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Exploring Teacher Learning-Practice in a PBL Context for Sustainable School Development: A Case Study from South Africa

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Abstract. Previous studies have documented the gaps between teachers' beliefs and practices. To further explore learning among teachers, this paper conducts an exploratory study of teachers' beliefs, examining their self-reported practices of project-based learning (PBL) in South Africa. It employs Q methodology, with 40 K–12 teachers participating ranking their most chosen practices from a set of 34 Q statements. The Q analysis results demonstrate a strong consensus regarding the participants' self-reported practices, highlighting their use of constructivist approaches in the classroom. Due to the complex and situated environment in which teachers operate, there were several areas in which there was a consensus on less constructivist and more traditional approaches to teaching. This reveals the inherently complex, non-linear, and provisional nature of professional development. The results of the study indicate that, with supportive policies at the institutional level and ongoing professional development, teacher practices can change. There is a hope that more schools will join the efforts of implementing PBL in a systemic and systematic mode, which will allow future studies to be conducted in different contexts to expand the understanding of teachers' beliefs and teaching practices.

Keywords: complexity theory; project-based learning; Q methodology; South Africa; teaching learning-practice

1. Introduction

In line with broader trends toward the global improvement of education quality, the South African National Development Plan 2030 (National Planning

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Commission, 2012) and the United Nations Sustainable Development Goal Declaration (United Nations, 2016) represent efforts to accelerate teaching and learning development. South Africa, dating back to 1994, has worked to develop curriculum reforms aimed at addressing inequality and other social justice issues that had been neglected under the apartheid regime (Chisolm & Fuller, 1996; Jansen, 1998) as well as to focus on improving the quality of education. These reforms, although not uncontroversial, represented a strong break from the former apartheid system and sought to more effectively prepare learners for the 21st-century demands of both life and work (Russell & Cranston, 2012). The National Curriculum Statement was introduced in 2002 (Department of Basic Education, 2002), and Curriculum 2005 (C2005) and Outcomes Based Education (OBE) were also launched. OBE, which was borrowed from countries like Canada, New Zealand, Australia, and the United States, underpins the social values of democracy, peace, prosperity, non-sexism, and non-racialism (Gumede & Biyase, 2016). In 2012, the Curriculum Assessment Policy Statement (CAPS) was introduced with a revised NCS.

Public spending on education has moved from a situation of extreme inequality based on race under apartheid, to effectively targeting economically disadvantaged children. Despite this largely positive trend, a more resilient legacy belongs to the low quality of education among historically disadvantaged sections of the school system. This problem severely constrains the education system's ability to provide many children from poor backgrounds with the skills and competencies they need to find a pathway out of poverty (National Planning Commission, 2011). Seepe (2020) argues that what is needed is a disruption of the spaces of learning and teaching. Teacher education must produce teachers for the future, which will inevitably be dominated by changes brought about by disruptive technologies and as well as transformations in the world of work (Du & Chaaban, 2020; Gravett et al., 2022). Of course, educational South African educational reform would necessarily need to consider the role of teachers—to bolster their training and innovate on their practices (Davids & Waghid, 2020). South African teachers, both individually or collectively, play a critical role in implementing education reforms at the curriculum level, especially in terms of how they enact their teaching practices and assessments (Gumede & Biyase, 2016).

Teachers have long been regarded as powerful change agents since their beliefs, values, knowledge, skills, teaching practice, and methods of learning are key components of educational change (Chaaban et al., 2019; Imants & van der Wal, 2020; Nxasana et al., 2023). Despite teachers' well-recognised role as change agents, the question of how their learning should be meaningfully supported so that they can act as desired in practice has not yet been conclusively answered (Opfer & Pedder, 2011; Strom & Viesca, 2020). While the prevailing approach to teacher professional development has been criticized as too linear, relying on the assumption that teachers automatically learn from knowledge transmission, recent literature has encouraged alternative ways of conceptualizing teacher learning as a complex dynamic system in which teachers' practice is core to their professional learning (Cochran-Smith et al., 2014; Opfer & Pedder, 2011; Russ et al., 2016; Taylor & Diamond, 2020). Further, Strom and Viesca's (2020) notion

of "learning-practice" emphasizes that learning and practice are entangled, informing each other rather than being separate processes. Additionally, they assert that although there are seeds of a "complex turn" in learning among teachers—meaning a stark shift in the literature on teacher learning and practice through evolving sociocultural and socio-material perspectives (Cochran-Smith et al., 2014; Opfer & Pedder, 2011; Strom & Viesca, 2020)—far more empirical research is necessary before a robust foundation for a complex conceptualization of teacher learning may be laid.

Taking this conceptual standpoint, this study focuses on exploring teachers' self-reported practices. The research context is a South African K-12 school (KN) at which problem- and project-based learning (PBL) was adopted in the school curriculum from 2017 to 2023. PBL, a prominent student-centred approach, is a method of learning and teaching that engages students in the simultaneous acquisition of professional knowledge and development of essential skills and competencies that aid in work on complex, authentic, and open-ended problems and projects (Al Said et al., 2019). The notion of PBL has been defined in various different ways and applied at different levels (Du et al., 2019). In the context of this study, we define PBL as a systemic practice that is routinely used as the core learning method in curricula—a practice through which students engage in self-directed learning by working on problems collectively in teams (Al Said et al., 2019; Nxasana et al., 2023).To support the desired outcomes of PBL, the school has made efforts to organize diverse professional development (PD) activities to help teachers learn how to practice PBL. Nxasana et al. (2023) previously explored teachers' pedagogical beliefs and how these beliefs support the constructivist approach to pedagogy in a PBL school context. The results of the self-reported survey of teachers we conducted draw a predominantly positive picture of teachers holding constructivist, student-centered pedagogical beliefs. However, the study also revealed a dualism in the teachers' beliefs, in that they still held traditional pedagogical (teacher-centered) beliefs regarding their roles and duties as teachers.

Previous studies have documented how teachers navigate the gaps between teacher beliefs and practices as a challenge in their professional learning (Chaaban, Wang, & Du, 2021; Chubbuck, 2008). To further explore teachers' learning about constructivism and PBL, this study explores teachers' actual practices. While teacher learning-practice has been studied in multiple ways, including through observation, interviews and video analysis, this study adopts Q methodology (Watts & Stenner, 2012) to explore teachers' subjective views, individually and collectively, about their actual practices. Specifically, this study aims to answer the following research question: What are the teachers' views on their learning-practice in a PBL school context in South Africa? The objective of the study is to explore whether the teaches practice more student-centred teaching practices after participating in PBL professional development activities. Forty teachers drawn from the 86 participants of the previous study on teacher beliefs, across different subjects, teaching experiences, and K-12 stages, participated in this study.

2. Conceptual Framework – Conceptualizing Teacher Learning-Practice through a Complexity Theory Lens

The past few decades have seen the rise of challenges to teacher learning and development in the transition from pre-service preparation and in-service training to classroom practice (Ell et al., 2017; Strom & Viesca, 2020). Most teacher learning and professional development models assume linear input-output models in which professional learning and development leads to improved teaching practice, leading to improved pupil outcomes and sustainable school development (Taylor, 2023). The main reasons for the difficulty of these transitions are associated with the distance between pedagogical preparation and the contexts that teachers are situated in, with regard to diverse student backgrounds and learning preferences, classroom sizes, intended outcomes, and test formats, among other factors (Opfer & Pedder, 2011).

Although the complex characteristics of the relationship between teacher learning, practice, learning outcomes and school development have been recognized, the field of teacher learning has been criticized for its prevailing conceptual focus on a linear, reductionist, and process-product driven approach that assumes a linear relationship between what teachers learn and what they practice (Opfer & Pedder, 2011). This approach assumes that teachers automatically transfer what they have learned to their classrooms with high fidelity (Popova et al., 2021; Strom & Viesca, 2020). However, some studies (Chubbuck, 2008; Newman, 2010; Popova et al., 2021) have identified gaps between the beliefs and practices of early-career teachers. This may be related to the fact that enacting transformative practices has not been articulated as a goal of structured programs for teacher education (Cochran-Smith et al., 2014). Further, Ell et al. (2017) documented several studies that found that teachers taught certain practices did not necessarily transfer that style of learning to their classrooms and schools. In addition, scholars have exposed the contextual factors (for example, school policies and resources) that limit the connection between teachers' learning and their practice (Boylan & Turner, 2017).

The current study joins the scholarly call for a complexity-based approach to teacher education (Cochran-Smith et al., 2014; Garner & Kaplan, 2021; Strom & Viesca, 2020). This approach emphasizes the interdependence between what teachers learn across various contexts and what they eventually bring to their schools and classrooms. In particular, Morrison (2008) suggested that, rather than looking at the world from a linear, cause-and-effect perspective, complexity theory provides a lens through which change, adaptation and development can be understood, thus providing an "*organic, non-linear and holistic approach to examining a phenomenon"* (p. 22).

Based on a systematic review of relevant literature, Opfer and Pedder (2011) contributed to the study of teacher learning by introducing the notion of a complex teacher activity system and highlighting how teachers can use this nested learning activity system to learn by interacting with their surroundings, which are at the core of their learning. Such a complexity theory framework allows for an understanding of teacher learning that is based on their relationships and

potential pathways by connecting teacher orientation, their nested systems of relationships, and self-organization towards emergence through actions in practice; this theory may explain why teacher learning may or may not transfer into practice.

The non-linear and holistic positioning of this study also highlights teacher learning as a system of learning that is evolving at every level, offering opportunities to capture the simultaneity of influences on teacher learning (Phantharakphong & Liyanage, 2022). These influences cover the manifold factors behind the development of individual student teachers embedded across multiple complex and multi-layered contexts, including their economic, historical, political, and sociocultural contexts (Chaaban, Sawalhi, & Du, 2021). Thus, this perspective requires an explicit analysis of the conditions, system interactions, and underlying causal structures that exert significant influences on learning among student teachers (Russ et al., 2016).

Following Strom and Viesca (2020), in this study underlines the inseparability learning and practice, since they are "*intertwined processes that co-constitute, or co-make, each other*" (p. 210). In line with this, McMillan and Jess's (2021) proposal of a complex adaptive view of teachers' classroom practice regards their learning of classroom practices as self-organizing, interrelated, emergent, nested and transformational (p. 3). Accordingly, the concept of adaptive classroom practice refers a complex process that requires teachers to go beyond the linear approach that treats teaching as knowledge transmission and instead engage in the enactment of agency, enabling them to influence and respond to the dynamic and constantly evolving environment in which they work (Imants & van der Wal, 2020). This study recognizes that teacher learning is a 'complex process', which requires cognitive and emotional involvement as well as 'capacity and willingness' to explore beliefs about the practice and possible alternatives, in diverse educational policy environments or school cultures, some of which are more appropriate and conducive to learning than others (Taylor, 2023).

3. A Constructivist Approach to Teacher Learning-Practice

Constructivism as a theory of knowledge and learning has been the major influence in contemporary education with the emphasis on providing students with opportunities to develop skills and knowledge for future utility (Mathews, 2020). The theory has is associated with the work of prominent 20th century educators including Frank Hayward, John Dewey, Carl Rogers, Lev Vygotsky, Jean Piaget, Jerome Bruner, Paulo Freire, Maria Montessori, amongst other (Hoidn & Reusser, 2020). While there are many definitions, interpretations and variants of what constructivist theory means (Topolovčan, 2023), most agree that it involved a dramatic change in the focus of teaching, putting the students' at the centre of learning and teaching (Applefield et al., 2001).

One of the important roles of teachers is to mediate learning in a way that allows students to independently and actively construct knowledge, to not only discover but also to transform incoming information, to check new information against old information, and to revise previous rules when they no longer apply (Olusegun,

2015). PBL is amongst the pedagogical approaches which aligns with the principles of constructivism (Renninger, 2024). However, from a pedagogical and didactic point of view, PBL is not synonymous with complete constructivist learning and teaching (Topolovčan, 2023). The constructivist approach to learning can be traced back to the work of Piaget and Vygotsky (Brooks & Brooks, 1993; Chen & Rovegno, 2000; Cobb, 1994). Vygotsky's (1978) sociocultural perspective stresses that shared discourse and social interaction promote deeper understandings of new information. Vygotsky offers a manner of understanding learning that frames the knowledge creation's cognitive and social aspects as interactive, linking thinking to activity.

Despite some criticism by some scholars (Topolovčan, 2023), constructivism's assertion that learners, older and younger, actively construct their experiences and knowledge through their environment has been accepted by many scholars around the world (Applefied et al., 2001, Yin et al., 2020). According to constructivism, conceptions of knowledge among learners are generally derived from a meaning-making process through which learners construct individual interpretations of their experiences (Applefield et al., 2001). Constructivism is a perspective which views human learning as an active process, i.e., something done by, not on or to, the learner herself (Driver et al., 1994; Driver & Easley, 1978). The core commitment of a constructivist position is that knowledge is not transmitted directly from one knower to another, but is actively built up by the learner (Sjøberg, 2007). Constructivism emphasizes knowledge construction rather than knowledge transmission or the mere recording of information conveyed by others.

In line with sociocultural perspectives on learning, the constructivist approach stresses that learners actively construct their knowledge from their prior experience and through their environment (Yin et al., 2020). Through this emphasis on knowledge construction rather than information transmission, constructivism positions learners at the center of the design and organization of curriculum and classroom activities as well as at the center of the assessment of learning outcomes (Olusegun, 2015). Following a constructivist approach to teacher learning implies that teachers learn through individual and socially mediated discovery-oriented professional learning and development activities which include sharing, discussions, collaboration, peer teaching observations, mentorship, reflection, and communities of practice (Applefield et al., 2001; Ventista & Brown 2023; Yuvayapan, 2013). This social interaction enables the teacher to acquire skills and competencies which may be adopted in teaching practice in constructivist classrooms.

In constructivist classrooms, the core of learning lies in understanding and applying concepts, constructing meaning, and thinking about ideas (Gordon, 2009). For constructivist teaching practices to be successful, teachers must be able to interpret their students' actions and responses, assess their own interpretations of students' knowledge, and make adjustments if their students fail to grasp the learning materials. However, Gordon (2009) warns that constructivism must not be confused with the student-centred models that have emerged in recent

decades. The author points to the need for a balance between teacher-directed and student-directed learning in constructivist classrooms, requiring teachers to take an active role in the learning process, including through formal teaching. Teachers therefore play an important role in facilitating and mediating learning.

Increasingly, efforts to improve K–12 schools and teacher-education programs are being based on constructivist learning theories. Teachers in constructivist classrooms such as those following PBL, take their students' prior knowledge and interests into account when designing learning curricula and learning activities (Olusegun, 2015). Classroom activities are designed to be meaningful for students, and are interactive and collaborative among the students (Chen & Rovegno, 2000). The teachers engage in dialogue with students by questioning, explaining, and challenging them, and by offering them timely support and feedback (Applefield et al., 2001). Learning and teaching materials include primary source material and diverse materials from various secondary sources, rather than just textbooks and worksheets. As Olusegun (2015) suggests, assessment involves not only tests, but also students' work, observations, and points of view. In constructivist classrooms, teachers often practice constructive alignment by specifying outcomes – what they intend students to learn – in advance, and then aligning their teaching activities and assessment methods to match those intended learning outcomes (Biggs & Tang, 2011; Wickstrom, 2015).

Constructive alignment is based on three theoretical assumptions—constructivism, cognitive psychology, and phenomenographic pedagogy—the goal being to consciously design learning outcomes, teaching/learning activities, and assessments so that they are connected to one another (Wickstrom, 2015). When practising constructive alignment, teachers come up with ways for learners to build knowledge by designing curricula, learning activities, and assessments that foster learning (Romanowski et al., 2023).

The present study which takes place in an environment in which PBL is practiced, summarizes three key dimensions of teaching practice based on a literature review of teacher learning and practice in K-12 school. These key dimensions are curriculum design, classroom activities, and assessment. Although not presented in the same order, these three aspects are aligned with the principles of "backward" lesson planning, which emphasizes student understanding and the acquisition of skills and competencies (Barr & Tagg, 1995; Reynolds & Kearns, 2023; Wiggins & McTighe, 2005).The backward approach to designing and planning lessons involves identifying learning objectives, basing assessments on learning objectives, and basing assessment criteria on authentic learning activities (Herro, 2018). These three dimensions of teaching practice are also somewhat related to the constructive alignment approach proposed by Biggs (1999), which involves an approach to curriculum design and teaching practice that seeks to optimize learning by ensuring congruence between learning outcomes, teaching and learning activities, assessments, and feedback (Gallagher, 2017).

The first key dimension of teaching practice is curriculum design, which reflects teacher beliefs. Curriculum design encompasses various components such as

learning objectives, learning principles, teaching and learning approaches, learning tools, contents, learning activities, and learning outcomes (National Research Council, 2012; Penuel et al., 2004). Learning tools and materials are the various supportive tools, materials, equipment, and resources provided by teachers to students to help them achieve their learning goals (Department of Basic Education, 2002; El-Abd et al., 2021). In addition to traditional learning materials such as textbooks, digital tools and diverse learning materials such as videos, pictures and games are used to foster students' learning interests and improve their learning experiences (Lo & Hew, 2017). Moreover, to create a constructivist classroom, self-guided learning materials based on real contexts have been widely used in K-12 education. They have been identified as an effective way to improve student learning outcomes, including not only their understanding of professional knowledge but also their general skills in problem-solving, teamwork, and critical thinking (Torp & Sage, 1998). To achieve effective curriculum design and maximize the quality of student learning, teachers need to apply constructive alignment principles to align desired learning outcomes with learning activities (Biggs, 1996).

The second key dimension is teachers' classroom activities in teaching practice, which refers to the actions taken by teachers to create a supportive environment that fosters students' academic, social, and emotional learning (Oliver et al., 2011). This aspect of teaching practice comprises teachers' organizational procedures, instructional strategies, time and space management, and formulation of behavior management plans (Hirsch et al., 2019; McLeod et al., 2003). Effective classroom activities enable teachers to create positive classroom environments in which students acknowledge expectations, learning objectives, and appropriate behaviors (Chaaban,Al-Thani, & Du, 2021). Research shows that teachers managing their classrooms and introducing classroom activities based on constructivist principles—going beyond simply keeping students quiet and maintaining silence in the classroom—significantly influences students' cognitive and behavioral engagement (Berger et al., 2018).

The last key dimension is assessment, which is also an indispensable part of teaching practice and should be constructively aligned with teaching and learning design (Biggs, 1996). The significance of assessment lies not only in its use to evaluate student learning outcomes, but also as a way of providing feedback to improve the quality of learning and teaching, influence teacher beliefs, and optimize future teaching practices (Bennett & Gitomer, 2009). According to constructivist teaching practice, to improve student learning it is important to adopt multiple assessment methods by designing both formative and summative assessment methods, diverse assessment tools, and assessment methods that involve the students themselves (Birenbaum et al., 2006).

Based on these three key dimensions of teaching practice, the concourse for this study was developed by combining traditional and constructivist perspectives on teacher beliefs. The details are introduced in the next section.

3. Research Method

3.1 Research Context

The present study is grounded in complexity theory and explores how teachers enact their teaching practice in the environment at KN School, which has implemented PBL since 2017. This K–12 educational institution implements PBL at the curricular level and provides its teachers with in-service pedagogical training courses on PBL. In-school professional development mainly takes the form of teacher workshops, which are provided to all teachers throughout the year and are broken down by school grade, phase, and subject. The aim of PBL professional development is to introduce teachers who have recently joined the school to PBL and to train them in PBL learning objectives, outcomes, teaching practices, and means of assessment. These teachers are exposed to PBL learning and teaching strategies to bolster their skills and competencies in subject integration, classroom management, classroom activities, and assessment. Teachers who have recently joined the school are assigned mentors, dubbed "critical friends", who guide them through PBL teaching processes and practices. KN School also conducts ongoing professional development training in the form of workshops for all of its teachers.

To gain a structured understanding of teaching practices and to provide a theoretical basis for teaching practice, this study adapts the Teacher Belief Survey (TBS) to assess the teachers' practices in relation to constructivist and traditional approaches to teaching and learning (Woolley et al., 2004). This study considers the constructive alignment (CA) between curriculum design, classroom activities and assessments (Romanowski et al., 2023).

3.2 Ethics Approval

Data collection, analysis and protection followed international principles (with consent forms signed by respondents) and GDRP regulations. Sizwe E. Nxasana has been a PhD student at Aalborg University's Department of Planning and Development since 1st July 2022. He is conducting research within the fields of Teacher Learning through Project-Based Learning (PBL) in the South African context. Aalborg University's institutional authority on research ethics confirmed in a letter dated 02 February 2023 that Sizwe E. Nxasana is qualified to work with the data collected. All research conducted under the auspices of the Department of Planning and Development must comply with the Danish Code of Conduct for research, the European Code of Conduct for Research Integrity, and various other rules of ethical scientific practice. Throughout his enrolment at Aalborg University, Sizwe E. Nxasana has fully complied with the regulations mentioned above.

3.3 Q Methodology

To understand teachers' preferences with regard to certain teaching practices at KN School, this study adopts Q methodology as it enables researchers to investigate teachers' individual and collective viewpoints on the research topic (Watts & Stenner, 2012). Unlike other research methods and given the complexity of teacher learning and how they enact their teaching practice, Q methodology is

relevant in highlighting significant patterns, where and how they differ and what dominant and minority viewpoints exist, which offers a deep insight into the discourses of participants (Molenveld, 2020). Q methodology is pertinent in the study of opinions, groups, and other areas of social sciences (Ramlo, 2024).

Q methodology was invented by William Stephenson in 1953 and was originally intended for use in the field of social science and psychology research, but has recently gained more attention in educational research (Lundberg et al., 2020). As Ramlo (2022) explains, Q methodology is regarded as "*inherently a mixture of qualitative and quantitative data and analyses*" (p. 226) because it decreases the social desirability bias that often occurs in qualitative studies and also takes account of participants' subjectivity, which receives limited attention in quantitative studies (Fluckinger, 2014). Thus, Q methodology was selected as an appropriate method for collecting the views and perceptions of clusters of teachers on their teaching practice, and as a way to highlight consensus, contradictions, and disagreements among teachers in terms of their approaches to teaching practice. Following a standard Q methodological procedure (Watts & Stenner, 2012), the data-collection and -analysis processes included the following steps: concourse development and Q-set construction; P-set selection; Q-sorting and post-sorting activities; Q factor analysis; and Q factor interpretation.

3.3.1 *Concourse development and Q-set construction*

A concourse is a list of all conceivable statements related to the research topic, and a Q set is the set of statements ultimately used in the Q-survey (Watts & Stenner, 2012). The concourse development strategy used in this study began with an exploratory study of the participating teachers' beliefs (Nxasana et al., 2023), which provided an initial overview of teachers' constructivist and traditional beliefs at KN School. This was followed by a review of relevant literature on teacher learning and practice. Considering teacher learning-practice as a complex dynamic system, three crucial components were identified through the literature review, namely 1) curriculum and teaching design, 2) classroom activities, and 3) assessment. The initial concourse was developed according to this construct. In addition, a follow-up study focused on the teaching practices that were applied in term 3 of the 2022 academic year at KN School, while statements from the TBS, which was adopted to explore teacher beliefs in KN School in our prior study, were also used as inspiration for the development of the Q concourse.

Following three rounds of research group discussion and external expert review, 30 statements from an initial 34 statements with action verbs relevant to teaching practice were chosen as the final Q sort. This covered various aspects of teaching practice, including curriculum design for intended learning outcomes, learning activities, learning tools, learning materials, and assessment methods, from both traditional and constructivist perspectives. To test whether the statements were understandable and meaningful for participants, a pilot Q study was conducted among three schoolteachers to collect their feedback. This resulted in a few minor edits to the statements. The final Q set is presented in Table 1.

Table 1: The study's Q set

Aspect	Dimension: traditional (T) vs. constructivist (C)	Statement	Randomized number
Curriculum and teaching design	T	I made choices for students regarding what they need to know.	12
	T	I attached importance to students' memory of knowledge in my subject.	6
	T	I mainly relied on the National Curriculum Assessment Policy Statement (CAPS) guidelines in my classroom practice.	20
	C	I integrated the National Curriculum Assessment Policy Statement with the school's guidelines.	10
	C	I adopted students' ideas when designing teaching and learning activities.	24
	C	I designed learning activities related to students' prior experiences.	23
	C	I supported students' well-being in their studies.	13
	C	I provided diverse learning materials (e.g., reading materials, videos, pictures).	1
	C	I used diverse digital tools to support my teaching.	15
	T	I used prescribed textbooks as major sources for student learning activities.	17
	C	I involved topics for my subject(s) that follow students' interests.	19
	C	I addressed real-life issues in my classroom teaching activities.	8
Classroom activities	T	I kept my classroom under my control.	2
	T	I intervened in disputes in the classroom.	14
	T	I kept a fixed timetable within my class hours.	9
	C	I let the students participate in the development of classroom rules.	25
	T	I gave tangible rewards to students in class for a job well	21

		done.	
	C	I tried to stimulate students' intrinsic interest to learn.	30
	T	I gave lectures as a significant part of my teaching.	26
	C	I enhanced students' social responsibility through teaching and learning activities.	4
	C	I used student learning outcomes to improve my teaching practice.	28
	C	I engaged students in collaborative learning.	29
	C	I engaged my students in tasks aimed at promoting their independent learning skills.	7
	C	I allocated time for students to share their work.	5
Assessment	T	I relied on written tests as a primary assessment method.	22
	C	I involved students in assessing other students' work.	11
	C	I involved students in assessing their own work.	27
	C	I aligned assessments with my teaching practice.	16
	C	I involved parents in the process of assessing student learning.	18
	C	I communicated efficiently with parents regarding my students' academic progress.	3

3.3.2 *P-set*

In Q methodology, the term P-set refers to the set of participants, which commonly ranges in size from 25 to 50 participants (Lundberg et al., 2020). The present study was a follow-up study of a previous research conducted in the same school context using survey technique to explore teachers' pedagogy beliefs (N = 83). The school employs 99 teachers of which 83 participated in the first study (Nxasana et al., 2023). The teachers included primary and high school teachers. An open invitation was sent to all the 83 teachers from the first study by email with a description of the study and a proposed schedule for Q sorting. All invited participants had at least one year of teaching experience at KN School and had been exposed to professional development training on PBL for at least 12 months. Out of the 83 invited participants, 40 participants who responded first within the given timeline were invited and they voluntarily participated in the Q study on an anonymous basis. These participants included 16 primary school and 24 high school teachers. This, together with the diverse teaching experience, subjects taught and gender provided a heterogenous group of participants who are relevant to the research question (Damio, 2016).

Table 2 reports the participants' demographic information.

Table 2: Participant information

Variable		Number
Gender	Male	12
	Female	28
Subject taught	STEM	9
	Accounting and Business	4
	Geography	5
	English	11
	Social Science and Humanities	11
Years of teaching experience	< 5	7
	5–10	11
	11–15	8
	16–20	6
	> 20	8

3.3.3 *Q-sorting and post-sorting activities*

The Q-sorting and post-sorting activities were conducted by participants who were physically present in one room at the same time in each of the campuses, with the process taking 45 minutes. Participants were given an informed consent form to sign, which explained that the Q study was voluntary and clarified the research objectives, procedure, and confidentiality. The Q sorting chart was structured as a continuum ranging from -4 ("did the least") to +4 ("did the most") with reference to the participants' teaching practice. During the Q sorting process, participants were asked the following question: "Among the following teaching actions, what did you usually do in your teaching practice?" They were then asked to assign a hierarchical position to each statement ranging from -4 ("did the least") to +4 ("did the most") (Figure 1), applying their subjective views of their teaching practice. As part of the Q sorting process, instructions for sorting and ranking were provided to the participants.

In post-sorting activities, additional qualitative data about participants' decisions and their demographic information was collected through open-ended questions. Specifically, participants were asked to elaborate on why they chose the two most (+4) and least (-4) relevant statements in the Q sorting process. They were also asked whether they felt that any additional statements relevant to teaching practice should have been included, and whether they would like to address any aspects of their participation in the Q study.

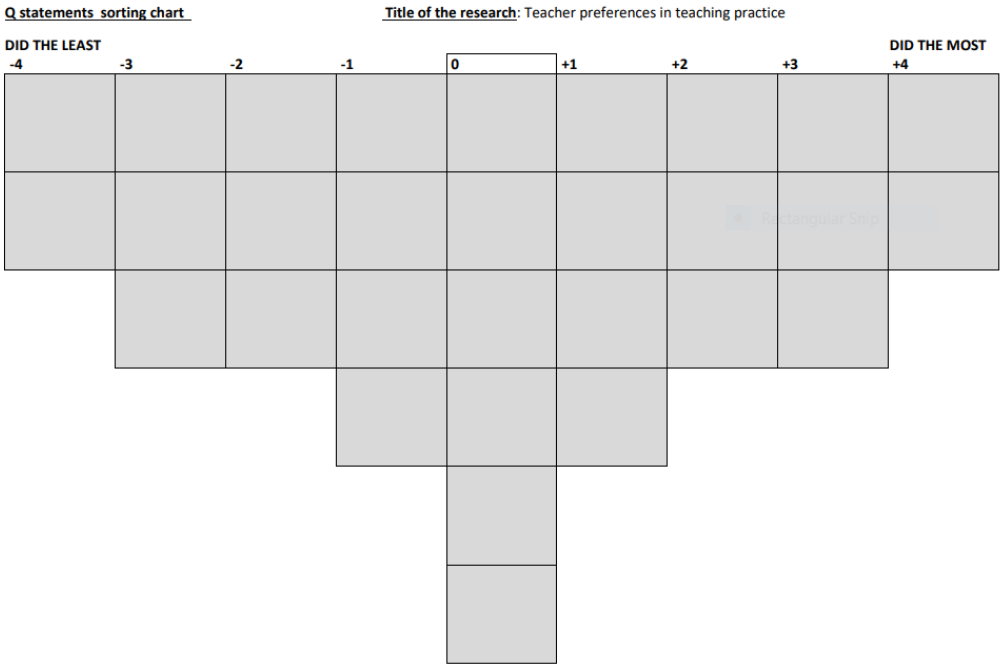

Figure 1: Q sorting chart

3.3.4 *Q-factor analysis*

A Q analysis tool, namely KADE, was used for the Q-sort correlations and inverted factor analysis. Raw data from the QMethod Software was imported into KADE (Banasick, 2019; Du & Lundberg 2021). Factor analysis, using centroid analysis and varimax rotation, was adopted to condense and analyze the data. The final factor solution indicated three factors.

The authors followed four principles during this process (Brown, 1996; Watts & Stenner, 2012): 1) eigenvalue > 1.00; 2) two or more participants who significantly loaded on one factor; 3) in each factor, the cross-product of the two highest loadings exceeded twice the standard error (1/ √No. of items); and 4) the theoretical significance and qualitative values of the results. Adopting a cut-off score of 0.456 (2.58* standard error, $p < 0.01$) (Brown, 1980, 1996) of the 40 valid respondents (Table 3) 25 significantly loaded onto one of the three factors. 12 participants loaded onto Factor 1, 10 participants loaded onto Factor 2, and 3 participants loaded onto Factor 3.

Table 3: Participants' loading results

Part. no.	Factor group	Factor 1	Factor 2	Factor 3
US37	F1-1	**0.6850**	0.0058	0.3155
US27	F1-2	**0.6778**	0.4416	0.2827
US16	F1-3	**0.6772**	0.3542	0.0402
US23	F1-4	**0.6761**	00464	0.4371
US1	F1-6	**0.6721**	-0.0043	0.1883
US21	F1-7	**0.6675**	0.1489	0.3079
US4	F1-8	**0.6194**	0.0834	0.2106
US20	F1-9	**0.5587**	0.1313	-0.2741
US18	F1-10	**0.5501**	0.3312	0.0154
US9	F1-11	**0.5427**	0.2962	0.1157
US22	F1-13	**0.5141**	0.2744	0.4338
US25	F1-14	**0.5125**	0.2580	0.2029
US26	F2-1	0.1651	**0.7060**	0.0411
US7	F2-2	0.3010	**0.6759**	0.1740
US33	F2-4	0.4170	**0.5742**	-0.0382
US17	F2-5	0.2444	**0.5510**	0.0274
US34	F2-6	0.1037	**0.5475**	-0.1751
US39	F2-7	0.1520	**0.5444**	-0.05
US5	F2-10	0.0166	**0.4911**	0.4383
US8	F2-11	0.3188	**0.4698**	0.4370
US31	F2-12	0.2816	**0.4590**	0.4509
US30	F2-13	-0.0447	**0.4573**	0.1337
US29	F3-1	0.4239	0.1131	**0.7582**
US12	F3-2	0.0579	0.1408	**0.6260**
US6	F3-3	0.1543	0.1684	**0.5133**
Compounded loaded participants				
US24	F1-5	0.6760	0.5144	0.1733
US28	F1-12	0.5197	0.4868	0.4036
US40	F2-3	0.5269	0.6135	0.0749
US15	F2-8	0.4857	0.5334	0.3783
US2	F2-9	0.4918	0.5212	0.1538
Insignificantly loaded participants				
US3	F1-15	0.4257	-0.0061	0.0386
US38	F1-16	0.4246	0.2092	0.0042
US35	F1-17	0.3914	-0.3716	0.3343
US10	F1-18	0.3003	0.1357	-0.058
US13	F2-14	-0.2478	0.2827	0.0668
US11	F2-15	0.0446	0.1866	0.1539
US32	F3-4	0.3869	0.0898	0.4441
US14	F3-5	-0.0705	-0.1133	0.4334
US36	F3-6	0.2841	0.1886	-0.4275
US19	F3-7	0.1575	0.0449	0.3885

3.3.5 *Q-factor interpretation*

Factor interpretation in Q methodology aims to provide a holistic overview of participants' collective viewpoints based on loading results, z-scores, and factor arrays, combining qualitative and quantitative characteristics (Brown, 1980). The factor array is based on the weighted mean score of each statement's ranking score, as determined by the participants loaded onto one factor; it indicates an "average" Q sort that represents the collective viewpoint of the participants in this group (Brown, 1980; Du & Lundberg, 2021, McKeown & Thomas, 2013). Examples are shown in Figures 2 to 4. KADE also mathematically identified distinguishing and consensus statements among the three factors. Highly qualitative and holistic factor interpretation in Q aims to suggest plausible, well-informed explanations for effects observed across the range of factor arrays (a weighted average of values per item within one factor). These factor arrays formed the basis of the abductive interpretation process, which usually begins with a within-factor interpretation supported by participants' demographic information (Du & Lundberg, 2021). The qualitative data from the participants' post-sorting written answers to open-ended questions were used as quotes to support the Q analysis results and explain the reasons for their sorting. The details are reported in the Results section.

4. Results

The following sections describe the consensus and differences among the three collective viewpoints (factors) emerging from the Q analysis, namely 1) addressing real-life issues with diverse learning materials; 2) implementing constructive alignment principles by connecting assessment and teaching design; and 3) supporting student learning with parental communication. The consensus among the three factors indicates that the participants used constructivist teaching practices with higher frequency than traditional teaching practices, which were practiced less frequently. The statements' numbers and the scores in the factor array of each factor are specified in brackets; for example, (#1/4) refers to statement 1 with a value of 4. Statements marked with D are distinguishing statements (p-value < 0.05), and D* indicates significantly distinguishing statements (p-value < 0.01).

4.1 Consensus

In the context of KN School, where PBL has been implemented as the main teaching and learning approach, in general the participants loading on the three factors highlighted student-centered learning. There was also a greater focus on constructivist learning than traditional teaching in their teaching practice. On the positive side, the participating teachers collectively reported that they mostly adopted teaching practices that aligned with a constructivist approach to curriculum and teaching design, including providing diverse learning materials (1/4, 3, 4), engaging students in collaborative learning (29/3.1.2), engaging students on tasks that enhance their independent learning skills (7/4,2,3) and using diverse digital tools (15/1, 2, 1) to enrich the student learning process. In line with these findings, they did not value the use of prescribed textbooks (17/-4, -3, -4) or using the lecture approach as a significant part of their teaching (26/-3, -3, -3). On the other hand, teachers loaded onto all three factors largely did not adopt constructivist approaches to assessment such as involving students in

assessing their own work (27/0, 0, -1) or asking them to assess others' work (11/-1, -1, -2). Further, they did not highlight the use of topics for their subject/s that aligned with their students' interests (19/-1, -1, -3).

4.1.1 *Factor 1: Prioritizing connecting real-life issues with diverse learning materials in the overall curriculum and teaching design*

Figure 2 illustrates the composite Q sort for Factor 1.

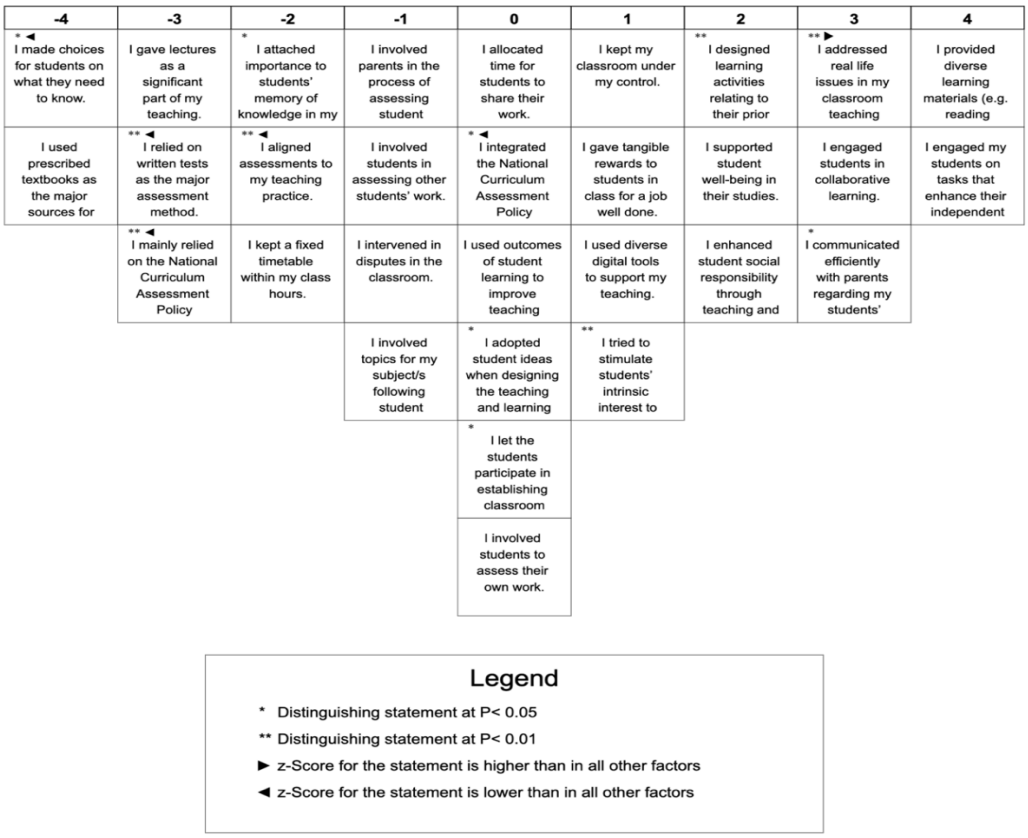

Figure 2: Composite Q sort for Factor 1

Twelve participants (seven females and five males) with between two and 23 years of teaching experience loaded onto Factor 1 (Figure 2). They taught a range of subjects: sciences, languages, and humanities in primary school and high school. While emphasizing student-centeredness in their classroom practice in general, the Factor 1 teachers emphasized addressing real-life issues in teaching design and classroom activities. By reporting a few conflicting practices and not emphasizing assessment, they were observed for struggling in between a power-balance in student-teacher control.

Specifically, with regard to teaching design these participants chose not to make choices for students about what they needed to know (12/-4D), nor to use prescribed textbooks as the major sources for student learning activities (17/-4), and not to attach importance to students' memory of subject knowledge (6/-2). Instead, they provided diverse learning materials (1/4) and digital tools (15/1),

and (particularly in comparison to other teachers), they emphasized real-life issues (8/3 D*) in teaching design. As Teacher F1-9 explained:

> "*I find that students learn better about things that they can relate to, including their surroundings, communities, and society. They learn better about their past experiences or the experiences of people they interact with on a daily basis. This stimulates their interest as we discuss solutions together. I understand that students have a voice; they are very inquisitive. Sometimes, they like their suggestions and opinions to be taken into consideration.*"

As explained by another teacher (F1-6), "*Our school has so much more advancement in technology. Therefore, it is easier to put information/activities/worksheets together for students without limiting them to prescribed textbooks.*" As written by another participant (F1-4), "*I believe that diverse learning materials are what set a PBL (project-based learning) school apart from every other school.*" Their classroom activities were also organized according to principles of student-centeredness and enhancing student engagement for both independent learning (7/4) and collaborative learning (29/3), instead of using lectures as a significant part of teaching (26/-3).

Taking a sustainable and holistic approach to maximizing student learning, they supported students' well-being during their studies (13/2), enhanced student social responsibility through teaching and learning activities (4/2), and communicated effectively with parents regarding their students' academic progression (3/3D). One participant (F1-11) stated,

> "*Students are as much functioning humans as I am. They need to be taken care of holistically as well as in a way that prepares them for the real-life situations and ideas they will come across outside of the classroom and school environment.*"

Nevertheless, these teachers struggled in their pursuit of a power balance between engaging their students and relinquishing too much control. For example, they were not sure about, or hesitated in, letting the students participate in establishing classroom rules (25/0) and in adopting student ideas in the teaching design (24/0). In contradiction to their classroom flexibility in terms of not keeping a fixed timetable within class hours (9/-2) and not intervening in classroom disputes (14/-1), they tried to keep the classroom under teacher control (2/1), and were hesitant to allocate time for students to share work (5/0).

Further contradictions were observed among these participants. While highlighting the involvement of students' prior experience (23/2 D*) and intrinsic interest (30/1 D*) in their daily classroom activities, they included fewer topics in their subjects that followed student interests (19/-1). Rather, they used extrinsic interest motivators by offering tangible rewards (21/1). Another contradiction was reflected in their assessment practice. Following the constructivist approach, they did not use written tests as the major assessment method (#22/-3, D*), but on the other hand, they did not emphasize the alignment between assessment and teaching practice (#16/-2, D*). Few reported involving students in self-assessment (27/0), peer assessment (11/-1), or involving parents in assessing student learning (18/-1). Such contradictions may be related to their reported dilemma regarding

differences in assessment policy between the national level and the school level, with the latter more explicitly emphasizing a constructivist approach. While they did not rely on the National Curriculum Assessment Policy Statement (CAPS) guidelines (#20/-3, D*), they were also hesitant about integrating CAPS with the school's guidelines (10/0 D).F1-11 said "*I do not know how to involve parents in the process of assessing students' learning*", while F1-13 commented that "*I trust my assessment skills and I adhere to the policies set out by the Department, and I am aware of the assessment tools at my disposal to help the students gain understanding of content.*"

4.1.2 *Factor 2: Prioritizing students' characteristics, including prior experience, interest, engagement, ideas, and outcomes, in their classroom practices*

Figure 3 illustrates the composite Q sort for Factor 2.

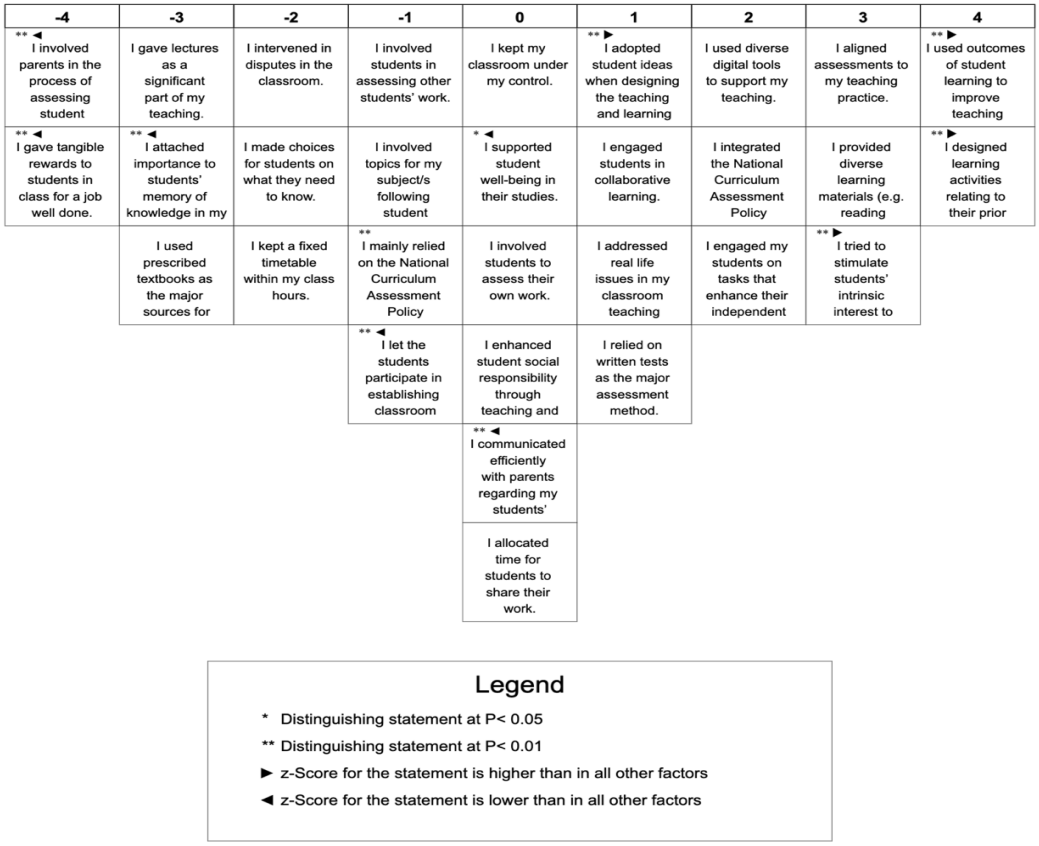

Figure 3: Composite Q sort for Factor 2

Ten participants (five females and five males) loaded onto Factor 2. These participants had between one and 34 years of teaching experience, with eight of the participants having taught for at least 10 years. Nine of the participants taught STEM subjects, and one taught history at high school level. Collectively, in their classroom practices these participants gave particular consideration to their students' characteristics, including their prior experience, interests, levels of engagement, ideas, and outcomes. Nevertheless, the participants reported struggling with conflicting assessment practices.

Specifically, as seen in Figure 3, Factor 2 teachers addressed students' previous experiences (#23/4, D*) and used student learning outcomes to improve their teaching (#28/4, D*). To elaborate on this, one participant (F2-4) wrote that: "*It is important to involve students taking into consideration their background knowledge since a child's mind is not an empty vessel.*"

By placing student-related aspects at the center of their practice, these participants reported that they made less use of lectures (#26/-3) and attached less importance to students' ability to memorize subject knowledge (#6/-3, D*). Rather, they emphasized engaging students in tasks that enhance their independent learning skills (7/2). To do so, they integrated student ideas into teaching design (#24/1, D*) and enhanced students' intrinsic interest in learning (#30/3, D*). Following these values, they seldom gave tangible rewards to students in the class for a job well done (#21/-4, D*). One participant explained the reason for this (F2-2): "*Tangible rewards have not been used in my lessons, but there is value in rewarding behavior and success.*"

Compared to the Factor 1 teachers, who scarcely addressed assessment practice, the Factor 2 teachers reported conflicting practices surrounding assessment. On the one hand, in contrast with the Factor 1 teachers, they emphasized aligning assessments to their teaching practice (#16/3), and integrating the National Curriculum Assessment Policy Statement (CAPS) with the school's guidelines (#10/2) instead of relying on CAPS alone (20/-1). Nevertheless, this emphasis on assessment seems to be mainly a component of a teacher-active/dominating approach, since they seldom involved parents in the process of assessing student learning (#18/-4, D*). Moreover, they did not involve students in peer assessment (11/-1) or self-assessment (27/0). Participant F2-6 explained, "*Normally I assess the results of the class assessment and I design my lesson according to what learners had challenges in.*"

4.1.3 *Factor 3: Emphasizing positive relations with students and parents but with a conflicting understanding of the constructivist approach to classroom practice.*

Figure 4 illustrates the composite Q sort for Factor 3. Three female participants who taught in primary school loaded onto Factor 3. While these Factor 3 teachers demonstrated their care for student well-being, and highlighted close communication with parents and positive relations with students, their understanding of the constructivist approach to classroom practice remained unclear and self-contradictory (Figure 4).

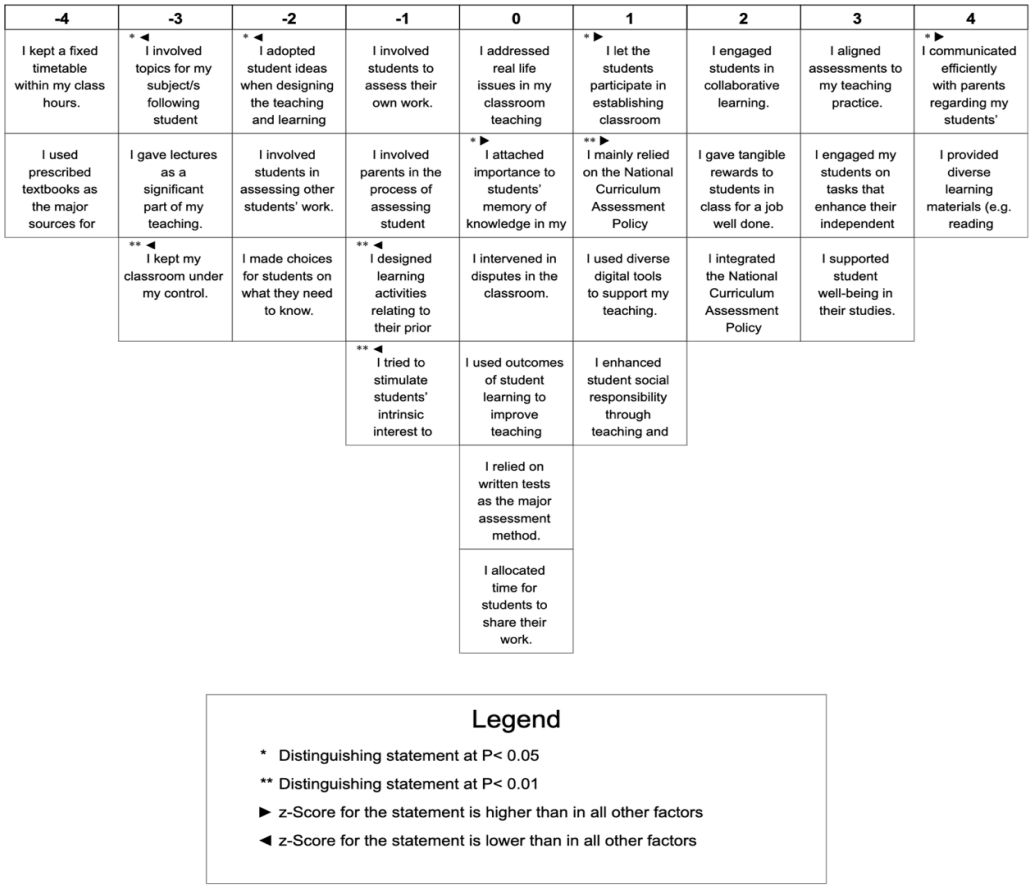

Figure 4: Composite Q sort for Factor 3

Specifically, the Factor 3 participants emphasized positive relationships with parents through efficient communication regarding students' academic progression (#3/4, D), good relationships with students through supporting their well-being (#13/3) and letting students participate in establishing classroom rules (25/1). This was captured by one participant (F3-2) who wrote, "*I generally believe that in order to keep a good relationship with a student, is to have an even amazing one with the parents, so effectively communicating with parents is one thing that kept the work going*."

Nevertheless, these teachers revealed conflicting attitudes to several other aspects. Regarding curriculum policies, they made efforts to integrate CAPS with the school's guidelines (10/2) while, in contrast to Factor 1 and 2 teachers, relying on the CAPS guidelines in their classroom practice (#20/1, D*). The resulting conflict led to further contradictory practices in assessment; while claiming to make efforts to align assessment to teaching practice (16/3), they did little to involve students in self-assessment (27/-1) or peer assessment (11/-2), or to involve parents in assessment (18/-1).

In terms of classroom activities, they underlined their efforts to engage students in independent learning (7/3), social responsibilities (4/1) and collaborative learning (29/2); however, in their teaching design they did little to involve students' prior experience (23/-1, D*), students' intrinsic interests (30/-1, D*),

students' ideas (24/-2, D), or topics which involved their students' interests (19/-3, D).

To maintain good relations with their students, they also used the strategy of giving rewards to students in class (21/2). Further, they emphasized flexibility as teachers by not to keeping the classroom under teacher control (2/-3 D*) and not following a fixed timetable during class hours (9/-4), as explained by one participant (F3-1): "*I believe that I should be flexible as a teacher. If my students need more time during a certain concept, I take my time with them, which affects the allocated time.*"

5. Discussion and Conclusion

To further explore teachers' views on their learning-practice towards sustainable school development, this study explored teachers' self-reported practice regarding constructivism approach to learning at KN School, where PBL has been implemented, after professional development training, and follows an exploratory study of their teacher beliefs (Nxasana et al., 2023). The Q methodology analysis identified a high level of consensus regarding the participants' self-reported practices, highlighting constructivist approaches in their classroom practices. The results reported a variety of teachers' struggles among the three significantly different groups of opinions, as quantitatively identified by the Q factor analysis. While Factor 1 struggled in between a power-balance in student-teacher control, Factor 2 struggled conflicting assessment practices between traditional and constructivist approaches, and Factor 3 showed their reported unclear and self-contradictory understanding of the constructivist approach to classroom practice. This is understandable given the fact that some teachers believe in and practice traditional approaches to learning and teaching (Nxasana et al., 2023).

There are also different interpretations of what constitutes constructivist and student-centred learning and teaching (Mathews, 2020, Topolovčan, 2023). Constructivist classrooms require teachers to consider how students are critically engaged and whether the learning outcomes are being achieved as student-centred learning and teaching is not generic (McKenna & Quinn, 2020). Given the complex and situated environment in which the teachers operated, there were a number of areas in which there was consensus on less constructivist and more traditional approaches to teaching. This reveals the complexity and the process of change through professional development, which is non-linear, holistic, and complex, involving individual, intrapersonal, and contextual components and emphasizing the connections between components (Boylan & Turner, 2017; Darling-Hammond, 2006; Morrison, 2008). This means that teachers' choices and emphases may vary according to diverse individual characteristics in relation to their beliefs (Chaaban et al., 2019; Du & Chaaban, 2020; Mihaela & Alina-Oana, 2015; Strom & Viesca, 2020), how they learn (Chaaban et al., 2023) or differences in the conditions in which they work, for example, in their students' characteristics (Barkatsas & Malone, 2005; McKenna & Quinn, 2020; Opfer & Pedder, 2011; Strom & Viesca, 2020).

In addition to the consensus, the Q factor analysis in this study also identified three factors, revealing three distinctive collective views among the participants with regard to their teaching practices. Factor 1 participants emphasized student-centeredness and reported that they mostly used diverse learning practices and teaching materials, and addressed real-life issues in their teaching design and classroom activities. These participants' practices reflected their beliefs about the principles of constructivism and PBL in relation to their choice of materials (Chen & Rovegno, 2000; Olusegun, 2015). However, they struggled in their pursuit of a power balance between engaging students and giving them too much control. They also did not emphasize constructive alignment between learning outcomes, teaching activities and assessments (Biggs & Tang, 2011; Wickstrom, 2015).

Factor 2 participants gave particular consideration to students' characteristics, including their prior experience, interests, engagement, ideas, and learning outcomes, in their classroom practices. These participants also reflected constructivist approaches to knowledge construction from prior experience (Applefield et al., 2001; Yin et al., 2020). Nevertheless, the participants also reported struggling with conflicting assessment practices. While they emphasized aligning assessments with their teaching practice and integrating the National Curriculum Assessment Policy Statement (CAPS) with the school's guidelines, this emphasis on assessment seems to have mainly been part of a teacher-active/dominating approach, since they seldom involved parents in the process of assessing student learning, or involved students in peer assessment and self-assessment.

While the first two factors included teachers with diverse demographic backgrounds in terms of their teaching experience and gender, the Factor 3 participants were mainly newly-employed teachers in the given schools. They collectively reported making efforts to enhance parental communication and student well-being, reflecting their care for students (Souto-Manning & Swick, 2006). These participants' understanding and practice of the constructivist approach to classroom practice remained unclear and self-contradictory. They underlined their efforts to engage students in independent learning, social responsibilities and collaborative learning. However, in their teaching design they did little to involve students' prior experience, intrinsic interests or ideas. This diversity in their practice reflects the complex nature of the reality of teaching practice (Garner & Kaplan, 2021; Johnson, 2009; Opfer & Pedder, 2011; Phantharakphong & Liyanage, 2022; Yuan et al., 2018).

Based on complexity theory, which enables researchers to consider diverse voices and not to marginalize or dispense with that which appears trivial or inexplicable (Du et al., 2021; Opfer & Pedder, 2011; Strom & Viesca, 2020), the results of this study illustrate the diversity and complexity of teachers' actual practices based on their constructivist and traditional teaching beliefs. Following complexity theory as applied to teachers' constant negotiation with the conditions in their environment when making choices and decisions about their actual practices (Mason, 2008; Morrison, 2008), the teachers in this study also reported a dilemma: They aimed to follow the curriculum while also adopting the PBL principles

applied in the given school context, which to a certain degree does not follow all aspects of the national curriculum standard. This also indicates that teachers' engagement in agentic practices should be supported by clearly defined policies to ensure that they feel safe (Du et al., 2022; Molla & Nolan, 2020).

6. Study Implications

The study has a few practical implications. First, it indicates that with top-down implementation of PBL, supportive policies at the institutional level, and ongoing professional development, teacher beliefs can change (Al Said et al., 2019; Chaaban et al., 2019; Du et al., 2019). This change in beliefs can impact the change from traditional teaching to constructivist learning. The results support the view that teacher learning takes place within a dynamic, complex system, where individual, intrapersonal, and contextual components are all involved in achieving the common goal of educational changes; this process takes time and is not "one size fits all" (Chaaban, Sawalhi, & Du, 2021; Chaaban et al., 2023; Du et al., 2021; Du & Lundberg, 2021; Sabah & Du, 2018). To promote beliefs into practice, it is essential to provide institutional support and sustained professional development training to create an environment of shared values and a community of practice.

Second, this finding, to a satisfactory degree, provides evidence that the outcome of providing professional development activities is to support teachers' readiness to put PBL into practice (Chabaan et al., 2023; Du et al., 2022; Du & Lundberg, 2021; Molla & Nolan, 2020). In the given context, all teachers were provided a series of professional development activities during their first year of working in this school in order to learn about the PBL principles (Darling-Hammond, 2006; Strom & Viesca, 2020), PBL-related curriculum mapping (Opfer & Pedder, 2011; van Schalkwyk et al., 2015), and teaching practices reflecting constructive alignment (Biggs & Tang, 2011). The findings on teachers' shared practices in this study suggest that such professional development activities are effective. While previous literature has shared concerns about the gaps between teachers' self-reported pedagogical beliefs and their actual practices (Chabaan et al., 2023; Darling-Hammond, 2006; Garner & Kaplan, 2021; Morrison, 2008; Opfer & Pedder, 2011), this study provides evidence of an alignment between teachers' practices and their beliefs following their self-reflection on beliefs, as revealed in our previous study (Nxasana et al., 2023). In particular, the outcome of the study suggests that meaningful professional development activities addressing the targeted goals (constructivism and PBL in this context) are key to supporting a connection between teachers' beliefs and practices (Chabaan et al., 2023; Du et al., 2022).

Third, working in an environment in which PBL has been practiced at the curricular and systemic levels may also be seen as contributing to teachers' engagement with practice, which helps support shifts in their mindset (Chabaan et al., 2023; Hoy et al., 2009; Sabah & Du, 2018).

In addition, the outcomes of this study offer a few recommendations for future ways to support meaningful teacher practices and ensure that they are aligned

with teachers' pedagogical beliefs, with the goal of supporting a constructivist approach to learning and teaching such as PBL. Firstly, it is important to connect teachers' beliefs and practices, and this becomes feasible when they are in an environment that emphasizes constructive alignment. In particular, alignment of school policy, the teacher evaluation system, teacher development methods and anticipated teacher practices may support long-term meaningful development of teachers' beliefs (Garner & Kaplan, 2021; Johnson, 2009; Morrison, 2008; Opfer & Pedder, 2011; Yuan et al., 2018). Secondly, teachers' professional development should be organized using a system-thinking approach which connects all the aforementioned aspects, and thus addresses teachers' individual professional agency (Du et al., 2021; Du & Lundberg, 2021; Garner & Kaplan, 2021; Imants & van der Wal, 2020; Molla & Nolan, 2020). Thirdly, better practices are needed to support early career teachers or teachers who are new to the PBL environment in order to support the development of their beliefs and practices in a meaningful way, for example by using strategies like mentorship and peer learning to support structured professional development (Chaaban, Sawalhi, & Du, 2021; Chaaban, Wang, & Du, 2021; El-Abd et al., 2021; Taylor & Diamond, 2020). Fourthly, it is important for professional development to support teachers in gaining a better understanding of their students and their learning needs in order to promote more constructivist classrooms (McKenna & Quinn, 2020). Curriculum, classroom activities and assessments must be designed in ways that ensure students are provided with the skills to make informed choices and to develop as independent lifelong learners (McKenna & Quinn, 2020). In addition, it is suggested that while ongoing initiatives require teachers to implement alternative teaching methods, such as PBL, it should also be highlighted that it can be empowering for teachers to experience the targeted change outcomes. For example, they can engage in PBL through professional development activities that adopt this method (Chabaan et al., 2023; Du et al., 2022; Du & Lundberg, 2021).

7. Study Limitations and Future Perspectives

This study has some limitations that potentially indicate a need for further investigation. First, the study focuses on exploring teachers' self-reported practices. While Q methodology provides a less sensitive approach, there may be potential gaps between teachers' self-perceived practices and how teacher practice can be perceived and experienced by others, such as peer teachers and students. Future studies may benefit from using multiple data sources to link self-reported teaching practices to the perspectives of other actors in order to build a better school ecosystem. Second, the Q methodology inherently creates factors that generalize the attitudes of similarly minded people to the research question. While statistical generalizability is not an aim of the Q methodology, future research with other teacher groups should investigate the relevant topics further. Third, teachers' beliefs and practices are not stable, which can introduce challenges and therefore change their reactions to changes in other elements in the complex system of the school environment, for example changes to the teacher evaluation policy or national curriculum standard. To address teachers' long-term professional learning, it would be useful to conduct longitudinal studies. Fourth, despite including participants with various levels of teaching experience who taught different subjects and grades, the outcomes are limited to the specific

context of KN School. The selection of participants teaching in only one school limits the transferability of the findings, especially given the institutional context and the top-down implementation of PBL at the school. There is a hope that more schools will join the efforts of implementing PBL in a systemic and systematic mode, which will allow future studies to be conducted in different contexts to expand the understanding of teachers' beliefs and teaching practices. Fifth, constructivism learning and teaching has many definitions, interpretations and variants (Topolovčan, 2023), leading to inconsistencies in its application by different teachers in their curriculum, classroom activities and assessment design. Sixth, teachers' understanding of their student learning needs also varies which makes the implementation of student-centred learning and teaching approaches complex.

Finally, among the 40 participants in this study, only 23 loaded significantly onto the three factors, and the opinions and responses of the remaining 17 participants were not taken on board, even though they also deserve attention; this is identified as a limitation of the Q methodology. Future research may explore teachers' individual opinions by adopting alternative methods such as interviews and longitudinal studies to gain deeper insights into participants' teaching beliefs and how they enact those beliefs in their practice.

8. Author Contributions

Conceptualization, Du, X. and Nxasana, S.E.; Methodology, Nxasana, S.E., and Du, X.; Validation, Nxasana, S.E. and Du, X: Formal Analysis, Nxasana, S.E. and Du, X.; Writing—Original Draft Preparation, Nxasana, S.E.; Writing—Review and Editing, Brogaard Bertel, L. and Du, X.; Supervision and Project Administration, Du, X. and Brogaard Bertel, L.

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11. Disclosure Statement

The authors report that there are no competing interests to declare.

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