and sinking. Without exception, all participants associated these concepts with the weight of objects, as reflected in their responses:

> 'When we talk of floating and sinking, we are talking in a situation whereby we are looking at things, eh, their heaviness and lightness, maybe using water to find out whether the object will float when put [*it*] in water, depending on its weight.' (Kat)

> 'Floating refers to objects which are not sinking in water, or I can say floating objects are light objects.' (Tsepo)
>
> 'Floating are the things that float in water; they float because of their density.' (Potso)
>
> 'Floating and sinking is a science activity; it is to teach learners science, floating and sinking, so that they know things that float and sink. Floating objects are light.' (Lefu)

It can be observed that the participants tended to link the concept of floating with lighter objects and sinking with heavier ones, which, as indicated by Qonita et al. (2019), is scientifically inaccurate. This perspective aligns with the explanations provided by Harrell et al. (2022), Hsin and Wu (2011) and Zoupidis et al. (2021), all of whom highlight that both young learners and their teachers commonly associate floating with objects that are perceived as light and small while categorising sinking objects as large and heavy.

We asked participants to explain what causes objects to float in water. Tsepo and Potso indicated that they float because they are light:

> 'Yes, except that they are light, I do not know.' (Potso)

Lefu and Kat explained that objects float because their density is less than that of water. For illustration:

> 'It is because their density is less than water. It is not heavier than water; therefore, the object will not sink in water.' (Kat)
>
> 'The shape and the materials of the object determine whether they will float or sink.' (Lefu)

We can deduce from Lefu's statement that she connected the shape and materials of an object to whether it will float or sink.

The four participants were presented with a scenario in which they were asked to elucidate the reasons why objects constructed from the same material, such as a metal ship and a metal spoon, might either float or sink. Their responses varied. Lefu suggested that the shape of the boat is what enables it to float, another participant said:

> 'And the ship is made of metal. And they are very big.' (Tsepo)
>
> One participant expressed some uncertainty, noting:
>
> 'I have forgotten when the force of gravity occurs and why it happens, but it has something to do with force.' (Pisto).

Other participant contributed her perspective with the following statement:

> 'I do not have any … I think it is made of some things, like it has an engine and steering, so, there is someone who is always there driving. So, it will not sink, it will go. But the spoon will sink because … [*laughing*].' (Kat)

Lefu attributed the buoyancy of the boat to its shape, while Tsepo offered the insight that it is made of metal. However, Tsepo's response lacked a clear explanation for why the ship floats, and her amazement seems to underscore her uncertainty, suggesting that she may not fully grasp the reasons behind the ship's ability to float. Ball et al. (2008) explain that teachers must have SCK that would help them to be able to explain to learners why objects float or sink in this context. However, participants' responses in this research show that their SCK is questionable.

Upon analysing the participants' responses, it becomes evident that they did not provide a precise scientific explanation for the principles governing the buoyancy of objects in water. They did not delve into the concept of buoyant force, as outlined by Qonita et al. (2019), which operates on objects to dictate whether they float, sink, or remain stationary. Instead, one participant mentioned the force of gravity, which, in the context of this phenomenon, is not pertinent.

Science processes skills applied by Grade R teachers in teaching floating and sinking concepts

During the interviews, participants were questioned about their familiarity with the science process skills that are essential for facilitating students' comprehension of the concepts of floating and sinking. The following insights were obtained:

> 'As they are learning, they will gain communication skills because they will be communicating; maybe they will get new words from that, they are going to observe, they are going to experiment.' (Potso)
>
> 'Oh, they will be observing, right? Then when we are done with their activities, we sit down and discuss about things that float and sink.' (Kat)
>
> 'The skill that they will have will be… eh [*murmuring, not providing an answer*].' (Tsepo)
>
> 'I think it will be why things float and why some things will sink. The other one will sink because of its weight or the material it was made of, like metal.' (Lefu)

Naudé and Meier (2020) highlight the significance of science process skills in facilitating young learners' comprehension of science concepts. Participants in this study showed little knowledge about science process skills. Potso emphasised the significance of communication and experimentation skills in her interview, while Kat highlighted observation skills. In contrast, Tsepo was unable to provide a response, and Lefu's answer did not pertain to any scientific skill, indicating a lack of understanding in this regard.

Discussion of the findings

This section delves into the crucial findings of the study. The primary objective was to investigate Grade R teachers' comprehension of the concepts of floating and sinking as well as how they apply this knowledge in their teaching practices. The main findings shed light on the fragmented nature of teachers' understanding of these concepts and their knowledge regarding them.

Fragmented comprehension of floating and sinking concepts

The findings of this study bring to light the fragmented nature of the participants' comprehension of floating and sinking concepts. Specifically, it indicates that while their CCK concerning these concepts appeared to be adequate, their SCK was somewhat lacking. All four participants exhibited a grasp of CCK. Their exposure to science during their college education contributed significantly to the methods and strategies they employed to facilitate their students' understanding of these concepts. This observation aligns with the findings of Sorge et al. (2019) and Barenthien et al. (2020), highlighting the role of in-service and pre-service programmes in enhancing teachers' content knowledge and pedagogical skills. Hence, it can be deduced that the participants' experiences in high school and college were instrumental in equipping them with the knowledge required to explain the foundational content associated with CCK, as elucidated by Ball et al. (2008). Furthermore, the participants demonstrated a clear differentiation between the concepts of floating and sinking, as anticipated. In conclusion, this study underscores a noteworthy discovery – that preschool teachers possess the anticipated CCK pertaining to the concepts of floating and sinking.

The participants in this study exhibited a noticeable deficiency in SCK, particularly when it came to providing a comprehensive explanation for the principles governing the floating or sinking of objects in fluids. This limitation suggests that they might encounter challenges when responding to students' inquiries about why certain objects float, while others sink. To assess their understanding, they were presented with a scenario involving a boat and a metal spoon, both constructed from the same material, which could either float or sink. Lefu held the misconception that the shape of an object, particularly that is triangular, influences its buoyancy. This belief aligns with a prevailing misconception in the literature, which posits that the shape of objects plays a significant role in their floating or sinking behaviours (Larsen et al. 2019). Kat, on the other hand, offered an explanation suggesting that a ship floats because someone is driving it, which does not align with the scientific principles governing this phenomenon.

From a scientific standpoint, the explanation provided by the participants is not accurate, indicating a limitation in their scientific comprehension of what causes boats to float. All four participants shared the misconception that objects float because of their lightness and sink because of their weight. This discovery holds significance, as it highlights how educators may assign incorrect meanings to fundamental scientific concepts because of their limited subject matter knowledge. This is particularly concerning in the context of early childhood education, where such misconceptions can have adverse effects on young learners. This finding underscores the importance of providing early childhood educators with opportunities for professional development programmes that expose them to content knowledge that surpasses the level they are expected to teach, as advocated by Hirsch et al. (2019). As emphasised by Ball et al. (2008), when teachers possess SCK, they are better equipped to respond to learners' questions with confidence and accuracy.

Limited knowledge of the procedural skills associated with floating and sinking

Another notable finding suggests that the participants had minimal familiarity with the science process skills associated with the concepts of floating and sinking. Only two of the participants, Potso and Kat, were able to mention a maximum of two process skills that they might employ in teaching the phenomena of floating and sinking. In contrast, Tsepo and Lefu were unable to mention any process skills. This discovery is particularly concerning because these concepts are included in the preschool curriculum, and it is expected that learners' scientific process skills should be nurtured. It aligns with the findings of Kazeni (2021), who reveals that preschool teachers often possess limited scientific knowledge and process skills. Stears et al. (2019) also highlight this knowledge gap among South African preschool teachers. Specialised content knowledge, explained by Ball et al. (2008), emphasises that proficient educators guide learners through processes to facilitate content comprehension. Contrary to this expectation, the study reveals that teachers have a limited grasp of science process skills. It is important to recognise that limited knowledge of science concepts could contribute to reduced learner motivation and poorer performance in science subjects.

Conclusion

The primary aim of this study was to explore knowledge of Grade R teachers concerning the concepts of floating and sinking through interview inquiries. It was uncovered that teachers possess a fragmented understanding of these concepts. While they have a basic knowledge of explaining these concepts, their capacity to elucidate why objects float or sink is somewhat limited. Moreover, their familiarity with the science process skills integral to these concepts is rather minimal. Consequently, this fragmented grasp of floating and sinking, combined with a paucity of expertise in science process skills, could potentially have detrimental effects on learners' scientific knowledge.

In light of the findings discussed earlier, this study underscores the importance of equipping preschool teachers with the curriculum concepts designed by educational developers for delivery to preschool learners. It is imperative to establish a harmonious alignment between the prescribed curriculum content intended for preschool learners and the content taught to preschool teachers during their college education. This alignment would ensure a seamless transition from teacher preparation to practical classroom implementation. Nonetheless, it is vital to underscore that the teachers' needs should not be assumed to be perfectly congruent with the learners' needs. Recognising this distinction is essential in crafting effective pedagogical strategies.

To enhance teachers' proficiency in this regard, it is strongly recommended to introduce in-service science content-oriented programmes aimed at bolstering their subject knowledge and pedagogical capabilities. Such programmes will contribute to a more robust foundation for early science education, ultimately benefitting both teachers and learners.

Furthermore, the findings highlight that Grade R teachers possess limited science process skills because three participants mentioned at least two whereas Yildiz and Yildiz (2021) signify at least six basic science process skills. This indicates a deficient grasp of the competencies necessary for effectively teaching concepts related to floating and sinking during the early years of education. This deficiency in knowledge could potentially lead to reduced motivation to teach science, as highlighted in the relevant literature reviewed within this study. Consequently, learners may establish a weak foundation in the realm of science, ultimately resulting in subpar performance in science-related subjects. Accordingly, there is an urgent call to enhance preschool teachers' comprehension of science concepts through comprehensive teacher education programmes. These initiatives aim to bolster their content knowledge and pedagogical skills, ultimately elevating the quality of science instruction at the preschool level.

It is important to recognise that while the results of this case study may not be broadly applicable to the larger population, they can provide valuable insights and contribute to the limited body of literature regarding the comprehension of fundamental scientific concepts such as floating and sinking within the realm of early childhood education. These insights are especially pertinent considering the potential repercussions for learners if these concepts are not adequately developed.

Acknowledgements

Competing interests

The authors have declared that no competing interest exists.

Authors' contributions

M.M.J.L. carried out a research study by organising, collecting, analysing and interpreting data as the principal investigator in her PhD research. J.L.C. and J.T. provided critical guidance in writing the research as well as providing technical guidance for all aspects of writing the article and reviewing and editing it. The final version of the manuscript was approved by all the authors.

Funding information

This study is derived from a PhD study that was supported by the South African National Roads Agency Limited (SANRAL) chair office at the University of the Free State.

Data availability

The data that support the findings of this study are available from the corresponding author, M.J.L.M., upon reasonable request.

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