

# Examining the role of Science Content Knowledge in early childhood classrooms: A scholarship of teaching and learning study of Grade R teachers

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## ABSTRACT

This study investigates the relationship between Grade R teachers' science content knowledge and their classroom practices within early childhood education contexts. This research explores how science content knowledge (CK) informs teaching practices among Grade R educators. Framed within the Scholarship of Teaching and Learning (SoTL) perspective, it responds to the gap in the literature on the influence of teachers' science content knowledge in early childhood science education. Shulman's Teacher Knowledge Framework and Ball et al.'s Content Knowledge for Teaching (CTK) form the theoretical framework of this study. The study adopted a mixed-methods sequential explanatory approach. The quantitative phase involved administering a structured CK survey to 100 Grade R teachers, followed by a qualitative phase with four purposively chosen participants. Qualitative data were collected through lesson plan reviews, classroom observations, and semi-structured interviews. In relation to science content knowledge, the findings revealed that teachers possessed expected levels of common content knowledge and sufficient horizon content knowledge, but showed limited specialised content knowledge. Although their CK levels were moderate, the study found little to no significant impact of science CK on classroom practices. This suggests that mediating factors, such as the quality of teacher training, curriculum demands, and contextual constraints, shape pedagogical decisions more strongly than content knowledge alone. The study recommends professional development programmes that strengthen specialised content knowledge while addressing contextual challenges. By linking CK, classroom practice, and SoTL inquiry, the study advances the discourse on early childhood teacher education and highlights the need for context-sensitive, evidence-based professional development.

**Keywords:** Content knowledge; Early childhood education; teacher knowledge; science education; SoLT

## INTRODUCTION

Early childhood education (ECE), particularly at the Grade R level (pre-primary), is widely acknowledged as foundational for children's lifelong learning trajectories. Yet in many low- and middle-income countries, the effectiveness of this stage is compromised by deficits in teacher

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preparation, science content knowledge, and pedagogical enactment.<sup>1</sup> Despite policy reforms that include free and universal primary education, challenges persist in delivering quality early learning, especially in science instruction, where teacher knowledge and practice remain underexplored. Teachers often lack adequate preparation from their initial training programs and express low confidence in planning and demonstrating science activities.<sup>2</sup> However, targeted professional development programs show promise for addressing these deficits. Content representations (CoRes) help teachers develop pedagogical content knowledge by making explicit connections between content, teaching, and learning, while building confidence in science instruction.<sup>3</sup>

Science education in early childhood plays an important role in enhancing curiosity, inquiry, and problem-solving skills that form the foundation for early learning. Early exposure to science enables children to develop critical thinking and reasoning abilities as they explore natural phenomena, engage in hands-on investigations, and construct meaning from everyday experiences.<sup>4</sup> Research highlights that young children are naturally predisposed to asking questions and seeking explanations, and science education capitalizes on this disposition to nurture cognitive and language development.<sup>5</sup> Furthermore, introducing science concepts at an early age promotes positive attitudes towards science, which can influence children's long-term interest and achievement in Science, Technology, Engineering, Arts, and Mathematics (STEAM) fields.<sup>6</sup> High-quality early science instruction also supports equity by providing opportunities for all children, regardless of background, to access meaningful learning experiences that link everyday knowledge to formal scientific understanding.<sup>7</sup>

Research has shown that when young learners engage with science concepts through play-based, inquiry-oriented methods, they develop stronger problem-solving abilities and are better prepared for later schooling.<sup>8</sup> However, despite policy emphasis on STEAM education, according to Alghamdi, early childhood classrooms often lack resources, and teachers frequently report limited confidence and content knowledge to effectively teach science. This situation highlights the critical importance of strengthening science education in early childhood as a lever for educational quality and equity in African contexts.

Moreover, there is a paucity of scholarship that integrates the Scholarship of Teaching and Learning (SoTL) framework into early childhood science education in Africa, despite its potential to foreground teachers' reflective practice and contextual challenges.<sup>9</sup> This gap suggests a need for research that not only examines teachers' science knowledge and practices but also adopts a SoTL-informed approach to generate insights directly applicable to classroom improvement in African early childhood settings. Thus, science education in the early years is not only foundational for academic success but also essential for developing informed, critical, and innovative citizens.

<sup>1</sup> Ayodele Ogegbo and Umesh Ramnarain, "Early Years Understanding and Implementation of Science Process Skills," *Education and New Developments*, 2020, 414.

<sup>2</sup> Michele Stears, Angela A James, and Saritha Beni, "Teaching Science in the Foundation Phase: Where Are the Gaps and How Are They Accounted For?," *South African Journal of Childhood Education* 9, no. 1 (2019): 1–9.

<sup>3</sup> Loyiso C. Jita and Maria Tsakeni, "Science Teachers' Perceptions of Their Knowledge Base for Teaching Force Concepts," *Journal of Baltic Science Education* 21, no. 4 (2022): 651–62.

<sup>4</sup> Karen McNerney et al., "Using a Scientific Enquiry Framework, Focusing on Questions, to Promote Enquiry Skills in Early Childhood," *Early Child Development and Care* 190, no. 1 (2020): 30–42.

<sup>5</sup> Zukiswa Nhase, Chinedu I O Okeke, and Christian S Ugwuanyi, "Using an Inquiry-Based Approach to Enhance Grade 3 Learners' Basic Science Concepts Development.," *Cypriot Journal of Educational Sciences* 16, no. 3 (2021): 1065–72.

<sup>6</sup> Ahlam A Alghamdi, "Exploring Early Childhood Teachers' Beliefs about STEAM Education in Saudi Arabia," *Early Childhood Education Journal* 51, no. 2 (2023): 247–56.

<sup>7</sup> Rebecca Kahmann, Mienke Droop, and Ard W. Lazonder, "Meta-Analysis of Professional Development Programs in Differentiated Instruction," *International Journal of Educational Research* 116 (2022): 102072, <https://doi.org/10.1016/j.ijer.2022.102072>.

<sup>8</sup> Cliona Murphy, Greg Smith, and Nicola Broderick, "A Starting Point: Provide Children Opportunities to Engage with Scientific Inquiry and Nature of Science," *Research in Science Education* 51, no. 6 (2021): 1759–93.

<sup>9</sup> Pat Hutchings, Mary Taylor Huber, and Anthony Ciccone, *The Scholarship of Teaching and Learning Reconsidered: Institutional Integration and Impact*, vol. 21 (John Wiley & Sons, 2011).

## THEORETICAL FRAMEWORK

The study draws on a multi-layered theoretical framework that brings together Shulman's Teacher Knowledge Framework,<sup>10</sup> the concept of Content Knowledge for Teaching (CTK),<sup>11</sup> and the Scholarship of Teaching and Learning (SoTL) perspective.<sup>12</sup> Combined, these frameworks offer a holistic basis for exploring how science content knowledge shapes teaching and learning within Grade R classrooms. Central to this framework is Pedagogical Content Knowledge (PCK), which bridges subject matter understanding with instructional strategies suited to learners' developmental levels.<sup>13</sup> For Grade R teachers, this perspective emphasises the need to not only know science concepts but also to translate them into meaningful, developmentally appropriate experiences that support young children's curiosity and conceptual growth. Extending Shulman's foundational work, Ball, Thames, and Phelps advanced the understanding of teacher knowledge through their CTK framework. Their model highlights that effective teaching requires more than a solid grasp of subject matter; it also demands specialised knowledge, such as presenting scientific ideas in ways accessible to young learners, and an awareness of how children think and where misconceptions may arise. This perspective directs attention to the concrete practices and reasoning strategies teachers use when introducing science in early years classrooms. In parallel, the SoTL framework contributes a reflective, evidence-based dimension. Hutchings, Huber, and Ciccone emphasise that SoTL promotes systematic inquiry into teaching and learning, positioning teachers as reflective practitioners who evaluate and refine their pedagogy. Within this study, the SoTL orientation informs the investigation of how Grade R teachers apply science content knowledge, make pedagogical choices, and reflect on their practice to support children's early engagement with science.

## LITERATURE REVIEW

### Conceptual foundations: teacher knowledge and early science

Shulman explains that teaching draws on several interconnected knowledge domains, such as subject matter knowledge, general pedagogy, curriculum, and pedagogical content knowledge (PCK), which involves reshaping disciplinary concepts for learner understanding. Expanding on this, Ball, Thames, and Phelps advanced the concept of teacher knowledge through the CTK framework, highlighting the significance of specialised content knowledge and teachers' understanding of content in relation to learners. Contemporary syntheses demonstrate that strengthening PCK/CTK in science is associated with improved instructional quality and, in many cases, learner outcomes, highlighting the salience of teacher knowledge for early science education. For illustration, Fukaya et al. examined the relationship between PCK and various teacher and student variables.<sup>14</sup> The study found that teachers' PCK was positively associated with their content knowledge and teacher efficacy. Additionally, PCK correlated with teaching quality and student achievement, highlighting its significance in effective science instruction.<sup>15</sup> Bayram-Jacobs et al. focused on science teachers' development of PCK during the enactment of socio-scientific curriculum materials. The research indicated that teachers' PCK for teaching socio-scientific issues was developed and strengthened through the use of specially designed curriculum materials, emphasising the importance of targeted professional development in enhancing teaching practices.<sup>16</sup> In addition, Fukaya et al examined an intervention study in mathematics and science education, which showed that teachers with stronger PCK tended to facilitate better learner achievement. This finding indicates that enhancing teachers' PCK has the potential to elevate both the quality of instruction and student performance.

<sup>10</sup> Lee Shulman, "Knowledge and Teaching: Foundations of the New Reform," *Harvard Educational Review* 57, no.1(1987):1–23.

<sup>11</sup> Deborah Loewenberg Ball, Mark Hoover Thames, and Geoffrey Phelps, "Content Knowledge for Teaching: What Makes It Special?" 2008.

<sup>12</sup> Ernest L Boyer, *Scholarship Reconsidered: Priorities of the Professoriate*. (ERIC, 1990).

<sup>13</sup> Erik Barendsen and Ineke Henze, "Relating Teacher PCK and Teacher Practice Using Classroom Observation," *Research in Science Education* 49, no. 5 (2019): 1141–75.

<sup>14</sup> Tatsushi Fukaya et al., "A Systematic Review and Meta-Analysis of Intervention Studies on Mathematics and Science Pedagogical Content Knowledge," in *Frontiers in Education*, vol. 9 (Frontiers Media SA, 2024), 1435758.

<sup>16</sup> Durdane Bayram-Jacobs et al., "Science Teachers' Pedagogical Content Knowledge Development during Enactment of Socioscientific Curriculum Materials," *Journal of Research in Science Teaching* 56, no. 9 (2019): 1207–33.

### Strengthening early science teaching

Global reviews of early childhood science education highlight three consistent levers: teachers' secure understanding of scientific concepts, facility with science process skills (e.g., inquiry, observation, prediction), and skillful use of representations and dialogue suited to young learners.<sup>17</sup> Several scholars have emphasised the importance of early childhood teachers possessing a secure conceptualisation of science concepts and proficiency in science skills processes to effectively facilitate student learning. For instance, Nhase, Okeke, and Ugwuanyi highlighted that teachers should model behaviours and skills, such as guiding students in investigations and helping them design and carry out experiments, to support content learning.<sup>18</sup> Likewise, Lintle et al. emphasise the importance of early childhood teachers choosing curricula that focus on science process skills and using classroom activities strategically to develop these skills, which are essential for effective student learning.<sup>19</sup> Additionally, Kun et al. add that engaging students with standard scientific explanations and helping them develop their own explanations of phenomena are central aspects of science education, which require early childhood teachers to have a deep understanding of scientific concepts.<sup>20</sup> It is a complementary strand that emphasises the SoTL, where teachers systematically examine their own practice, reflect on evidence, and disseminate insights as part of continuous professional development.

### Policy, practice and gap

South Africa's Curriculum and Assessment Policy Statement (CAPS) positions knowledge, skills, and values as grounded in local contexts while responding to global imperatives; in the Foundation Phase, science is largely embedded within Life Skills through exploration and play.<sup>21</sup> Empirical studies reveal uneven understandings of natural science in the Foundation Phase and uncertainty among teachers about how to enact inquiry-rich lessons, highlighting gaps in both content knowledge and PCK.<sup>22</sup> Moreover, teacher identity further suggests that strengthening teachers' science knowledge can enhance their science-teacher identity, leading to more authentic pedagogy.<sup>23</sup> These views seem to assert that system-wide reforms to strengthen early learning, including the extension of Grade R, should respond to the urgency of developing teachers' science capacity amid persistent resource constraints.

Recent case studies with Grade R teachers show fragile conceptual understanding of buoyancy and related phenomena, which limits teachers' ability to design explanations or scaffold inquiry.<sup>24</sup> In addition, Pakombwele and Tsakeni's research on science process skills in early childhood classrooms reveals uneven use of observing, classifying, predicting, and testing, recommending targeted professional development to strengthen teachers' science concepts and inquiry practices. Jita and Tsakeni's analysis of teacher preparation also points to misalignments between training and classroom demands, particularly in subject content knowledge and PCK.<sup>25</sup> Accordingly, Stears, James, and Beni

<sup>17</sup> Maraisane, Lintle, Loyiso Jita, and Thuthukile Jita. "Engagement of science process skills for teaching science concepts in early childhood." *Journal of Childhood, Education & Society* 5, no. 2 (2024).

<sup>18</sup> Nhase, Okeke, and Ugwuanyi, "Using an Inquiry-Based Approach to Enhance Grade 3 Learners' Basic Science Concepts Development."

<sup>19</sup> Lintle Maraisane, Loyiso Jita, and Thuthukile Jita, "Engagement of Science Process Skills for Teaching Science Concepts in Early Childhood," *Journal of Childhood, Education & Society* 5, no. 2 (2024).

<sup>20</sup> Zuhdan Kun Prasetyo, Ahmad Syawaludin, and Anatri Desstya, "Integration Indigenous Science in Merdeka Curriculum to Strengthen Scientific Literacy and Environmental Care in Elementary Schools: Need Analysis," *Edelweiss Applied Science and Technology* 8, no. 5 (2024): 1062–70.

<sup>21</sup> Department of Basic Education (DBE), *Curriculum and Assessment Policy Statement (CAPS): Life Skills Foundation Phase* (Pretoria: Department of Education, 2011).

<sup>22</sup> Marissa Rollnick and Elizabeth Mavhunga, "The Relationship of PCK Knowledge to Practice: A Case Study of Two Pre-Service Teachers Teaching Chemical Equilibrium," in *Conference of the Southern African Association for Research in Mathematics, Science and Technology Education, Port Elizabeth, South Africa*, 2014; Meganathan Moodley, *Science Teachers' Attendance of Professional Development Programmes and Their Use of Computer Software in Teaching* (University of Pretoria (South Africa), 2015).

<sup>23</sup> Umesh Ramnarain and Manzini Hlatswayo, "Teacher Beliefs and Attitudes about Inquiry-Based Learning in a Rural School District in South Africa," *South African Journal of Education* 38, no. 1 (2018): 1–10.

<sup>24</sup> Mamontsuo Lintle Maraisane, "The Influence of Lesotho Grade R Teachers' Science Content Knowledge on Their Classroom Practices" (University of the Free State, 2020).

<sup>25</sup> Maria Tsakeni and Loyiso Jita, "School Leadership Practices for Science and Mathematics in High-Stakes Testing Environments: An Integrated School Leadership Approach," *Perspectives in Education* 37, no. 2 (November 27, 2019): 98–109, <https://doi.org/10.18820/2519593X/pie.v37i2.7>.

strengthen that regional work on teachers' views of the nature of science shows that epistemic understandings shape classroom dialogue and task design, critical for early childhood science learning.<sup>26</sup>

Few studies follow Grade R teachers as their content knowledge develops into practice; foundational science topics in early childhood curricula remain under-examined; and locally grounded SoTL projects in early childhood education are scarce. This study addresses these gaps by examining how Grade R teachers' science content knowledge shapes and is shaped by practice through a SoTL-informed lens.

## **METHODOLOGY**

The context of this study is in Lesotho. It employed a mixed-methods sequential explanatory design, which allowed for the integration of quantitative and qualitative approaches to gain a comprehensive understanding of the role of science content knowledge in early childhood education, using the lens of a SoTL study of Grade R classrooms. The design was chosen to first establish broad patterns through a survey and then to explain and contextualise these findings through in-depth qualitative inquiry.

In the quantitative phase, a structured science CK survey was administered to 100 Grade R teachers. The survey consisted of items designed to assess teachers' common content knowledge (basic scientific facts and concepts), horizon content knowledge (awareness of how concepts connect across topics and grade levels), and specialised content knowledge (ability to represent, explain, and anticipate misconceptions). The sample was drawn from a range of schools to ensure diversity in teacher experience, training backgrounds, and teaching contexts. Data from this phase were analysed descriptively and inferentially to identify overall strengths and weaknesses in teachers' science CK.

The qualitative phase was conducted with a purposively selected sub-sample of four teachers, chosen on the basis of survey results to represent varying levels of content knowledge. Data collection involved lesson plan analyses, classroom observations, and semi-structured interviews. Lesson plans were examined for the inclusion and sequencing of science concepts, observations focused on instructional strategies and representations of science knowledge, and interviews explored teachers' reflections on their science teaching practices.

This two-phase design provided both breadth and depth: the survey highlighted patterns across a large sample, while the qualitative inquiry offered rich insights into how CK was enacted in practice, as well as the contextual factors mediating its use. Triangulation of these data enhanced the validity of findings and supported an interpretation of the role of science CK in early childhood classrooms.

## **Ethical Considerations**

This study adhered to established ethical standards for research involving human participants. Prior to data collection, ethical clearance was obtained from the university's ethics committee, ensuring compliance with institutional research protocols. In addition, permission was secured from the Lesotho Ministry of Education, followed by formal approval from the respective school principals. Participation was entirely voluntary. Participants were provided with detailed information about the aims, scope, and procedures of the study, and informed consent was obtained before their involvement. They were made aware of their right to withdraw at any stage and were assured that declining participation would not affect their professional standing in any way. To protect participants from potential harm, strict measures of confidentiality and anonymity were observed. Pseudonyms (Mrs Kat, Mrs Pinki, Mrs Neo and Mrs Thato) were used in reporting data, and any identifying details were removed from transcripts and classroom materials. Data were stored securely, accessible only to the researcher, and used solely for academic purposes.

## **PRESENTATION AND DISCUSSION OF FINDINGS**

The survey results revealed variations in Grade R teachers' science content knowledge (CK) across three domains: Common Content Knowledge (CCK), Specialised Content Knowledge (SCK), and

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<sup>26</sup> Stears, James, and Beni, "Teaching Science in the Foundation Phase: Where Are the Gaps and How Are They Accounted For?"

Horizon Content Knowledge (HCK). Figure 1 below shows Grade R teachers' science content knowledge.

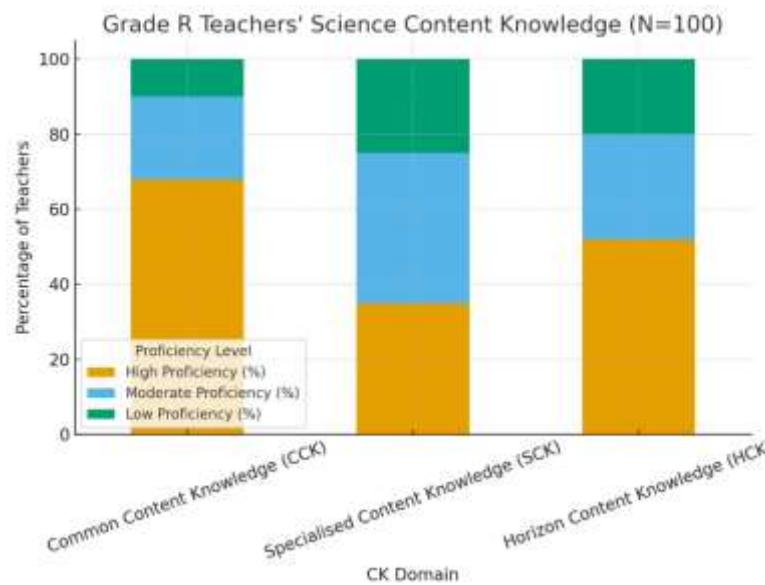


Figure 1: Grade R Teachers' Science Content Knowledge (N=100)

The results show that CCK was the strongest domain, with 68% of teachers demonstrating high proficiency, reflecting a solid grasp of basic science concepts. However, SCK was notably weaker, with only 35% of teachers achieving high proficiency. This indicates that while teachers could identify and state science facts, they struggled to explain underlying mechanisms or apply concepts beyond surface-level understanding. HCK showed moderate strength, with 52% achieving high proficiency, suggesting some ability to connect science concepts across topics and grade levels. The table below shows Spearman correlation coefficients between questionnaire domain averages.

Table 1: Spearman Correlation coefficients (p-value) and Interpretation among Knowledge Domains (N=100)

	r-value	p-value	Strength & Direction	Statistical Significance
CCK ↔ SCK	0.363	0.0002	Moderate positive correlation	Significant (p < 0.05)
CCK ↔ HCK	0.446	< 0.0001	Moderate positive correlation	Highly significant (p < 0.01)
SCK ↔ HCK	0.123	0.2228	Weak positive correlation	Not significant (p > 0.05)

\*Significant at p<0.05

The Spearman correlation analysis revealed significant positive associations among some dimensions of teachers' content knowledge. A moderate positive correlation was found between CCK and SCK ( $\rho = 0.36, p = 0.0002$ ), indicating that teachers with stronger general content knowledge also tend to possess higher levels of specialised knowledge. Similarly, CCK showed a moderate and statistically significant relationship with HCK ( $\rho = 0.45, p < 0.0001$ ), suggesting that teachers who demonstrate a broad understanding of content are also more capable of making conceptual connections across topics. In contrast, the relationship between SCK and HCK was weak and not statistically significant ( $\rho = 0.12, p = 0.22$ ), implying that these two knowledge domains function relatively independently within this sample. The findings align with prior research indicating that early childhood

teachers often possess fragmented science knowledge, particularly in SCK, which is crucial for addressing misconceptions and answering learners' deeper questions.<sup>27</sup>

Data collected from lesson plans analysis, classroom observations, and interviews were generated from the topic that was taught during data collection, which was on floating and sinking concepts. The following section presents and discusses findings from that qualitative section, in which three themes were generated.

### **Common Content Knowledge (CCK)**

The interview responses and classroom observations indicated that all participating teachers possessed adequate foundational knowledge of the basic science concepts related to floating and sinking. For example, when explaining why certain objects float or sink, most teachers correctly identified key factors such as material density and the concept of displacement. Mrs. Pinki, who had studied science more extensively in high school, demonstrated slightly stronger and more detailed foundational knowledge, which translated into clearer explanations during her lessons.

One example of the observed lessons that indicates knowledge of foundational skills is from Mrs. Thato's classroom. She had a class of twenty learners. Thato positioned herself on a small chair facing the children, who were arranged in a horseshoe pattern on the mat. To introduce the lesson, she began by reading a biblical story about Noah's ark. She then engaged the learners with questions around the words "water" and the idea of a boat "floating."

#### **Lesson segment 1**

**Teacher:** *In the story, we heard that the boat was able to float. Now, can you tell me what other objects you think might float on water? (She repeated the question.)*

**Learner 1:** *A bottle top.*

**Teacher:** *You believe a bottle top can float? (She turned to another learner.)*

**Learner 2:** *A stone.*

**Teacher:** *Does stone float?*

**All learners:** *No.*

**Teacher:** *Alright, think about this: when you are swimming, are you floating or sinking? (She repeated the question.)*

**Learner 3:** *You sink.*

**Teacher:** *You sink? And what happens when someone is drowning?*

**Learner 4:** *They are sinking.*

**Teacher:** *So, sinking as well? But remember, when you swim correctly, your body can float. Now, before we carry out the experiment, tell me, why do you think some objects float while others sink in water?*

In the above lesson segment, the teacher attempts to build on learners' prior knowledge by linking the story of Noah's ark to real-life examples of floating and sinking. Through questioning, she encourages learners to suggest objects that might float or sink, which shows an effort to stimulate prediction and reasoning. However, the responses indicate that learners are uncertain about the scientific concepts underlying buoyancy. For instance, one learner mentions a stone, which they all recognise cannot float, while another suggests that people sink, overlooking the conditions that allow the body to float when swimming. The teacher tries to clarify by distinguishing between sinking, drowning, and floating, but the discussion remains largely at the descriptive level rather than moving toward conceptual understanding. Importantly, the teacher ends by posing an open-ended question, "Why do you think some objects float, and others sink?" which signals a shift towards inquiry, setting the stage for the upcoming experiment that could help learners construct meaning through hands-on exploration. This aligns with the lesson plan analysis, which showed that teachers generally included

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<sup>27</sup> Kiray, S. Ahmet, Bilge Gok, and A. Selman Bozkir. "Identifying the factors affecting science and mathematics achievement using data mining methods." *Journal of Education in Science Environment and Health* 1, no. 1 (2015): 28-48.

sufficient information in their instructional materials, reinforcing the survey results that foundational content knowledge was sufficient across the participants.

### Specialised Content Knowledge (SCK)

Despite the solid foundation, significant gaps emerged in specialised content knowledge, especially when teachers were probed for deeper explanations. For instance, when asked why a pin sinks but a boat made from the same metal floats, three of the four teachers provided explanations that reflected common misconceptions. These included attributing floating purely to object shape, such as a triangular form, or external factors like someone “driving” the boat.

Mrs. Kat said that objects float because they are light, a view also shared by Mrs. Pinki, who remarked, “*Yes, apart from being light, I am not sure.*” In contrast, Mrs. Neo explained, “*It is because their density is less than water. Since it is not heavier than water, the object will not sink.*” Similarly, Mrs. Thato responded: “*I think the object floats because it is lighter than water.*” When asked to elaborate on her reference to density, Mrs. Neo added that the “*shape and materials of the object determine whether its density is greater or less than water.*” Noting her partial understanding, a scenario that involves two objects made of the same material (a metal spoon and a ship) was given to probe further why one sinks and the other floats. She still emphasised the material, despite the clarification that both were composed of the same substance. She later pointed out that the ship’s shape, “*with a triangular front and an oval-like underside, contributes to its ability to float.*” None of the four participants recognised that it is the volume of the ship, which reduces its density, that enables it to float. For example, Mrs. Kat candidly admitted, “*Let me answer for myself, I don’t really know... I think it is made of things like an engine and steering, and because someone is driving it, it won’t sink. But the spoon will sink because...*” (laughing).

The data illustrate a range of understandings and misconceptions among the participants regarding why objects float or sink. Three of the teachers (Mrs. Kat, Mrs. Pinki, and Mrs. Thato) explained floating in terms of an object’s “lightness,” reflecting a common everyday belief that weight alone determines whether something floats. This view is documented as a prevalent misconception among both learners and educators.<sup>28</sup> Such reasoning oversimplifies buoyancy and overlooks the relationship between mass, volume, and density that underpins the scientific explanation.

By contrast, Mrs. Neo provided a more advanced response by invoking the concept of density and acknowledging the influence of shape and material. While this demonstrates partial conceptual understanding, her reasoning remained incomplete. Faced with the example of a spoon and a ship, objects made of the same material but with different outcomes in water, she initially reverted to the material-based explanation before attributing the ship’s floating to its shape. This response suggests fragmented knowledge, where isolated scientific ideas (density, shape) coexist with misconceptions, a pattern observed in studies by Maraisane and Jita and Tsakeni about teacher knowledge in physical science concepts.<sup>29</sup>

Classroom observations corroborated these findings; during lessons, the participants struggled to articulate accurate scientific reasons beyond superficial attributes. Only Mrs. Neo, out of the four participants observed, provided an age-appropriate, observation-based explanation that connected learners’ experiences with scientific principles, demonstrating partial mastery of specialised content knowledge. This gap suggests a need for professional development focused on deepening teachers’ conceptual understanding and ability to convey nuanced scientific explanations.

### Horizon Content Knowledge (HCK)

Lesson plan analysis showed that teachers made efforts to connect scientific concepts to learners’ everyday lives by using familiar household items as examples to illustrate floating and sinking. However, these connections often remained on a surface level and were not systematically developed

<sup>28</sup> Zoupidis, Anastasios, Anna Spyrtou, Dimitrios Pnevmatikos, and Petros Kariotoglou. “Teaching and learning floating and sinking: Didactic transformation in a density-based approach.” *Fluids* 6, no. 4 (2021): 158.

<sup>29</sup> Maraisane, “The Influence of Lesotho Grade R Teachers’ Science Content Knowledge on Their Classroom Practices”; Jita and Tsakeni, “Science Teachers’ Perceptions of Their Knowledge Base for Teaching Force Concepts.”

to foster a broader conceptual understanding or to link across science topics. Classroom observations reflected a similar pattern, where teachers introduced relatable examples but did not consistently guide students to make connections between these observations and overarching scientific principles. Figure 2 below shows familiar objects that teachers used to embark on the floating and sinking experiment.



*Figure 2: Picture of Mrs. Thato's classroom experiment*

When interviewed, teachers expressed an awareness of the importance of contextualising science learning but lacked strategies to deepen these connections effectively. This indicates an opportunity to enhance horizon content knowledge through training that emphasises integrating real-world contexts with conceptual frameworks to enrich student learning. A finding corresponding to Prasetyo, Syawaludin, and Desstyia views on the importance of training to enhance teacher knowledge.

The combination of quantitative and qualitative findings highlights a fragmented profile of science CK among Grade R teachers. While most teachers had adequate CCK and some HCK, the limited SCK posed challenges in classroom practice. This gap suggests that teachers may unintentionally reinforce misconceptions, potentially hindering learners' conceptual development in early grades. Most importantly, the study found that content knowledge alone did not strongly predict teaching quality. Factors such as prior training, curriculum constraints, and classroom context influenced how teachers enacted science lessons. This supports the argument that teacher preparation should integrate both disciplinary depth and pedagogical strategies, equipping teachers not only to "know science" but also to teach it meaningfully at the foundation phase (SoTL).

## **RECOMMENDATIONS**

The findings of this study point to the need for strengthening Grade R teachers' science content knowledge in ways that directly inform classroom practice. Targeted professional development is essential, with workshops that combine theoretical understanding and practical strategies to make science accessible for young learners. Greater curriculum alignment is also recommended to ensure that the science content expected of teachers is age-appropriate and supported with adequate teaching aids. In addition, fostering collaborative professional learning spaces, such as teacher learning circles and mentorship programmes, can enhance both confidence and pedagogical competence in teaching science. Teacher education programmes should also embed pedagogical content knowledge explicitly to ensure that teachers are able to transform scientific concepts into meaningful early childhood learning experiences.

Beyond teacher practice, broader systemic support is necessary. Adequate provision of low-cost and contextually relevant resources will help teachers implement inquiry-based approaches even in resource-constrained settings. Policymakers should prioritise early childhood science education as a foundation for future STEM engagement, while recognising and incentivising teachers who demonstrate innovation in this area. Further research is also recommended, particularly longitudinal studies that examine the long-term impact of enhanced teacher knowledge on learner outcomes, as well

as explorations into the role of digital and play-based approaches in enriching science learning in Grade R classrooms.

## CONCLUSION

This study examined the role of science content knowledge in early childhood classrooms through a Scholarship of Teaching and Learning approach and Content Knowledge for Teaching, combining survey data from 100 Grade R teachers with in-depth insights from four selected participants. The findings reveal that while teachers recognise the importance of science in early childhood education, many experience challenges in translating their knowledge into effective classroom practice due to gaps in content knowledge, limited pedagogical strategies, and inadequate resources. These challenges underscore the complex relationship between what teachers know and how they teach, particularly in the foundational years of learning.

The study contributes to the growing body of research that emphasises the centrality of teacher knowledge in shaping learners' early experiences with science (SoLT). It highlights the need for deliberate professional development, stronger curricular alignment, and supportive policies that empower teachers to engage young learners in scientific exploration from an early age. By foregrounding the role of teacher knowledge, the study also opens avenues for further research into innovative pedagogical approaches, resource provision, and the long-term impact of science education in early childhood. Ultimately, enhancing teachers' science content knowledge is not only a professional imperative but also a critical investment in fostering curiosity, inquiry, and a strong foundation for lifelong learning in the sciences.

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