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Critical View of Scaffolding Techniques in Teaching and Learning of Mathematics

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ABSTRACT

Scaffolding technique involves changing the level of support for learning. A teacher of more advanced peer increases or decreases the level of guidance or support according to the students' need for the desirable learning outcome. It is based on social learning which takes place with more capable person's support or guidance with social interactions until the successful completion of the task. The aim of the present study is to discuss the definitions of scaffolding and its meaning and types of scaffolding techniques. Also, discuss Vygotsky's theory of social learning of students with teacher and peers promotes their skills and mathematical language development for successful learning, Bruner's scaffolding for the process of learning to retain the acquired knowledge which lead to discovery learning, Piaget's scaffolding to make the students to construct knowledge through organizing and reorganizing prior knowledge to the new learning situation. Moreover, the role of the teacher as a system of scaffolds, scaffolding support in the classroom, group learning, scaffolding with critical thinking, teacher's instructional design, teacher-student interaction, and mathematical modeling to make the process of teaching and learning of mathematics successful.

1. Introduction

According to theories of learning on constructivism active learning and construction knowledge independently make the learners build their knowledge gradually. Scaffolding technique is based on social learning which takes place with more able person's guidance along with proper communication in the social context of learning. Vygotsky's social learning theory in which zones of proximal development (ZPD) bridges the gap between the learners' actual developments measured by his solving problem independently and his potential development measured by his problem-solving ability under the adult guidance and talented peers.

Students can learn with teachers, any adult that is known to them, talented peers in the classroom and even they learn with talented members of family or neighbors. However, in such situation knowingly or unknowingly intrapersonal communication and interpersonal communication skills develop in an individual in social learning context (Vygotsky, 1978).

Assistance, guidance, and help are the basic terms in scaffolding. While using scaffolding in teaching the teacher should be aware of how to provide support during theory and practical classes. It takes place in the zone of proximal development. The support provided by the teacher should make the learners improve further continuously. Hence, for the sustainable development towards learning with one's mind might be difficult. Therefore, there should be another mind to support for the prosperity of the learning. Scaffolding sometime might seem to be strong at the beginning, there would not be any support if the task is achieved and later it might be used in accordance with students' need. The usage of scaffolding in the classroom depends on the teacher and his theoretical knowledge of social learning. He should have the knowledge of when it should be given, how it should be given and how it should be gradually withdrawn to stand on his own feet to construct new knowledge (Amerian & Mehri, 2014).

2. Theoretical Background

2.1 Piaget's Theory to Students' Education

Piaget emphasizes that students can learn best through active participation in learning and seeks solutions themselves; he does not encourage teaching techniques which make the students be passive listeners in the classroom. Instead, he encourages students' discussion of tasks, discovery learning, inquiry-based learning, and reflective learning for all subjects and not rote learning and blindly imitating the teacher. Effective teachers plan well before they help the students in the classroom and make the learning situations to learn by doing. This kind of learning atmosphere promotes students' to think and discover. Teachers listen to students, see their process of learning and question them systematically to understand the tasks in meaningful ways. They ask pre-planned questions to improve students thinking ability. Generally, students have many ideas about the natural and physical world. Teachers should not think that students do not have knowledge; they come to the classroom with an empty mind. They have the idea of spatial thinking, sense of time, measurement, social learning and so on. The teacher should not insult the students when they respond to specific question incorrectly. Instead, he should appreciate student's sincere effort and make him understand why it is wrong. Students' learning in the classroom should take place naturally. Students should not be forced or pressurized to do too much in their early development. The teacher should motivate students for mental preparedness before they begin to learn. The teacher should give the opportunities to students in the classroom to explore and discover, see their interest and active participation in the activities. Math lessons might be

constructed by the students in the classroom such as verifying algebraic equations using interlocking cubes, verifying theorems on circles and triangles and etc. Puzzles and games to promote mathematical thinking to enrich the learning experience (Santrock, 2009, p. 50).

2.2 Bruner's Theory to Students' Education

It is obvious that according to Jerome Bruner's the basic scaffolding of learning for school students need help from the teachers or capable persons or adults to learn the new concepts through active participation. It is a natural phenomenon that students will have hesitation how to start or begin their work which would support them in the process of learning. Moreover, they seek the help from the teacher or peers. But they think independently and acquire the knowledge and skills, therefore, the support given by the teacher or peers should be slowly withdrawn after tasks achieved. However, scaffolding techniques narrow down their ideas and focus to achieve the learning goals.

2.3 Vygotsky's Theory to Students' Education

Vygotsky emphasizes that assessment of the students in the classroom should focus on students zone of proximal development. The skillful person can plan according to the individual differences in the group before beginning the instruction to accomplish the tasks. Teaching should begin with zone's higher limitation; therefore the students can reach the goal with the scaffold to acquire the higher level of skill and knowledge.

The skillful person can offer enough assistance to bridge the learning. For example, he may ask, "Do you need any help to make you understand easily?" Or keenly observe students process of learning, their participation and involvement in their group work, sharing their knowledge, develop mathematical communication, encourage each other to achieve the desired goals. He may observe some students hesitate to ask the doubt, when they hesitate, encourage them to practice the skill. Also, he may observe their intensity and trials and provide support when needed. While watching their process of work student may forget the formula or steps involved in the process then he should appreciate their effort and offer support to do next (Santrock, W 2009, p. 54).Vygotsky focus towards transforming the classroom with his famous thoughts such as cultural and social development through self-regulation, scaffolding, private speech, sharing activity and play as an important activity among students in the classroom (Hyson et al., 2006).

2.3.1 Zone of Proximal Development

Vygotsky's term ZPD for the variety of tasks that are very difficult for students to acquire the required skills but that can be achieved through proper guidance and assistance from elderly persons or more-skilled students. In the lower limit, the level of problem-solving reached on the tasks the students working individually whereas in the level of additional responsibility students can accept with the assistance of skilled persons (Santrock, 2009, p. 3).

3. Group learning

Group learning in a student-centered, collaborative classroom with printed learning materials help students work through the math and provide the opportunities for students to explain their reasoning as they construct and interpret mathematical models. Students can build on prior knowledge and intuition as they develop conceptual understanding and procedural knowledge when they engage with a variety of real-world and mathematical problems. They develop the social relationship; help each other, share each other, and discuss their viewpoints for the social construction of knowledge. They can get more opportunity to develop their knowledge and understanding and it is more convenient, they can spend the time to learn and can communicate with peer-group learners related to the constructive works, unlike lecture-based classroom teaching.

4. Scaffolding

Scaffolding refers to different kinds of instructional techniques which help students' gradual development towards deep understanding also leading to greater independence in the learning process (The Glossary of Education Reform, 2015). Effective scaffolding consists of many kinds of temporary support and mechanisms that drive the learners towards to think critically engaging with active participation. Scaffolding helps students attain their goal beyond what they actually could do on their own also they can accumulate knowledge, develop the skills and to become independent learners (Mehisto, 2017).

Scaffolding plays an important role in the language development of the child in the learning process and creating the good atmosphere in the learning setup to make the learning easy and successful and ultimately the child acquire required skills (Bruner, 1983). According to Goos (2004) different definitions of scaffolding teacher pre-plans and determines to facilitate the students with free flow of conversation within the classroom to build knowledge in a constructive way. He plays the role of partner with the children during dialogs to attain his goals.

Scaffolding to refer to the variety of instructional techniques can be used in order to develop students understanding and also connects the process of independent learning. The teacher provides the different level of support at different places which would help the learners aptly to improve their learning without interruption also gradually reaches to acquire the required learning skills. He withdraws the support when the students are successful in learning tasks, then he gradually increases more responsibility for the learning process of the student.

Scaffolding connects the previous learning and new learning. One of the goals of scaffolding is to reduce the undesirable behaviour of students and their perception of learning in the classroom when they get confused or discouraged, lack of interest when trying to solve a difficult task without the support or assistance, direction or understanding they required to complete it (The glossary of education reform).

4.1 Scaffolding in the classroom

Scaffolding as an instructional technique can be used in the classroom in which the teacher provides tasks that enable the

students to build on old knowledge and internalize new concepts or ideas. Facilitate the students to understand that how to connect previous learning with new knowledge; guide them through verbal and nonverbal communication.

4.2 Scaffolding with critical thinking

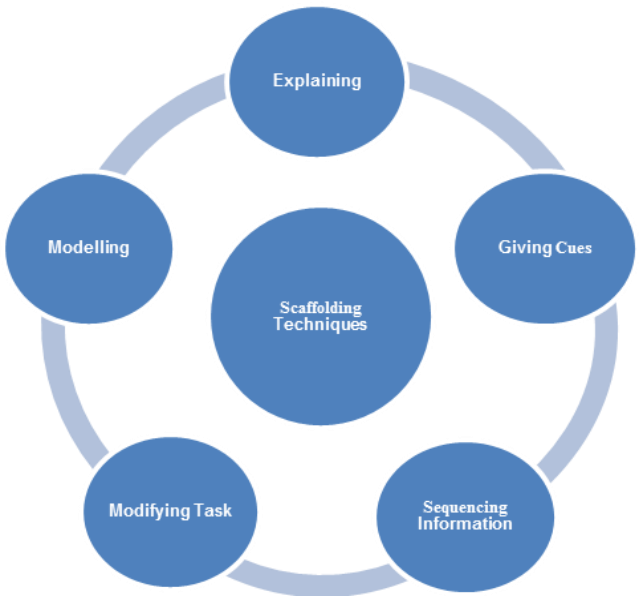
Teachers may feel that more material is required to teach the lessons. Despite, let them take it as an opportunity to challenge students and help them to augment their critical thinking skills. Critical thinking cannot be taught because it is not a skill. Nevertheless, it may be applied to the needs of the lesson. The tactics used in one subject can't necessarily be used in others as they are very much domain specific. This simply means that teachers' job is to teach their students many and varied strategies that they can use in different contexts.

When teachers focus on spatial intelligence using scaffolding first, decide on an overall theme of the unit, next, find or create an image that represents this idea moreover divide that image into thirds. Identify, clarify and make key terms and mathematical expressions visible so that students can more easily verbalize elements of the image (Donna, 2012).

4.3 Scaffolding techniques

The following are scaffolding techniques:

- Explaining: providing guidance and practice
- Giving Cues: giving clues for intuitive learning, constructive sequence of questioning and feedback for reflective practices
- Sequencing the whole information
- Modifying task: structuring the whole information into simple way of understanding
- Modeling: thinking in terms of real-world (Pritchard & Woollard, 2013)



(Source: Adapted from the book Psychology for the Classroom: Constructivism and Social Learning)

Fig. 1 Scaffolding techniques

Scaffolding techniques can be used at the various agencies such as teachers, artifacts, design including the whole-class setting. (Smit et al., 2013).

5. Role of a teacher

The teacher plays the different role of scaffolder to provide scaffolding support in the classroom.

- **Teacher As Support:** providing a well planned framework and assigns the task where the children feel good and take it as a challenge and works willingly and share their suggestions, ideas with peers.
- **Teacher As Prompt:** using appropriate questions to redirect the student's thinking or providing alternate suggestions, examples and counter examples with simple language.
- **Teacher as critical listeners and provider of feedback:** commenting critically the learners' works the way in which they can understand and might suggest getting solution to other ways.
- **The teacher as simplified:** breaking problem with many smaller steps so that learners could make the link between the steps easily move on to further steps to reach the learning tasks.
- **Teacher as motivator:** giving suitable encouragement of every progress of the learners.
- **Teacher as highlighter:** pointing out the significance of the tasks or questions wherein the learners need more attention.
- **Teacher as model:** lead the students with broad idea in the process of learning using suitable techniques in the classroom (National Strategies, 2007).

6. Scaffolding Support and Guidance

The term scaffold means the teacher extends his support to the learners until the learning task is understood. The teacher could use the scaffolding techniques such as clarifying doubts, listening responses, reinforcing important concepts/strategy and assessing students' progress. The instructor provides instructional support to construct knowledge in their own way of learning. The temporary support provided by the teacher will be withdrawn after the learning task achieved (Casem, 2013).

According to Vygotsky's theory of social learning in which Zone of Proximal Development for teaching students needs lots of opportunities to learn with the teacher and more skilled peers. Teachers play the role of facilitators and guides, more capable peers serve as tutors. When task-oriented interactions led by the teacher in the classroom develops students cognitive skills. Various levels of scaffolding assistance over the tasks will support to achieve every individual in the classroom as per their nature of learning. The teacher could invite the students' responses; clarify their doubts, reinforce important facts, evaluate students' work through scaffolding technique in the classroom. As constructivism recognizes teacher should encourage more student-centered learning in order to construct knowledge in their own phase of learning wherein scaffolding technique is the teaching methodology (Casem & Oliva, 2013).

There are different models of distributed scaffolding such as differentiated scaffolding, redundant scaffolding, and synergetic scaffolding. First combines various forms to address the needs of the learning, the project BGuILE (Tabak & Reiser, 1999; Reiser et al., 2001) and the instrument Explanation Constructor (Sandoval & Reiser, 2004). Second, refers to other kinds of guidance but goal towards the same need. Third refers to multiple occurrences together and interaction support for the same need (Tabak, 2004).

According to Tanner and Jones (1995) successful teaching of mathematics has two most important teachings styles such as dynamic scaffolders and the reflective scaffolders. Scaffolding to support reduces the degrees of freedom from problem-solving or proving theorems and etc. so that the child can develop his concentration more in complicated skills in the process of acquiring knowledge (Mercer, 1995).

6.1 Contingency Support

To increase the efficiency of the scaffolding support, the teacher should understand the pre-requisite knowledge of the students on the learning tasks before teaching the lesson. The teacher has to diagnose students' understanding completely in the specific area of the task in order to know the current level of competence before providing additional help. It would connect the learning without the barrier in the further step of learning. Gaining knowledge depends on using scaffolding techniques appropriately among the learners and their direct work experience, deep involvement in the process of learning and completes the task on time brilliantly. The teacher provides guidance to students in the needful situation then there would be a platform for meaningful learning (Van de Pol, Volman, & Beishuizen, 2010).

6.2 Instructional design

Instructional scaffolds promote students learning through dialogue between the pairs or among small groups, feedback and shared the responsibility of every individual. Understand the variables in functions to locate them in graph students need scaffolding support in the form of axes (Ayalon et al., 2016). School achievement can be measured by the students' engagement on the learning process including in learning mathematics. Learning enrichment or diminish depends on the learning environments provided by the school and utilization of the teachers (Fredricks et al., 2016). Instructional plans and designing the learning task strike the balance between students' decision-making in mathematics and accomplishment of the task. Teacher instructional challenges support the students' avoidance of the completion of the task. Providing a well-organized framework of teacher's scaffolding by which open-ended questions can be identified and utilized with ease and also promote collaborative learning in mathematics (Chan & Clarke, 2017). The instructional approach can be combined with cognitive and social learning with practical instruction to develop conceptual understanding as well as deeper learning skills in mathematics.

6.3 Teacher-student interaction

Teacher-student interaction plays the significant role in the process of learning at all to grade levels (Pianta et al., 2012) and it is classified into three teacher-level supports such as the organization of the classroom, instructional guidance and emotional guidance which motivate students to engage in learning mathematics. Successful teachers used instructional procedures frequently in the classroom teaching for grade 3 to degree level for the learners' cognitive development of the shows evidence of nearly fifty reviews. (Wood et al., 1976; Palincsar & Brown, 1984; Paris et al., 1986).

Three different types of important interactions take place in scaffolding between the learners and learning materials, student and teacher and the teaching material in the classroom and the teacher (Kim et al., 2007). According to Adler et al., (2001) most mathematics education research reveals that the relationship between formal and informal mathematical language is drawn from the theoretical perspective. There is different idea/opinion about the mathematical language such as terms, notations, terminologies and etc. will be discussed between two individuals in a dialectic method. Students become skillful in reasoning, logical thinking, and computational work when they use the mathematical language effectively (Wegerif's, 2008). There will be behavioral changes of the students in the process of engagement in learning mathematics. There are many articles of socio-cultural research in mathematics education talks about teaching strategies to enrich student engagement in the classroom (Watt & Goos, 2017).

Scaffolding technique smooth interaction between the teacher and students can be widened to cooperative learning (Rojas-Drummond & Mercer, 2003), scaffolding in peer-group learning (Ferna´ndez et al., 2001) and all groups in the classroom settings (Smit, Van Eerde, & Bakker, 2013; Puntambekar & Hu¨bscher, 2005; Cazden, 1979). Smit et al., (2016) consider genre pedagogy increases the students' high degree of skills in the mathematical language for interpretation of line graphs. The teacher can use scaffolding strategies to develop students' concentration on the domain of linguistic features of the language. There are three characteristics of scaffolding such as responsiveness, diagnosis, and handover to independence according to scaffolding literature.

6.4 Modeling

Modeling is considered as one of the techniques in scaffolding (Smith, 2006; Lee, 2001; Hmelo-Silver et al., 2007; Yelland & Masters, 2007; Silliman et al., 2000; Hung, 1999). Making models in mathematical learning by which learners can understand the concepts, explain in their own way and link the learning with the real-life situation. According to Ang (2009), Empirical, deterministic and simulation modeling approaches are used commonly depending on the purpose. According to Houston et al., (2010) solving real-world problem frequently in mathematics is the modeling in mathematics.

Students enhance their modeling skills by which they could be able to face the future problems while solving day-to-day problems with mathematics (Galbraith, 2011). Model making, scaffolding techniques, communication, and duration of the study, checking the pre-requisite knowledge and skills, feedback on planning can be used in the cognitive and meta-cognitive design to reflect the students' deep learning (Moore, 2005). Teacher scaffolding support is vital in the mathematics classroom for the implementation of mathematical modeling on a solution plan (Schukajlow, Kolter, & Blum, 2015).

According to Julie and Mudaly (2007), there are two types of modeling lessons such as modeling as vehicle and modeling as content, the first modeling type motivates and enriches students' mathematics learning and the second modeling type focus on modeling competency in students.

Teachers should organize the learning materials in the classroom for the expected learning outcome for the students and then divide them into small groups for mathematical modeling. Give them clear instruction to go through every stage to perform the tasks according to the constructive model of the lesson plan. Let students construct knowledge in their own way of learning and develop their mathematical communication by social interaction with peer-group. They would be discussing interestingly, each other; how to start with the collective idea? What should be the role of every individual in the group? And how their work should be the best similar to other groups in the classroom and so on. The teacher would be observing the cognitive learning of every group and he will support the group if they need. Their physical experience and social learning of real-life problems using mathematical modeling in the classroom with at most care and guidance given by the facilitator and experts in every group hopefully every student can excel in the real world.

7. Conclusion

Scaffolding techniques in constructivist teaching and learning in the social context can enrich the students learning in the classroom. According to Piaget students, there should be scaffolding support by the teacher to explore and discover knowledge whereas Vygotsky's theory had gone further that not only scaffolding support with the teacher but also with more-skilled persons. The commonality of both the cognitive and social learning theories is teachers play the role of facilitators, guides rather than molders and directors of learning. And, Bruner's theory of the basic scaffolding provided by the teachers or peers should help the learners towards discovery learning and he emphasizes the importance of students' active process of learning rather than the product. Teacher's instructional scaffolding support creates opportunities for the deep learning and discovery learning, enables students to engage and discuss in a meaningful way by small and large groups and motivates the students to understand and creates the conducive and congenial atmosphere in the classroom. It also provides individualized instruction to students in small groups, creates opportunities for peer-tutoring and learning and looks into the learning environment with at most care. Teachers can use the suitable scaffolds for diverse learning in the classroom and mathematical communication of students and also make them become independent learners.

Mathematical modeling is to engage students with the learning task by using scaffolding techniques in the appropriate way to succeed the learning goals without taking away the freedom of the children and allowing them to learn and explore for their own style of learning which would make every individual learn mathematics in the meaningful way (Redmond, 2012). The future study should focus on the role of the teacher having the eagle-eye view of the classroom teaching and learning with scaffolding techniques to increase learners' interest and develop the good sense of understanding the tasks for long-lasting memory.

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