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Context-Based Teaching in Mathematics Education: Theoretical Foundations and Teaching Models

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Abstract

The main objective of this paper is to discuss the theoretical foundation of Context-Based Teaching (CBT) models. It reviews the philosophical assumptions: cognitive constructivism, social constructivism and realistic mathematics education (RME) and established teaching models: DILA (display, inquiry, learning community, and authentic assessment) model, the 5E instructional model, the CTCA (culturo-techno contextual) model, and the REACT (relating, experiencing, applying, cooperating, and transforming). Through the comprehensive review, it is found that these foundational pedagogical theories and instructional models related to the CBT approach enhance students' motivation, engagement, and conceptual understanding. Among them, the REACT model is effective for contextualizing mathematics teaching in real-life situations. Therefore, this review provides an insight into adopting the REACT model for CBT-based interventions and curriculum reform in diverse settings of mathematics education.

Keywords: Cognitive constructivism, social constructivism, REACT model, mathematics education

Introduction

Mathematics learning is ingrained within the context of society, students' motivation and learning environment that award opportunities for students' engagement. Learning effectiveness increases when students connect mathematical concepts to their familiar real-life experiences and contexts (Saputra et al., 2022). In the same way, teachers can teach Mathematics meaningfully when it is linked to real-life experiences and real-world situations, promoting active student engagement in the mathematics classroom (Williams, 2007). This teaching-learning phenomenon is regarded as a context-based learning strategy. Contextualizing mathematics teaching and learning approaches in the classroom promotes students' participation in learning activities, making concepts more memorable, understandable, and applicable to everyday life (Frimpong et al., 2023). As a result, this fosters positive attitudes toward mathematics among students, along with a sense of ownership of their learning and improved achievement.

Context-based teaching (CBT) integrates inquiry learning, project-based learning, problem-based learning, cooperative learning, and authentic assessment (Glynn & Winter, 2004). The essential activities of it are making valuable connections, performing significant activities, engaging in self-regulated learning, working in groups, thinking critically, and fostering creativity. Additionally, maintaining students' personalities and learners' success requires the support of adults. Achieving high standards and using authentic judgment are the main components of CBT approach. Similarly, the primary principles of CBT approach include developing self-regulated learners, anchoring teaching and learning in students' life contexts, teaching and learning in multiple contexts, using problem-based learning, utilizing independent groups, and assessing students' progress through authentic assessment (Sears, 2002). CBT approach, based on students' needs and experience (Satriani et al., 2012), connects the content of the material to the context of daily life of the students (Selvianiresa & Prabawanto, 2017) in order to relate subject matter content to real-world situations. This approach has seven components: constructivism, inquiry, asking, learning communities, modeling, reflection, and actual assessment (Solissa et al., 2023). The discovery of meaning is a central characteristic of CBT (Johnson, 2002). CBT improves students' conceptual understanding (Kristidhika et al., 2020), develops their mathematical connection ability (Ikhsan & Subianto, 2018), increases students' engagement in mathematics (Mentari & Syarifuddin, 2020), and motivates and positively perceives mathematics.

The teaching learning issues related to mathematics learning are inseparable from problems in real life (Afni, 2020). Connections and problem solving are crucial issues in mathematics learning (National Council of Teachers of Mathematics [NCTM], 2000). Students can connect mathematical concepts with real-world situations in CBT approach (Williams, 2007). It is a newly established teaching model in which students' learning process is based on their real-world situations (Merawan & Duskri, 2021). CBT approach intervention in mathematics classroom teaching to develop critical thinking, problem solving, and collaboration skills (Yunitasari et al., 2023), and also create a meaningful learning environment wherein the teaching learning process of mathematics may be designed with students' context and learning materials related to their daily life activities (Reyes et al., 2019).

CBT approach has been applicable in different aspects of mathematics learning. Various studies have shown that CBT in mathematics learning improve students mathematical literacy (Afni, 2020), reduce anxiety of students towards mathematics (Yunitasari et al., 2023), enhance learning efficiency (Pinwanna, 2015), develop positive attitudes towards mathematics (Adamu, 2020), develop self-regulated learning (Merawan & Duskri, 2021), improve on ability to understand mathematical concepts (Dianartasi & Sthephani, 2021), increase mathematical critical thinking ability (Kurniati et al., 2015), develop creativity and critical thinking in leaning mathematics (Khadka, 2021), positive perceive with statistics promote in higher order thinking skills (Raub et al., 2015), improve problem solving skills (Eshetu & Assefa, 2018). CBT approach, based on the REACT model, is mostly useful in mathematics education (Crawford, 2001). It is a recent innovative constructivist teaching approach that aims to enhance meaningful mathematics learning through contextualization and localization of mathematics content to its context with real-life activities, experiences, and scenarios.

It shows that Context-Based Teaching (CBT) improves mathematical understanding, engagement, problem-solving skills, and higher-order thinking skills. However, a gap remains in discussing the theoretical foundations related to CBT. In this context, this study aims to discuss the theoretical foundations such as constructivism and realistic mathematics education that underpin the CBT approach in mathematics education. Besides, it also examines major instructional models such as REACT, DILA, 5E, and CTCA, and their relevance in applying CBT in mathematics classrooms.

Research Methodology

This paper used a qualitative approach as a theoretical literature review to discuss the different theoretical perspectives (Snyder, 2019). Particularly, the review focused on theories such as cognitive constructivism, social constructivism, and realistic mathematics education (RME). Furthermore, the paper examined different context-based teaching models, including the DILA model, the 5E instructional model, the CTCA model, and the REACT model, related to the context-based teaching approach in mathematics education. Moreover, it critically examines, organizes, and interprets these key theoretical foundations for CBT coherently (Torraco 2005).

Results and Discussion

This section examines two theories: Constructivism (Cognitive and Social) and Realistic Mathematics Education (RME) and teaching models based on the CBT. This theoretical review supports for adopting a suitable teaching module and guidelines for implementing the CBT approach in mathematics education.

Constructivism

Constructivism suggests that knowledge is constructed by learners' experiences and interactive environments (Alanazi, 2016) and advocates a participatory approach, particularly through students' active engagement in the learning process (Fernando & Marikar, 2017; Major & Mangope, 2012). Learners create knowledge through interaction with prerequisite knowledge and new contextual knowledge. Moreover, constructivism advocates interactive teaching practices rather than rote memorization and repetitive lecturing (Null, 2004). In interactive learning learners interact with their surrounding environment and social context (Fosnot, 2013). Moreover, the constructivist theory emphasizes contextualized teaching (Johnson, 2002), and mathematics teaching and learning activities are connected to students' daily life activities and their real-world experiences in the CBT approach (Bhure et al., 2021; Hakim et al., 2020). In this context, cognitive and social constructivism is further explained, connecting them with CBT.

Cognitive Constructivism

The cognitive development theory focuses on individual learning through cognitive development. It is compressed into four development stages: sensorimotor, concrete operational, preoperational, and formal operational, and four key concepts: schemas, assimilation, accommodation, and equilibration (Piaget, 1976). The assimilation concept relates to preexisting knowledge of learners with cognitive structures, and the accommodation stage plays a mediator role between the contradiction of new information and pre-existing cognitive structures (Piaget, 1983). Powell and Kalina (2009) argue that "students' schemes are constructed through assimilation and accommodation and balanced by equilibration" (p. 243).

As stated in cognitive constructivism, teachers should create opportunities for students to build their existing knowledge (Lefa, 2014). It emphasizes the interaction between students and their learning environment, suggesting that teaching materials should be designed based on the learners' surroundings (Simatwa, 2010). Cognitivist teaching methods integrates new knowledge with existing knowledge and support students in adjusting their mental models to incorporate new information effectively (Piaget, 1977). Effective teaching strategies should be developmentally appropriate, contextually relevant, and learner-centered (Lesgold, 2004; Piaget & Tenzer, 1967). Active engagement and schema development are key elements of cognitive theory (Al-

Suqri, 2015) and are used in the CBT process (Powell & Kalina, 2009) in mathematics learning.

Social Constructivism

Social constructivism emphasizes that learning is primarily a social process where learners construct knowledge through collaboration and communication with others (Powell & Kalina, 2009). Meaningful learning is enhanced when learners engage in social activities through interaction and collaboration in various contexts (Amineh & Asl, 2015). The learning process is not isolated from the social context, and it is intertwined with the construction, interpretation, and understanding of that context (Adams, 2006; Vygotsky, 1962). The theory advocates a social and collaborative activity-based teaching approach where learners create meaningful learning and knowledge through interaction with each other (Saleem et al., 2021).

Teaching strategies based on a constructivist approach involve students constructing knowledge using their meaningful experiences or context with guidance from an instructor or a more knowledgeable peer (Schreiber & Valle, 2013). This means that learners learn through a social process, meaningful context, and interaction with each other. The teaching approach is centered on interactive and cooperative learning (Prawat, 1992) and emphasizes CBT, where students actively engage in creative activities and learning (Dagar & Yadav, 2016). CBT approach applies in mathematics learning to enhance students' engagement and learning achievement.

Realistic Mathematics Education

Realistic Mathematics Education (RME) emphasizes learning and problem-solving through everyday contextual problems and learner-relevant contexts. This approach allows learners to reinvent mathematical concepts and promote interactive teaching and learning experiences (Fauzan et al., 2002). RME focuses on student-centered learning where the teacher acts as a facilitator, guiding students in solving contextual issues based on their experience and knowledge (Laurens et al., 2017). The key characteristics of the RME include understanding contextual problems, discussing them, and finding solutions (Yuwono, 2007). RME advocates CBT in mathematics presenting "realistic" situations that engage students in the learning process (Van den Heuvel-Panhuizen & Drijvers, 2020). This approach has been reflected to enhance students' cognitive achievement and motivation in mathematics learning (Laurens et al., 2017; Zakaria & Syamaun, 2017). Therefore, by aligning teaching interventions and takes with learners' contexts, RME supports create a more relevant and engaging learning environment. RME encourages mathematics within a framework that closely matches context-based mathematics teaching. Based on theories, CBT models are also there to make mathematics teaching effective and contextual, which are discussed in the following sub-sections.

Teaching Models Supporting CBT

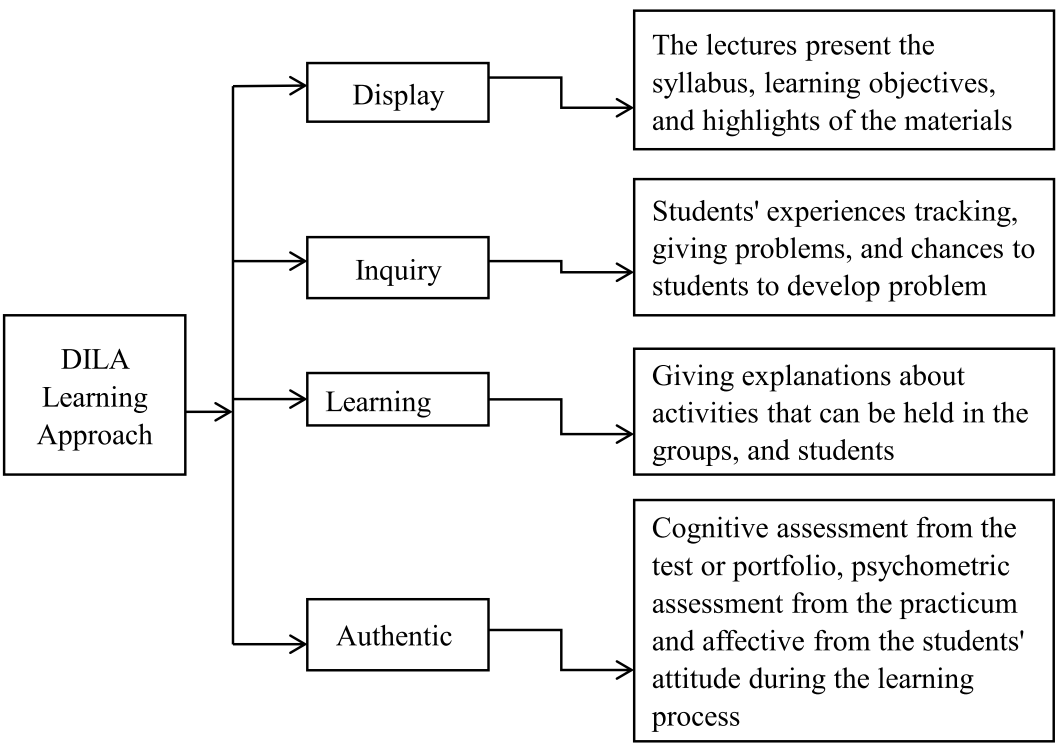
Teaching models operationalize the principles of Constructivism and RME to make CBT applicable in mathematics classrooms. Among the various models, REACT, DILA, 5E, and CTCA are prominent, which are discussed below.

DILA Teaching Model

DILA teaching model integrates seven components of the CBT approach: constructivism, inquiry, questioning, learning communities, modeling, reflection, and authentic assessment (Fadhilah et al., 2018). It also emphasizes contextual, student-centered learning and collaboration (Fadhilah et al., 2019). The teaching and learning process in the DILA model involves four key steps, as illustrated in figure 1.

Figure 1

Steps of DILA Learning Approach



Note. Fadhilah et al. (2018)

5E Instructional Model

The 5E model consists of five cognitive stages: engagement, exploration, explanation, elaboration, and evaluation. Each phase plays crucial role in the learning process, which is described as:

***Engagement**,* the first learning phase aims to activate prior knowledge and generate interest in new concepts through engaging activities that stimulate curiosity (Bybee et al., 2006). At the beginning of the learning lesson, teachers use warm-up activities to motivate students to develop different ideas and ask queries based on the related topic (Tezer & Cumhur, 2017), connecting to content to their experiences and existing knowledge.

In the ***exploration*** phase, students engage in inquiry-based activities that promote collaborative learning and facilitate the identification of existing concepts while encouraging conceptual change (Duran & Duran, 2004). Teachers act as facilitators, guiding students through hands-on activities that allow them to formulate hypotheses (Tezer & Cumhur, 2017); (Omotayo & Adeleke, 2017) and work together to explore the subject matter.

*The **explanation*** stage focuses on classifying key concepts introduced during the engagement and provides students with opportunities to demonstrate their understanding and process skills comprehensively (Bybee et al., 2006). In this stage, teachers directly introduce new concepts, processes, or skills, guiding students towards a deeper comprehension of the material (Omotayo & Adeleke, 2017).

During the ***elaboration*** stage, students apply their newly acquired knowledge and skills to further enhance their understanding of the concept (Duran & Duran, 2004). Through additional experiences and activities, students strengthen their grasp of the subject matter and develop a more comprehensive practical understanding (Bybee et al., 2006).

The final stage ***evaluation*** involves students assessing their own understanding while teachers evaluate their progress towards achieving educational goals (Artun & Coştu, 2013). This phase allows for reflection on the learning process and helps students and teachers gauge the effectiveness of the instructional model. The detail of the 5E instructional model is presented in given table 1.

Table 1

Description of the Stages of 5E Instructional Model

Phase	Description
Engagement (5-10min)	The teacher or a curriculum task assesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities

Exploration (20-25min)	The teacher or a curriculum task accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities
Explanation (15-25min)	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration (25-30min)	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop a deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation (5-10min)	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

Note. Bybee et al. (2006)

The 5E instructional model promotes student engagement and participation in the learning process (Turan & Matteson, 2021), improves students' conceptual understanding in mathematics learning (Artun & Coştu, 2013), and enhances learning outcomes for them in mathematics (Omotayo & Adeleke, 2017; Rahmadina & Slamet, 2024).

Culturo-Techno-Contextual Approach

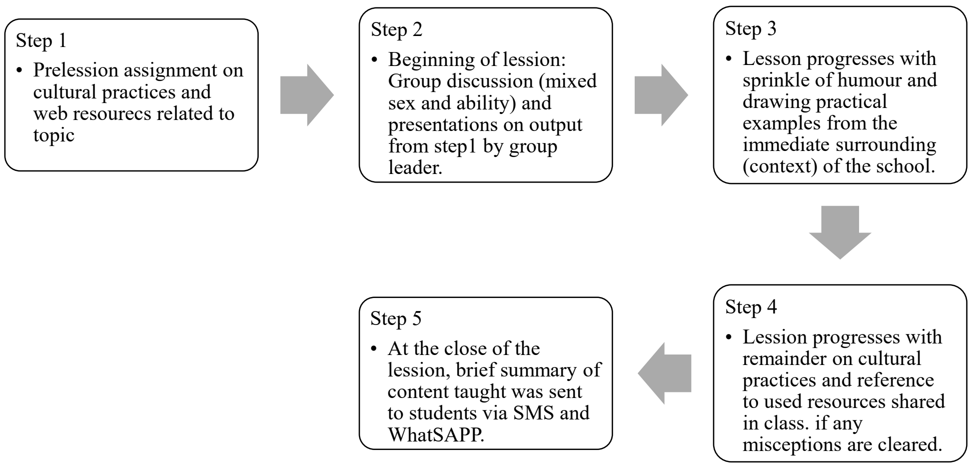
The culturo-techno-contextual approach (CTCA) is a teaching method that combines culture, technology, and the local environmental context into the teaching and learning process. Developed in 2015 after 40 years of experience, it incorporates three philosophical perspectives to shape its framework: Ethno-philosophy (Kwame Nkrumah) for culture, Techno-philosophy (Martin Heidegger) for technology, and Contextualize (Michael Williams) for context-related environments (Abdulhadi et al., 2023).

The Process of Learning in CTCA

Before each lesson, students are informed of the topic to be covered in class and are instructed to engage in two preparatory activities: watch a relevant lesson video on YouTube related to the topic or concepts to be learned, and use the information gained from the video to interact with parents or other adults about cultural practices or local knowledge connected to the content (Oladejo et al., 2022). The learning process in the CTCA model is presented in figure 2.

Figure 2

The Process of Learning in the CTCA Model



Note. Ademola et al. (2023)

REACT Model

REACT model is a contextual teaching and learning approach consisting of five stages: Relating, Experiencing, Applying, Cooperating, and Transferring (Crawford, 2001). The main stage of REACT model in mathematics is explained as follows;

In the ***relating*** stage, students connect new concepts to their prior knowledge or real-life experiences (Quainoo et al., 2021). This connection enhances the motivation of students, as the materials become meaningful and completely familiar them (Crawford, 2001).

In the ***experiencing*** stage, teaching materials are carried out in the class to provide hands-on experience (Abebe et al., 2024) at this stage. Students learn through discovery, exploration, and invention (Crawford, 2001) by engaging in real-life activities. Furthermore, experiencing learning enables students to learn by doing mathematical activities through exploration, discovery, and search.

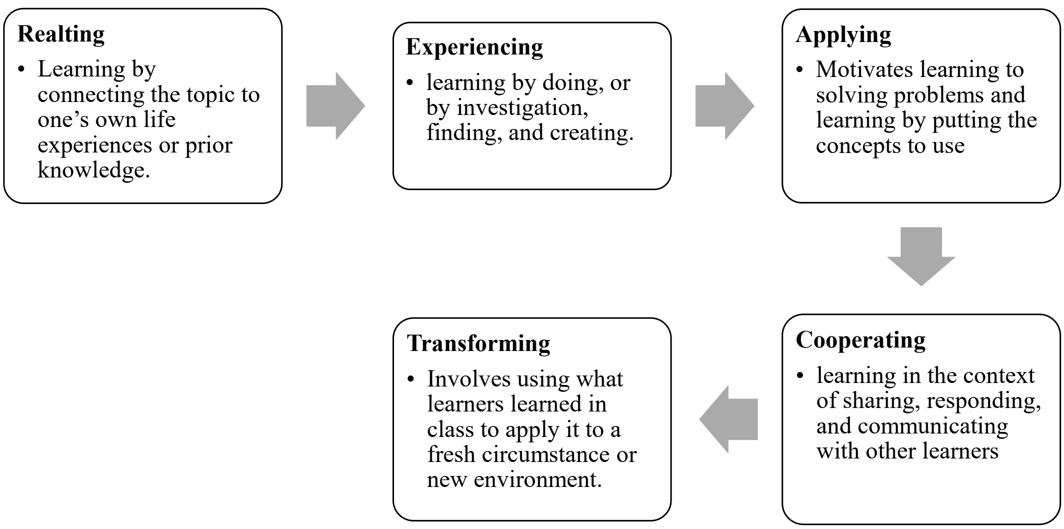
After experiencing the stage, the students move to the ***applying*** stage in which teachers create the relevant exercise, and let the students learn by putting the concept to use in real activities such as solving problems (Crawford, 2001).

In the ***cooperating,*** students learn through cooperation and collaboration with their peers (Crawford, 2001). Students learn new knowledge, share opinions, respond, and maintain communication with other students.

In the stage ***transferring,*** the teacher provides space for students to think and deduce their concepts learned (Sari & Rosjanuardi, 2018). Students apply their prior knowledge to express and generalize for new studies. The steps of learning based on the REACT model are illustrated in Figure 3.

Figure 3

Steps of REACT Learning Model



Note. Abebe et al. (2024) and Crawford (2001)

REACT model is interrelated with the principle of CBT, as each stage emphasizes connecting learning content with students' daily life experiences (Mutlu, 2023). As Widada et al. (2019) affirm, the REACT model is effective and applicable in mathematics teaching. It fosters active learning, self-regulated learning, problem-based learning, and active engagement, in contrast to traditional strategies.

REACT model based on context, access, knowledge, practices, and flexibility. It is suitable for mathematics lessons, enabling students to relate mathematical problems to daily life by making discoveries and applying mathematical concepts. It is widely used in mathematics teaching and learning fields. RACT model is based on constructivist learning theory, in which teaching mathematics should be meaningful by being localized and contextualized with real-world issues. The numerous studies showed that a context-based teaching approach based on REACT model is highly motivating, promotes conceptual understanding, collaborative learning, enhanced engagement, and increased achievement in mathematics Teaching. In this regard, the intervention manual of the approach is mainly based on the stage of REACT model in this study.

Conclusion and Implications

Major learning theories such as cognitive constructivism, social constructivism, and realistic mathematics education are useful for teaching mathematics, which focus on learner-centered, experience-driven, and real-world context-based mathematics instruction. They highlight that learners construct knowledge through interaction with their environment, social collaboration, and problem-solving in meaningful contexts. Through the analysis of CBT teaching models such as the DILA model, 5E instructional model, CTCA, and the REACT model, these models are useful for inquiry, collaboration, context-awareness, reflection, and active learning in mathematics. Among them, the REACT model is particularly suitable for mathematics teaching due to its alignment with constructivist principles and emphasis on contextualizing mathematical content through real-life applications.

Among these various teaching models, the REACT model is used widely in international arenas. This model's flexibility, student-focused design, and alignment with constructivist learning principles are useful for improving student motivation, engagement, conceptual understanding, and academic success in mathematics. However, it has not been effectively adopted in the Nepalese mathematics educational context. Therefore, this review could help bridge this gap by using the REACT model as the main framework for implementing CBT in mathematics classrooms in Nepal.

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