EMOTIONAL SCAFFOLDING: MENDING EMOTIONS IN SCIENCE EDUCATION

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This paper is an effort to highlight the importance of emotional scaffolding in science learning which is emerging and contributory in effective science education. The role of emotions in improving learning engagement and interest in learning science is highlighted. Without undermining the importance of content knowledge, the added role of emotions to create an emotional attachment to the subject learnt is outlined. The authors used the concept of Pedagogical Content Knowledge and the concept of Zone of Proximal Development to stress and highlight the need for pedagogical knowledge of teachers as well as the support that a teacher should provide learners in their learning process. The significance of emotions in learning is highlighted and emotional scaffolding is proposed as a means to create interest and engagement among learners in science and science education.

Keywords: Emotional Scaffolding, Zone of Proximal Development, Pedagogical Content Knowledge.

Science Education in the Present Context

Science is the only subject which has influenced the human race more than anything else (Ramakrishnan, 2017). On the theoretical backing of science, technology has evolved and is the driving force behind the developments and scientific advancements in the modern era. Science has intertwined with human affairs in such a manner that it is difficult, rather, impossible to eliminate the influence of science from everyday life. Scientific literacy is a must for the current generation to cope-up with the technologically and scientifically advancing world. The scientific literacy is the capacity of an individual to make decisions with the help of science by the application of scientific processes and understanding (National Research Council, 1996) that they have learned or acquired. Teaching science and scientific methods means to develop the ability to think rationally and solve problems and to make informed decisions. The development of scientific literacy needs a perfect understanding and application of science process skills. Mastery in science process skills is the basis of fronting real-life problems by means of scientific method (Lloyd and Register, 2003). Developing scientific literacy, science process skills, etc. are to be the integral part of science education in schools.

Science education is one among the important school subjects due to its relevance in daily lives of students (Importance of

Science Education in Schools, 2017). The students develop the problem-solving, critical thinking and many other higher order skills mainly in science classes. These skills help the students succeed in science as well as in life. Even though science is one of the two subjects that claims the highest respect among other subjects (Scherer, 2004), many students have a distaste to science and even feel that they are not for learning science (Peffer, 2020). Even after seeing the leap in science and technology and the job prospective of science graduates, this hatred and fear of science still prevails among the school goers.

Challenges in Science Education

There is an inconsistency in the development of science education and pure science. The science education is lagging far behind the applied part of science and technology in terms of development (Ruiz, *et al.,* 2014). The advances in pure and applied science and the associated technology, is almost happening in a speed which is unimaginable but the same trend is unfortunately not present in science education. World Conference on Science held in Budapest in 1999 pointed out that the renewal, expansion and diversification of all the fields of basic science education is the need of the hour. The same conference further emphasises the need for skill development as well as blending the scientific and technological knowledge in the science education so that the students could be well equipped to meet the real-life requirements (as cited by Ruiz *et al.,* 2014). Even though different international organisations bat for science education through various declarations and conferences, in the ground level, science education is not progressing as expected. Lack of interest and motivation of students (Bergin, 1999; Hidi and Harackiewicz, 2000), students' misconception that science is a difficult subject (Crawley and Black, 1992; Havard, 1996), the negative views (Bencze and Hodson, 1999) and beliefs of teachers (Milner, *et al.,* 2012) are the major detrimental variables behind science education. Along with these, many of the teachers perceive that teaching of science is challenging (Boakye and Ampiah, 2017; Mtsi and Maphosa, 2016; Reddy, 2004). Insufficient in-service training for science teachers, compartmentalisation of science subjects, role of students as passive listeners and insufficient laboratory facilities are also reported as the challenges of science education (Kaptan and Timurlenk, 2012). The students can be oriented and their preconceptions and even misconceptions can be corrected but a much more focused effort is needed to strengthen the teachers and teaching.

Teacher in Science Learning

All the phases of teaching—the pre, interactive and the post active, is being influenced strongly by the knowledge that a teacher possesses (de Jong *et al.,* 2002) about the subject matter and of students. According to Shulman (1987), the knowledge that help a teacher in teaching comprised of seven different categories—pedagogical content knowledge (PCK), subject matter knowledge (SMK), general pedagogical knowledge (GPK), curricular knowledge, knowledge of learners, knowledge of learning context and knowledge of educational purpose The SMK is comprised of two areas; knowledge of teacher about the concepts and theories of a selected topic as well as knowledge about the epistemology of science (Shulman, 1986). So, it can be thought that one of the elements that make a good science teacher is their grip over subject matter knowledge (SMK). Various researches were conducted to identify the relation between SMK and good teaching (Childs and McNicholl, 2007; Kind, 2009) but the studies could not prove the same except highlighting the fact that SMK is a pre-requisite for good teaching (Mizzi, 2013). Those who are having mastery in SMK tend to teach in a straight-line process of knowledge transmission. The mere knowledge transmission is not enough for deep learning (Kind, 2009) or effective teaching. The importance of pedagogical content knowledge (PCK) for effective teaching is stressed by Shulman. He argued that PCK is also needed for science teachers to blend content and pedagogy and to instruct students in tune with their diverse abilities and interests (Shulman, 1987). So, SMK is needed for clear and deeper understanding about the concepts of science topics, but to transact it in an effective manner deeper PCK is inevitable for teachers. In Shulman's own words, PCK is the "...ways of representing and formulating the subjects that makes it comprehensible for others" (Shulman 1986, p9 as cited by Gess-Newsome, 2001). It can be argued that all the other six categories of knowledge that a teacher need to possess get subsumed under PCK since it is more inclusive and touches both cognitive as well as affective aspects of learning.

Each student possesses their own ideas about the content or the subject matter. A teacher should have an idea about the previous knowledge that the students have. This knowledge is the fundamental part of pedagogical content knowledge of teacher. The teacher should understand the ideas held by the students and transform the content in to a form which the students can comprehend and interpret easily (Shulman 1986), and is an expression of pedagogical content knowledge of the teacher. When the teacher recognise and understand the students' ideas, they can decide the best experiences and examples that helps them to concretise their understanding. In science classes, knowledge about students' ideas is specifically useful for a teacher to decide how to teach the content to make children enjoy learning (Geddis *et al.* 1993). The constructivist paradigm also supports this view.

The interaction of children with the environment is crucial in their concept formations (Vygotsky, 1986). This would be more effective, if the child gets opportunity to interact with more knowledgeable elders such as teachers. The constructivist perspective is useful to teach science concepts to primary school children (Harlen and Qualter, 2018). Edwards and Mercer in 1987 (as cited by Akerson and Flick, 1999) mentioned that 'common knowledge' evolves out through classroom discussions about any of the topic that is being discussed in the classroom due to the mutual influence of ideas brought to the classroom by students as well as teachers, if the teachers follow a constructivist philosophy. The ideas that children bring in to the classroom should be used or considered by the teachers as a means to support (scaffold) the students to construct their own concepts with much more accuracy.

Both Shulmans' as well as Vygotsky's perspectives contribute to effective and meaningful science education in school level by stressing the importance of learning experiences provided by the teacher. The quality of educational experiences provided by the teachers is the main factor which determines the attitude of children towards learning science (Murphy and Beggs, 2001; Osborne *et al.* 2003). The rote memorisation and teacher dominant classrooms are no longer advocated in science education. Provision for student-centric learning environment, catering individual learning needs of students through differentiated instructional strategies and a focus on the outcome-based curriculum are identified as the aims of teaching science (Parker, Osei-Himah, Asare, & Ackah, 2018). The curriculum focusses on activity-based and child-centric learning, where there is a stress for the development of critical thinking (Davidson, 2010) and other higher order skills among learners. If teacher fails to develop these process skills, then the learners remain passive and get demotivated and lose their interest in learning science. Many studies have pointed out that the students are losing their interest and motivation for learning science (Boakye and Ampiah, 2017; Mtsi and Maphosa, 2016; Reddy, 2004) and one among the major reason is ignorance of teachers about the appropriate teaching methods (Boakye and Ampiah, 2017).

Engaging Students through Scaffolding

Motivation is one of the major factors that contribute to students' classroom engagement and hence meaningful learning (Saeed and Zyngier, 2012). Better engagement in learning activities contribute to improved academic achievement (Frydenberg *et al.* 2005; Ryan and Deci, 2009). When the students are engaged and involved in their works, they will be delighted even though the task is difficult (Schlechty, 2001). Engagement is a way to enhance students' motivation and participation in learning activities (Appleton *et al.* 2008; Li and Lerner, 2011). The active involvement of children in learning activities is known as classroom engagement (Skinner, Kindermann *et al.,* 2009). The support provided by teachers in learning tasks found to act as a motivational factor for improving the students' engagement in learning activities (Perry *et al., 2010* ; Wang and Eccles, 2013). This support is called as scaffolding. When the students are engaged in learning activities, they are able to work with others and are able to transfer what they have learnt for solving problems (Jones *et al.,* 1994). Students found to remain engaged in learning activities, if the task includes elements of creativity, curiosity and opportunity for collaboration and a feel of success (Strong *et al.,* 1995).

Learning is not a mere comprehension of content but involves its own discoveries of relations and ideas often flagged with surprise and delight (Rosiek, 2003). Unlearning and re-learning take place when a child tries to develop own ideas with the help of teachers. In the self-learning efforts, the students sometimes face humiliations or failures, sometimes they are compelled to change their beliefs (Rosiek, 2003), but they feel happy and satisfaction once they could break the learning barriers. The constant support of teacher is necessary in this effort and the barrier that the child crosses is called as the zone of proximal development (ZPD). It is the distance between a child's ability to solve a problem independently and under the guidance of more knowledgeable adults such as teachers (Vygotsky, 1978). Even though the concepts of zones or the distance between zones are not defined precisely (Wertsch, 1984), it will give an idea about the significance of scaffold to be offered by teachers in students' learning. There is no exemption for science learning too. It needs more effective scaffolding, since there are many detrimental learner variables and only a best teacher could help the learner to overcome these issues in science learning.

The 'Feelings' in Science Education

We cannot say that learning is exclusively cognitive in nature, especially in science. It has an elements of feelings intertwined with. The affective and cognitive domains are interrelated (Alsop and Watts, 2000), but there is a dearth of researches on the role of affective domain on learning science. Unfortunately, science and science learning are projected as a rational and analytical subject with more objectivity and no emotionality (Brígido *et al.*, 2010). The research conducted by different researchers identifies the importance of emotions in science education and suggests the need to consider affective dimensions too along with cognitive dimensions (Koballa and Glynn, 2007). The review studies conducted by Zembylas (2004) identified the role of emotions in curriculum planning and transaction of science subjects. The affective domain or dimensions acts as a governing entity of effective science learning (Brígido *et al.,* 2010). Teachers found to use emotional knowledge to perform teaching and to strengthen their connection with students as well as the content they are teaching (Brígido *et al.,* 2010). So, in teaching and learning of science, we cannot undermine the emotional aspects associated with it. Emotional engagement in science can help to minimise the unappealing feelings associated with the analytical and rational nature of science.

Emotions acts as a bond between individuals and help in classroom collaboration which would contribute in effective classroom learning. Thus, emotions affect the teaching-learning environment and is endorsed by the theory of constructivism (Ross, 2006). Emotions are active behind all the decision-making processes, since all the actions of humans have an emotional element associated with it (Jeong *et al.,* 2016). If teachers ignore the emotional aspects while teaching, it would hinder the concept attainment and development (Duit *et al.,* 2008). In case of science and mathematics, emotions play a pivotal role in learning (Pintrich *et al.,* (2013) (as cited by Jeong, *et al.,* 2016) reported that the positive emotions improve science learning by engaging students in learning activities. Hence, it can be mentioned that the emotions play a crucial role in science learning and positive emotions complements effective learning: through making students more engaged and interested in learning activities.

Emotional Scaffolding for Better Learning

When a child tries to perform a difficult task without assistance, the failure may cause emotional disturbance and frustration. This, in turn, lead to disliking of the subject and unfortunately, it happens more in science subjects. A teacher with mastery in content and pedagogy, can make a difference by keeping learners engaged and interested in learning by providing proper learning support. The learning support that a teacher provide are called as the scaffolds. Providing a simplified version of a lesson, teacher describing a concept in multiple ways, teacher describing the purpose of learning activity well in advance are some of the examples where the instructional scaffolding is taking place (The Glossary of Education Reform, 2015).

The term scaffolding has been used as a metaphor in educational context by Wood, Bruner and Ross in 1976 represent how the knowledgeable people support the children in their learning tasks and help them to perform difficult tasks which otherwise they cannot do themselves. Ausubel in 1963 and Bruner in 1960, also used the term scaffolding, but in different educational contexts. Even though, Vygotsky has not used the term scaffold, (Stone, 1998), but his concept of teaching that is taking place in the zone of proximal development (ZPD) (Wells, 1999), is directly, connected with scaffolding. The recent researches again pointed out that to make scaffolding much effective, it is necessary to give due importance to the affective elements of teacher-learner relationship (Stone, 1993). The affective elements are mainly comprised of the emotional part associated with learning.

The importance of emotional aspect in successful scaffolding is highlighted by Rosiek (2003) and is called as emotional scaffolding. A long-term research on pedagogical content knowledge for the identification of unique aspects which needs to be known only by a subject teacher (Rosiek, 2003), resulted in the identification of scaffolding practices especially the one which influences the emotional response of a student to an idea (Rosiek and Begetto, 2009), and is later called as emotional scaffolding. Even though the original definition of scaffolding had inherent emotional aspects, the emotional dimension was ignored and the focus was more towards cognitive scaffolding (Rosiek and Begetto, 2009). Emotional scaffolding focused on the emotional responses of students to the content. So, there is an increased focus of emotional elements of learning in the strategies of scaffolding. Emotional scaffolding is a temporary activity initiated by the teacher to provide pleasant emotional experiences associated with the content among learners which in turn, can enhance and sustain motivation and collaboration.

Studies such as Schuster (2000), and Henderson *et al.* (2002) (as cited by Meyer and Turner, 2007), have revealed that the goals of emotional scaffolding are achievable in different types of classroom interactions. It can positively influence the classroom interactions and can contribute to increased student autonomy in learning. The students' involvement in learning activities can also be improved through appropriate emotional scaffolding strategies (Meyer and Turner, 2007; Stuhlman and Pianta, 2001). When the learning tasks are beyond the capacity of a child to perform independently, then it is necessary that the teachers should provide emotional scaffolding, so as to cater the childs cognitive as well as affective learning needs. To provide emotional scaffolding to students, the teacher should have a clear understanding of the subject matter as well as the role and influence of emotions in the students' learning experiences (Rosiek, 2003). This can be attained through incorporating various strategies in teaching such as using metaphors, citing instances from daily experiences, using familiar and common examples, using the previous knowledge of the students for introducing new concepts, providing freedom for expression, generating curiosity through various methods like puzzles, riddles, etc. and many other strategies deemed appropriate by the teacher. Teacher has to take enough care in the selection of appropriate strategy that suits the nature of the content as well as the learner.

In a classroom, suppose the teacher is teaching the functional areas of brain, she can use a picture of brain with proper verbal labels to teach the concept in a traditional manner. For example, if she wants to teach about the area of brain associated with hearing, she can make a pointer to temporal lobe with writing 'hearing'. The same topic she can teach with the same picture of brain, but instead of verbal labelling, she can paste a smaller picture of an ear just near the temporal lobe. This might look bizarre or intriguing but would attract students' attention by triggering curiosity, interest, imaginations, etc. This example outlines one instance of emotional scaffolding that can be used in science classroom. It was proven that intriguing photographs increases student engagement and thinking as well as help to perform tasks smoothly and to make more detailed conclusions (Gonchar, 2016). The inspiring images of deep space found effective while teaching astronomy (Arcand *et al.,* 2010). The students found motivated to learn the scientific importance of pictures that create wonder or awe- experience among them (Smith, *et al.,* 2011).

Science Education and Emotional Scaffolding

As already mentioned, science learning can be effective, if the teachers can provide emotional support along with the provision of content knowledge to the learners when they are struggling with the abstractness of science or trying to move through ZPD. Experienced teachers are doing this but might not be in a systematic manner. The effectiveness of emotional scaffolding has already been established in different learning environments and learning activities (van de Pol *et al.,* 2016). The difficulties and the lack of interest in science learning can be solved to certain extent, if the science teachers use emotional scaffolding purposefully and effectively. It is also revealed that students' involvement in learning activities can be improved through proper emotional scaffolding (Meyer and Turner, 2007; Stuhlman and Pianta, 2001). Existing research reveals that emotional scaffolding can help to create conducive learning in the classrooms (Meyer and Turner, 2007; Stuhlman and Pianta, 2001).

In secondary level the students feel stressed - especially academic related, teaching learning related and relationship related issues while learning (Sripongwiwat *et al.,* 2018). This stress would be more while learning science. The academic related stress can decrease the motivation among secondary and tertiary level learners and increases the risk of being dropped out from schools (Pascoe *et al.,* 2020). Emotional support can help an individual to cope up with the stress (Priem and Solomon, 2015) as well as to get engaged well in learning activities (Skinner *et al.,* 2009). Moreover, studies proved that emotional scaffolding is beneficial among elementary learners (McCaughtry, 2004; Meyer and Turner, 2007; Rosiek and Begetto, 2009).

The required academic support essential to make learning of science interesting should come from teachers so as to make students engaged in learning with less stress. Effectiveness of science education cannot be ensured only by the subject mastery of the teacher. It requires students' involvement and pedagogical knowledge of teacher, where the later can further enriched by effective emotional scaffolding. If a science teacher can use well-planned emotional scaffolding strategies, the students will get emotionally attached to the subject and once the learning is emotionally reinforcing, they feel science less threatening and get engaged and involved in science learning. They will no longer feel science topics are alien to them and would enjoy experimenting and would learn to learn from failures.

A Few Words of Caution

We have argued that emotional scaffolding can be a best tool for effective science education. Learning would be joyful and pleasant if a tinge of emotional element is associated with it. We are not of the opinion that all the teacher can provide emotional scaffold while teaching any of the science topics, neither we advocate to follow a standard procedure to provide emotional scaffolding. Some topics might be so abstract and the students might struggle to learn such topics. Here the teacher can make use of appropriate scaffolding strategies. This would help the child to ride over the ZPD with ease and confidence to reach the Level of Potential Development (LPD). If the content is not much demanding from the side of the child, then for learning the same, emotional scaffold might not be inevitable. It is the freedom of the teacher to decide what has to be done to make the science learning meaningful and worthy.

Emotional scaffolding is one among the many paradigms, which a teacher can effectively use in science teaching. It is also recommended that the curriculum of pre-service and in-service teaching should have an element of emotional scaffolding and its effective use, so that the novice as well as the regular teachers can understand the concept and can use it for improved science education in the schools.

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