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Science

SCAFFOLDING AS EVINCIVE ON SCIENCE ACHIEVEMENT

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ABSTRACT Scaffolding i.e. making a difficult task simpler by the variation in momentary assistance on demand is a useful strategy for learning science. Children gradually become the independent learners keeping instructor as facilitator after the responsibility for task performance transferred to their cognitive reach. The present study is experimentally designed to enquire the effects of scaffolding on science achievement after the incorporation of specific experimental manipulations. Eighty 6th standard learners of a WBBSE run Bengali medium regular govt.-aided co-educational rural HS school in South 24 Parganas district, W. B. constitute the sample of the study – divided into two equivalent halves through randomisation after the administration of entry-level pre-test – impartially for one half (40) treated with Problem Solving Method (PSM) of teaching and the rest (40) by Play Way Method (PWM) of instruction for the transaction of selected science lessons in three units. The data collection process involves the administration of two scales PPPSSLQ and SAT in three units to assess peers scaffolding and achievement respectively of the two groups after the instructions of nearly two months duration. Peers scaffolding is found to be independent of the applied variation in teaching methods i.e. PSM and PWM of teaching. The study discloses peers scaffolding to be significantly effective merely on Unit III science achievement for the learners instructed by PSM of teaching and for the analysis merged for the differentially treated all the sample. But no significant effect of peers scaffolding on achievement is observed in case of PWM of teaching.

KEYWORDS : Scaffolding, Peers scaffolding, Achievement, Science lessons, Teaching method.

INTRODUCTION

As an worth strategy for science learning scaffolding is believed to facilitate meaningful knowledge construction from on-going discussion, scientific inquiry, experimentation towards the successful grasp in abstract science concepts (Hogan & Pressley, 1997; Harlen & Elstgeest, 1997; Berk & Winsler, 1995; Reiser, 2004; Quintana, Reiser, Davis, Krajcik, Fretz, Duncan, Kyza, Edelson & Soloway, 2004; Sherin, Reiser & Edelson, 2004; Pea 2004; Ertmer & Glazewski, 2019). For learning essentially to be a social process in social constructivism, there is both the horizontal and vertical construction of knowledge respectively from peers and more knowledgeable others. The temporary assistance from adults as cultural agents for vertical construction of knowledge is termed as adult scaffolding while that from peers for horizontal construction is termed as peers scaffolding. Scaffolding is generally imparted through intersubjectivity (Newson & Newson, 1975 as cited in Berk & Winsler, 1995), assisted performance (Tharp & Gallimore, 1988; Gallimore & Tharp, 1990), guided participation (Rogoff, 1990), distributed cognition (Belland, 2011), distributed scaffolding (Tabak, 2004; Puntambekar & Kolodner, 2005) etc.

Scaffolding is nothing but momentary help provided during an on-going task performance while needed. Original task remains same but is made easier, simpler with breaking down whole the task into it's component parts and upon imposing added variation in the amount of temporary assistance on demand. The amount of assistance becomes faded upon observing child's satisfactory progress with taking increasing responsibility of the task. Thus, the outcome of providing scaffolding presumes a child to take risk to gain higher order understanding. The role of instructor is here only to play as a facilitator. Scaffolding in classroom situation can involve modelling, recognizing learner's needs, interest, current level of knowledge, updating teaching strategies, providing clues, hints, giving example, highlighting important feature of a task (Schwieter 2010; Wood, Bruner & Ross, 1976), strategy suggestion, precising problem definition, acknowledging learner's contribution in different words, clarifying next step in problem solving, adjusting the amount of instructional support (Wertsch, 1984), comparing and representing abstract lesson at concrete level (Eshach, Dor-Ziderman & Arbel, 2011), maintaining interest throughout a task, interpreting errors, convincing performance standard of a task (Rojas-Drummond, Torreblanca, Pedraza, Velez & Guzman, 2013; Trif, 2015), completing learner's partial and fragmented response, refocusing attention towards conflicting situation, manipulating task, demonstrating problem solving process by parts to induce discovery learning (Benson, 1997), slowing down the pace of lesson delivery on demand and repeating, providing opportunities to apply previous knowledge into new situation (Broza & Kolikant, 2015), providing opportunities for checking counter argument, fading of supports and prompts.

Peers scaffolding adds an important domain to learning science. Peers with heterogenous abilities make differences in group contribution to live science reasoning, joint problem solving (Belland, 2011), explanation, argument cum counter argument. Peers scaffolding involves the strategies of comparison of group members responses (Kollar & Fischer, 2010), rejection and correction of false ideas (Lin & Samuel, 2013), being persuaded from group interest in concept construction, support for affective component like providing full freedom to express views, creation of stress-free, fear-free environment (Cheng & Ku, 2009; Pishghadam & Ghadiri, 2011), exposure of problems from various angles, suggesting another pattern in problem solving (Azer, 2009), peer feedback (Gielen, Peeters, Dochy, Onghena & Struyven, 2010; Cho & MacArthur, 2010; Duran & Monereo, 2005), group confirmation on specific response, incorporation of new ideas to live group discussion, gradual detection and improvement of learner's weaker section in science lessons etc.

RESEARCH LITERATURE

A discourse analysis in a collaborative action research setting P. Panagiotis and K. Panagiotis reported although teacher's role in collaborative inquiry is nothing but facilitative, children's meaning making gets enriched with the enhanced quality of social interactions among peers. C-T Hsin and H-K Wu, 2011 showed that children's scientific understandings of floating and sinking enriched after the scaffolding intervention in scaffolding-material and scaffolding group. Children's variety of explanation about the concepts got reduced and tuned with science's views in line with the incorporation of the buoyancy concept. Maternal scaffolding also found to be related with the performance of problem solving task of medium and high difficulty when instructional input falls within the limit of children's cognitive ability through the agency of their emerging private speech (Beherend, Rosengren & Perlmutter, 1989). Cognitively appropriate challenging task i.e. after converting the task appropriate for child's ability thus fostered the children's private speech utterance leading to the successful progress of the task. In this regard through experimentation C. S. White and B. H. Manning (1994) were successful to disclose that verbal scaffolding instructions with nurturing of children's private speech can improve their problem solving ability. The treatment group significantly surpassed the control group in using Level IV facilitative metacognitive/affective private speech for better performance of the assigned problem solving tasks. L. E. Berk and S. T. Spuhl (1995) also replicated this findings that by developing self-regulatory capacity, parental scaffolding assisted in task performance for the transfer of effective task strategies. At the lower success rate, parents were prone to provide more scaffolding in block and matrix task (Pratt, Kerig, Cowan & Cowan, 1988). Authoritative parenting style for scaffolding exerted better performance across the tasks. By structural equation modelling approach, maternal verbal scaffolding at 3 years of age of at-risk developmental problem improved children's later problem solving

skills, language, memory etc executive functions at 6 years of their age through the skills carried over at 4 years of age (Landry, Miller-Loncar, Smith & Swank, 2002). Significant speech performance relationship was found by the application of adult scaffolding (Winsler, Diaz & Montero, 1997). Taken private speech as mediator for task performance, there was the significant difference between the speech production with and without scaffolding intervention. Task relevant speech production was greater than silence in case of successful task completion after scaffolding. Children found tended to succeed on next task, after scaffolding, if they use the strategy of private speech.

The joint effect of teacher and peers scaffolding exerts on learner's decision-making process during a virtual discourse act (Pata, Lehtinen & Sarapuu, 2006). S. Shin, T. A. Brush and K. D. Glazewski (2020a) anticipated that learners perceptions of teacher cum peers scaffolding can have impact upon group performance as well as individual academic achievement. Discourse within symmetric groups pairing through physics pre-test score can impart peers scaffolding at two different levels – superior group demonstrated enhanced level of scaffolding discourse through metacognitive, procedural input of talk by prompting collaboration, responding, reporting with no significant difference in the group learning gains (Martin, Gnesdilow & Puntambekar, 2015). In small group learning, teachers tended to form asymmetric group on the basis of achievement, ethnicity while students to homogeneous group based on gender, ethnicity (Webb, Baxter & Thompson, 1997). But B. Barron (2003) could not found prior achievement of group members as a factor towards problem-solving outcomes rather group performance depends upon the features of solution proposal along with the quality of their social interaction. Thus, peers scaffolding is critical to develop the insight on how to jointly manage the task characteristics towards fruitful task outcomes. Group symmetry with respect to individual contribution to the on-going group discourse about calculus-based physics content are the better predictor of challenging problem-solving outcome (Brookes, Yang & Nainabasti, 2021). How members in a group 'positions' themselves to achieve group equality in discourse contribution is the key for group effectiveness in joint problem-solving work. C. M. Gnadinger (2008) demonstrated that peers scaffolding in peer collaboration of primary classroom occurs through questioning, providing feedback, instructing and modelling at learners zone of proximal development. Further Shin et al.'s, 2020b other study identified nine strategies of peers scaffolding students utilised during the group activities in technology-enhanced inquiry based learning environment i.e. procedural assistance, feedback, elaboration and clarification prevailed predominantly during the interaction. Although both the quantitative and qualitative feedback from peers and experts found differed in reciprocal virtual peer assessment for secondary school science students, the peer recommendation was scientifically valid for decision making strategies (Hovardas, Tsivitanidou & Zacharia, 2014). On contrary, S. Gielen, L. Tops, F. Dochy, P. Onghena and S. Smeets, 2010 observed no significant difference in student's performance, though improved, emerged from the peer and teacher feedback for reporting of about half of the sample's acknowledgement that peer feedback is helpful.

Primary student's conceptual understanding got improved in scaffolding instructional discourse, formative assessment and peers assisted learning conditions even for students with poor language proficiency too in last two conditions (Decristan, Hondrich, Buttner, Hertel, Klieme, Kunter, Luhken, Adl-amini, Djakovic, Mannel, Naumann & Hardy, 2015). Domain specific scaffolding and peer assessment scaffolding exerted significant effect on the accuracy of task performance in variety of conditions (Konings, van Zundert & van Merrienboer, 2019). Achievement in scaffolding based self-regulated learning system found enhanced other than formal learning system at higher education level in Pakistan (Ghazi, Gilani & Shahzada, 2013).

Objectives of the study

$\mathbf{O}_1$. To identify the more effective teaching methods in terms of peers scaffolding in science for 6th standard learners.

$\mathbf{O}_2$. To compare the effects of scaffolding from peers and teacher on achievement of science for 6th standard students.

HYPOTHESES

$^0\mathbf{H}_1$. There is no significant difference in peers scaffolding between the students instructed by problem solving and play way method of teaching.

$^0\mathbf{H}_{2.1}$. There is no significant difference in achievement of Unit I and Unit II for 6th standard students treated through the presence and absence of peers scaffolding in problem solving method of teaching.

$^0\mathbf{H}_{2.2}$. There is no significant difference in achievement of Unit III and Unit II for 6th standard students treated through the presence and absence of peers scaffolding in problem solving method of teaching.

$^0\mathbf{H}_{2.3}$. There is no significant difference in achievement of Unit I and Unit II for 6th standard students treated through the presence and absence of peers scaffolding in play way method of teaching.

$^0\mathbf{H}_{2.4}$. There is no significant difference in achievement of Unit III and Unit II for 6th standard students treated through the presence and absence of peers scaffolding in play way method of teaching.

$^0\mathbf{H}_{2.5}$. There is no significant difference in achievement of Unit I and Unit II for all the 6th standard students treated through the presence and absence of peers scaffolding.

$^0\mathbf{H}_{2.6}$. There is no significant difference in achievement of Unit III and Unit II for all the 6th standard students treated through the presence and absence of peers scaffolding.

METHODOLOGY OF THE STUDY

Research Method

Experimental research method for post-test only two randomised equivalent groups factorial research design has been selected to conduct the on-hand study.

Sample and sampling

All the 6th standard learners of Kamdevpur Snehabala Milan Vidyapith, a higher secondary rural govt.-aided school following WBBSE curriculum of study in South 24 Parganas district of W. B. participated in the study.

Establishment of equivalent group

Two groups are formed on the basis of their entry level general science achievement pre-test scores in relation to the dependent variable of the study and the group equivalency is established through randomisation from each segment of hierarchical level in the following way –

Table – 1group Equivalence: Random Assignment Of Students Between Two Groups

Pre-test score level	Section A_2 (Strength – 71)	Group A	Section A_1 (Strength – 71)	Group B
Upper level	60 x 30% = 18	12	64 x 30% = 19	12
Middle level	60 x 40% = 24	16	64 x 40% = 26	16
Lower level	60 x 30% = 18	12	64 x 30% = 19	12
TOTAL	60	40	64	40

One group is impartially treated with Problem Solving Method (PSM) of instruction and the rest by Play Way Method (PWM) of instruction for the transaction of science lessons. During group formation, we specially care for not to disturb the normal classroom set up rather we identify such students whose scores not to be considered in our final data analysis than exchange of students between the two sections.

Moreover, the group equivalency is statistically crosschecked on the basis of their pre-test score's Mean, Standard Deviation and t-ratio.

Table – 2 T-test: Comparison Of Pre-test Score Between Psm And Pwm Group

Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Standard Error (SE)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
Group A Pre-test score	40	26.93	7.13	1.13	78	0.19	0.85	Not Significant at 0.05 level
Group B Pre-test score	40	27.25	7.80	1.23				

$t(78) = 0.19, p > 0.05$

Thus, the mean score of pre-test score for Group A does not significantly differ from that of Group B. So, there is no significant difference between the two groups in terms of achievement, the dependent variable of the study. The gender details of the group members are as follows –

Table – 3 Gender Distribution Of Sample Size

Group	Boys	Girls	Total	% of Boys	% of Girls	Total
PSM	17	23	40	42.5%	57.5%	100%
PWM	13	27	40	32.5%	67.5%	100%
Total	30	50	80	75%	125%	200%

Major variables of the study

1.Independent variable – Scaffolding (Peers & Teacher), Teaching method (PSM &PWM).

2. Dependent variable – Achievement.

Tools of the study

A compiled version of Peer Participation in Peers Scaffolding for Science Learning Questionnaire (PPPSSLQ) for assessing peers scaffolding and three self-made tools of Science Achievement Test (SAT) to assess achievement in science are administered for data collection.

Description of Peer Participation in Peers Scaffolding for Science Learning Questionnaire (PPPSSLQ)

The hierarchical dimensional adaptation of peers engagement from M. B. Parten's study (1932) for children's social participation is integrated in PPPSSLQ as an operational measure of the variable peers scaffolding - Parallel, Associative, and Cooperative. The item scoring range of the tool follows 1 for strongly disagree to 5 for strongly agree in the 5-point Likert scale. The reverse coded items follow the scoring in reverse order. The scores reported all represent the positively worded versions of negatively worded items through data analysis. The Likert scale bears the Cronbach's alpha reliability coefficient as 0.727 and the validity of 0.853.

Table – 4 Summary Of PPPSSLQ

Measuring Variable	Level/ Dimension	Initial try-out item	Item analysis technique	Final item	Reliability	Validity
Peers Scaffolding (PS)	Level I: Parallel; Level II: Associative; Level III: Cooperative.	111	Popularity test	60	0.727	0.853

Description of Science Achievement Test (SAT)

The science textbook (2014) for 6th standard class following WBBSE curriculum of study is thoroughly reviewed for the selection of lessons for which the problem solving and play way method can be applied. The total selected lesson is divided into three units for which separate achievement test is developed.

The achievement tests cover the dimension of Understanding, Application and Skill level where analyzing, evaluating and creating objectives are merged into Skill level as per the revised Bloom's taxonomy of educational objectives. The tests are constructed by MCQ 1 mark carrying for each right response in higher order cognitive levels. The blue print of the achievement test can be tabulated as –

Table – 5 Blue Print Of The Science Achievement Test

Content	Objective			Total	Weightage
	Understanding	Applying	Skill		
Unit I Science Achievement Test					
Changes around us	3	4	2	9	28%
Element, Compound and Mixture	12	6	5	23	72%
Total	15	10	7	32	100%
Unit II Science Achievement Test					
Measurement	7	6	4	17	53%
Elementary concepts of force and energy	8	4	3	15	47%
Total	15	10	7	32	100%
Unit III Science Achievement Test					
Motion and stationary state in gas and liquid	6	5	2	13	41%
Tools and lever	9	5	5	19	59%
Total	15	10	7	32	100%
Weightage	47%	31%	22%	100%	

The tests are developed as Criterion Referenced Test (CRT) in higher order cognitive levels after the exclusion of knowledge level objective. It is difficult for item analysis of CRT items as it is meaningless (Sax, 1974; Gronlund & Linn, 1985; Ebel & Frisbie, 2009; Anastasi & Urbina, 2010). Difficulty value should be determined with the objectives (Understanding, Application, Skill) of high content validity. Same is true for the discrimination index i.e. meaningless as the test objective should not reflect to assess individual difference rather than attainment of mastery of lessons and skill.

For the judgment of an item to be included in final test, the following criteria is considered –

Variable	Range of Value	Interpretation
Discrimination Index (DI)	0.40 & up	Very good item
	0.30 to 0.39	Good item
	0.20 to 0.29	Marginal item
	Below 0.19	Poor item
Difficulty Value (DV)	25% ≤ DV ≤85%	

However, the above criteria is not strictly maintained; some relaxation is considered in the final construction of the mastery test with an emphasis of retaining some items of high content validity. The final form of the three achievement test contained 32 items each distributed contentwise among understanding, application and skill level objective.

Table – 6 Summary Of SAT

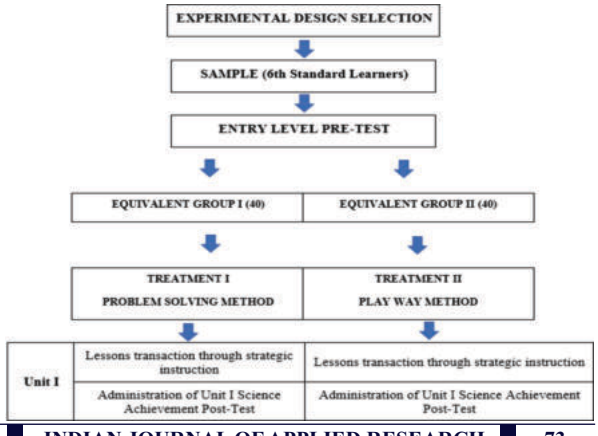
Tool	Measuring Variable	Initial try-out item	Item analysis technique	Final item	Reliability	Validity
Science Achievement Test (Unit I)	Achievement	48	Difficulty Value, Discrimination Index	32	0.643	0.802
Science Achievement Test (Unit II)	Achievement	41	Difficulty Value, Discrimination Index	32	0.637	0.798
Science Achievement Test (Unit III)	Achievement	47	Difficulty Value, Discrimination Index	32	0.651	0.807

Procedure of experimentation

Once the two equivalent halves through randomisation after the administration of entry level pre-test of the dependent variable are formulated, impartially for one (40) is treated by problem solving method (PSM) of teaching as suggested by research literature that scaffolding exerts impact through the agency of learners private speech and also consistent with Vygotsky's (1987) views that private speech emerges in greater proportion upon facing with problem solving situation and the rest half (40) by play way method (PWM) of teaching for his acknowledgement (1978) of the importance of play, a potential source of child's lot of freedom and autonomy in establishing tentative rules of playing, rule-governed practice in performance, imagination development and 'internal transformations' in child development during schooling age for the transaction of selected science lessons in three units.

We apply the group interaction model twice before the Unit I and Unit III post-test in order to ensure the occurrence of peers scaffolding. Based on the pre-test result, the researcher selected 12 high achiever students in each group. Then high achievers of PSM group are made to interact with the average and low achievers of PWM group in group activity such as to occur effective collaboration in joint problem solving, small range activity, group discussion before answer writing etc. and vice versa. Every time high achievers are selected based upon the result of last administered achievement test. We administered Unit II post-test without applying the group interaction model and peers scaffolding. The duration of the experiment was about for a period of two months. The execution of whole experimentation can be represented as –

RESEARCH DESIGN SELECTION



Unit II	Lessons transaction through strategic instruction	Lessons transaction through strategic instruction
	Administration of Unit I Science Achievement Post-Test	Administration of Unit I Science Achievement Post-Test
Unit III	Lessons transaction through strategic instruction	Lessons transaction through strategic instruction
	Administration of Unit I Science Achievement Post-Test	Administration of Unit I Science Achievement Post-Test
Administration of Peer Participation in Peers Scaffolding for Science Learning Questionnaire		

DATA ANALYSIS AND RESULTS

The sample responses are organised in tabular form by Microsoft Excel 2016 software to test the hypotheses framed according to the research objectives. The statistical techniques and tests of bar diagrams, descriptive statistics, t-test for mean difference are performed on the tabulated data in Excel worksheets for data analysis with interpretation.

Table – 7 t-test: Comparison Of Peers Scaffolding Between PSM And PWM Groups

Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
Peers scaffolding of PSM group	40	217.05	29.87	78	0.64	0.52	Not Significant at 0.05 level
Peers scaffolding of PWM group	40	212.95	27.39				

$t(78) = 0.64, p > 0.05$

Thus, the mean score (217.05) of peers scaffolding for problem solving method instructed group does not significantly differ from that (212.95) of play way method instructed group.

Table – 8 t-test: Comparison Of Unit I, Unit II And Unit III Achievement For PSM

$^0H_{2.x.}$	Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
$^0H_{2.1.}$	Unit I Achievement of PSM	40	16.23	4.60	78	1.37	0.17	Not Significant at 0.05 level
	Unit II Achievement of PSM	40	14.85	4.36				
$^0H_{2.2.}$	Unit III Achievement of PSM	40	17.33	4.59	78	2.47	0.02	Significant at 0.05 level
	Unit II Achievement of PSM	40	14.85	4.36				

$^0H_{2.1.} - t(78) = 1.37, p > 0.05$; $^0H_{2.2.} - t(78) = 2.47, p < 0.05$

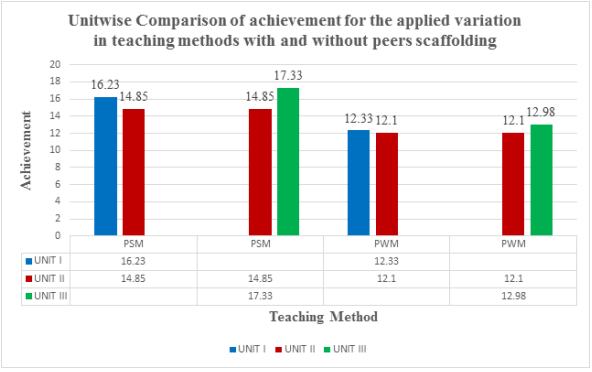
In PSM, although the mean score (16.23) of Unit I achievement does not significantly differ from that (14.85) of Unit II achievement for testing $^0H_{2.1.}$, the 't' value 2.47 for $^0H_{2.2.}$ is significant at 0.05 level suggesting, thereby, Unit III achievement differ significantly from Unit II achievement i.e. peers scaffolding exerts significant effect on Unit III achievement in unit differentiation in terms of achievement after the treatment.

Table – 9 t-test: Comparison Of Unit I, Unit II And Unit III Achievement For PWM

$^0H_{2.x.}$	Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
$^0H_{2.3.}$	Unit I Achievement of PWM	40	12.33	3.83	78	0.27	0.79	Not Significant at 0.05 level
	Unit II Achievement of PWM	40	12.10	3.74				
$^0H_{2.4.}$	Unit III Achievement of PWM	40	12.98	5.08	78	0.88	0.38	Not Significant at 0.05 level
	Unit II Achievement of PWM	40	12.10	3.74				

$^0H_{2.3.} - t(78) = 0.27, p > 0.05$; $^0H_{2.4.} - t(78) = 0.88, p > 0.05$

In PWM, both the 't' values appear not to be significant i.e. peers scaffolding fails to exert significant effect on Unit I and III achievement i.e. closed to Unit II achievement in terms of mean score.

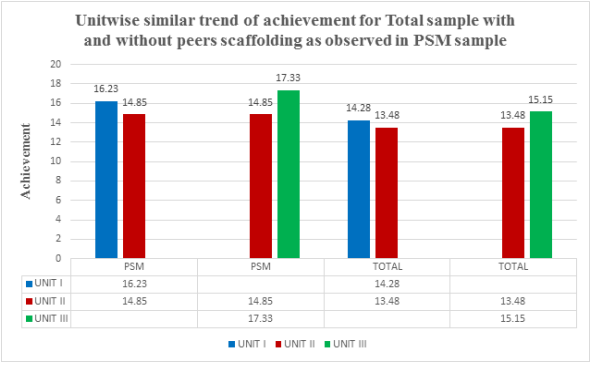


Table–10 t-test: Comparison Of Unit I, Unit II And Unit III Achievement For All Learners

$^0H_{2.x.}$	Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
$^0H_{2.5.}$	Unit I Achievement of All learners	80	14.28	4.64	158	1.14	0.26	Not Significant at 0.05 level
	Unit II Achievement of All learners	80	13.48	4.27				
$^0H_{2.6.}$	Unit III Achievement of All learners	80	15.15	5.28	158	2.21	0.03	Significant at 0.05 level
	Unit II Achievement of All learners	80	13.48	4.27				

$^0H_{2.5.} - t(158) = 1.14, p > 0.05$; $^0H_{2.6.} - t(158) = 2.21, p < 0.05$

When the analysis is merged for the differentially treated all the sample, the above table follows the trend of effect of peers scaffolding on achievement overall as yielded by the learners instructed by PSM of teaching i.e. the dominance of the effect of PSM over PWM of teaching in the analysis of total sample observed.



DISCUSSION

There is no effect of peers scaffolding on teaching methods i.e. peers scaffolding is found to independent of the applied variation in teaching methods. Learner's participation in peer collaboration and peers scaffolding for science learning exert significant effect merely in Unit III science achievement for the learners instructed by PSM of teaching and

the analysis for the whole learners consisting with other studies of K. D. Simons and J. D. Klein, 2007; K. Morgan and D. W. Brooks, 2012; S. Shin, T. A. Brush and K. D. Glazewski, 2020a; B. Barron, 2003; D. T. Brookes, Y. Yang and B. Nainabasti, 2021; K. D. Konings, M. van Zundert and J. J. G. van Merrienboer, 2019; S. R. Ghazi, U. S. Gilani and G. Shahzada, 2013; D. Fung, V. Hung and W. Lui, 2018. That rings true to avoid emerging frustration during problem solving adjusted at appropriate task difficulty level rather than the reduction in task itself functioning for independent competence level through the agency of scaffolding (Diaz, Neal & Amaya-Williams, 1990; Lu & Law, 2012). Imposing optimal challenge in problem solving mode of instruction facilitates learners competence cum performance after the needs of scaffolding best suited and tuned to their ability level within the zone of proximal development (Kim, Belland & Axelrod, 2019), thereby, duly validating instructor-prompted questioning being more effective in ill-structured problem solving task (Byun, Lee & Cerreto, 2014; Ge & Land, 2003). Peer collaboration in joint problem solving or collective learning is not found to exhibit significant effect in case of Unit I science achievement (Cheng & Ku, 2009; Martin, Gnesdilow & Puntambekar, 2015) in spite of the installation of group interaction model in the two experimental groups at the prevailing conditions of expert and novice combination. Although the expert and novice interaction found optimum during task performance (Azmitia, 1992; Saleh, Lazonder & de Jong, 2005), our analysis does not support the view for Unit I science achievement only. It is due to the closeness of their mean achievement scores at moderate level in the higher order learning outcome after the exclusion of knowledge level learning objective. Sometimes novices do differently from experts to identify a faulty diagnosis task in an electric circuit outperforming experts (Besnard & Bastien-Toniazzo, 1999), thereby, creating a chance for lesser interaction. Regardless of peers scaffolding, there is an invariable trend of learner's achievement in science demonstrated for the instruction exerted by PWM of teaching. This is in contradictory to the study of K. R. Fisher, K. Hirsh-Pasek, N. Newcombe, R. M. Golinkoff, 2013 where guided play instructed group yielded higher gain of shape knowledge compared to free play or didactic instructed group; D. E. Kanter, S. Honwad, J. D. Adams and A. Fernandez, 2011 where guided play promoted inquiry-based science learning and A. Saleh, C. Yuxin, C. E. Hmelo-Silver, K. D. Glazewski, B. W. Mott, J. C. Lester, 2020 too.

Educational implication

[i] The teacher should provide ample opportunity for interaction among students in problem solving method of instruction.

[ii] But the teacher should cautiously control the group activity exposed in multiplicity of opportunities for play way mode of instruction such as to occur effective peer learning as our data does not support the peer interaction for peer learning reflected in achievement in play way instruction.

[iii] Use of group interaction model is suggested i.e. high achiever of one section should be interacted with average and low achiever of other section for effective interaction cum scaffolding.

[iv] The science teachers should create varieties of learning contexts both at individual and group level. It helps to fulfil learner's rich opportunities, experiences in learning science arguably to judge acquired knowledge into new situations.

[v] On implementing scaffolding strategies, learner's autonomy should be preserved along with the maintenance of their task interest.

CONCLUSION

Advancement in science education adversely profits a nation towards its technological field of development. Day-to-day innovation, strategical improvement on science application should be enhanced at par the pace with globalization. Thus to develop and hence nourish, cultivate the spirit of science among the budding science learners at grassroot level, scaffolding for science learning bears a pivotal role for maintaining and sustaining the interest of science. The present study reveals the significance of peers scaffolding as an worth strategy for Unit III science achievement for the instructions exerted by problem solving method of teaching. There should be enough space for social interaction among the science learners about the creation of learner's curiosity, eagerness, zeal for natural phenomena, however, to whatever extent evoked along with already present, should be oriented properly in line with science's views away from the possibility of emerging misconception during the co-construction of knowledge. Thus instructors should carefully note about the specific components of scaffolding e.g. prompting, peers cooperative activities, sharing specific strategy, being tolerable with other's contradictory views etc at specific relevance to have remarkably desired effect in the direction of effective science learning. That is scaffolding should be imparted dynamically on observing the learner's progress on a tsk and then gradually faded in accordance to their independent competence.

REFERENCES

1. Anastasi, A., & Urbina, S. (2010). *Psychological testing*. New Delhi: PHI Learning.
2. Azer, S. A. (2009). Interactions between students and tutor in problem-based learning: The significance of deep learning. *The Kaohsiung Journal of Medical sciences,* 25(5), 240-249. doi:10.1016/S1607-551X(09)70068-3
3. Azmitia, M. (1992). Expertise, private speech and the development of self-regulation. In R. M. Diaz, & L. E. Berk (Eds.), *Private speech: From social interaction to self-regulation*. Hillsdale, NJ: Erlbaum. Retrieved from Amazon kindley edition.
4. Barron, B. (2003). When smart groups fail. *The Journal of the Learning Sciences,* 12(3), 307-359. doi:10.1207/S15327809JLS1203_1
5. Behrend, D. A., Rosengren, K., & Perlmutter, M. (1989). A new look at children's private speech: The effects of age, task difficulty, and parent presence. *International journal of behavioural development,* 12(3), 305-320. doi:10.1177/016502548901200302
6. Belland, B. R. (2011). Distributed cognition as a lens to understand the effects of scaffolds: The role of transfer of responsibility. *Educational Psychology Review,* 23(4), 577-600. doi:10.1007/s10648-011-9176-5
7. Benson, B. K. (1997). Coming to terms: Scaffolding. *The English Journal,* 86(7), 126-127. doi:10.2307/819879
8. Berk, L. E., & Spuhl, S. T. (1995). Maternal interaction, private speech, and task performance in preschool children. *Early childhood research quarterly,* 10(2), 145-169. doi:10.1016/0885-2006(95)90001-2
9. Berk, L. E., & Winsler, A. (1995). *Scaffolding children's learning: Vygotsky and early childhood education*. Washington, DC: National Association for the Education of Young Children.
10. Besnard, D., & Bastien-Toniazzo, M. (1999). Expert error in trouble-shooting: an exploratory study in electronics. *International Journal of Human-Computer Studies*, 50(5), 391-405. doi:10.1006/ijhc.1999.0251
11. Brookes, D. T., Yang, Y., & Nainabasti, B. (2021). Social positioning in small group interactions in an investigative science learning environments physics class. *Physical Review Physics Education Research,* 17(1), 010103-1 – 010103-13. doi:10.1103/PhysRevPhysEducRes.17.010103
12. Broza, O., & Kolikant, Y. B.-D. (2015). Contingent teaching to low-achieving students in mathematics: challenges and potential for scaffolding meaningful learning. *ZDM Mathematics Education,* 47(7), 1093-1105. doi:10.1007/s11858-015-0724-1
13. Byun, H., Lee, J., & Cerreto, F. A. (2014). Relative effects of three questioning strategies in ill-structured small group problem solving. *Instructional Science,* 42(2), 229-250. doi:10.1007/s11251-013-9278-1
14. Cheng, Y.-C., & Ku, H.-Y. (2009). An investigation of the effects of reciprocal peer tutoring. *Computers in Human Behavior,* 25(1), 40-49. doi:10.1016/j.chb.2008.06.001
15. Cho, K., & MacArthur, C. (2010). Student revision with peer and expert reviewing. *Learning and Instruction,* 20(4), 328-338. doi:10.1016/j.learninstruc.2009.08.006
16. Decristan, J., Hondrich, A. L., Buttner, G., Hertel, S., Klieme, E., Kunter, M., … Hardy, I. (2015). Impact of additional guidance in science education on primary students' conceptual understanding. *The Journal of Educational Research,* 108(5), 358-370. doi:10.1080/00220671.2014.899957
17. Diaz, R. M., Neal, C. J., & Amaya-Williams, M. (1990). The social origins of self-regulation. In L. C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of sociohistorical psychology* (pp. 127-154). Cambridge: Cambridge University Press.
18. Duran, D., & Monero, C. (2005). Styles and sequences of cooperative interaction in fixed and reciprocal peer tutoring. *Learning and Instruction,* 15(3), 179-199. doi:10.1016/j.learninstruc.2005.04.002
19. Ebel, R. L., & Frisbie, D. A. (2009). *Essentials of educational measurement*. New Delhi: PHI Learning.
20. Ertmer, P. A., & Glazewski, K. D. (2019). Scaffolding in PBL environments: Structuring and problematizing relevant task features. In M. Moallem, W. Hung, & N. Debbagh (Eds.), *The Wiley handbook of problem-based learning* (pp. 321-342). New Jersey, USA: Wiley Blackwell.
21. Eshach, H., Dor-Ziderman, Y., & Arbel, Y. (2011). Scaffolding the "Scaffolding" Metaphor: From inspiration to a practical tool for kindergarten teachers. *Journal of Science Education and Technology,* 20(5), 550-565. doi:10.1007/s10956-011-9323-2
22. Fisher, K. R., Hirsh-Pasek, K., Newcombe, N., & Golinkoff, R. M. (2013). Taking shape: Supporting preschoolers' acquisition of geometric knowledge through guided play. *Child Development*, 84(6), 1872-1878. doi:10.1111/cdev.12091
23. Fung, D., Hung, V., & Lui, W. (2018). Enhancing science learning through the introduction of effective group work in Hong Kong secondary classrooms. *International Journal of Science and Mathematics Education*, 16(7), 1291-1314. doi:10.1007/s10763-017-9839-x
24. Gallimore, R., & Tharp, R. (1990). Teaching mind in society: Teaching, schooling, and literate discourse. In L. C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of sociohistorical psychology* (pp. 175-205). Cambridge: Cambridge University Press.
25. Ge, X., & Land, S. M. (2003). Scaffolding students' problem-solving processes in an ill-structured task using question prompts and peer interactions. *Educational Technology Research and Development*, 51(1), 21-38. doi:10.1007/BF02504515
26. Ghazi, S. R., Gilani, U. S., & Shahzada, G. (2013). Comparison of students' academic achievement in scaffolding based self-regulated learning system and formal system of learning at higher education level. *International Journal of Research in Social Sciences*, 3(2), 134-143.
27. Gielen, S., Peeters, E., Dochy, F., Onghena, P., & Struyven, K. (2010). Improving the effectiveness of peer feedback for learning. *Learning and Instruction,* 20(4), 304-315. doi:10.1016/j.learninstruc.2009.08.007
28. Gielen, S., Tops, L., Dochy, F., Onghena, P., & Smeets, S. (2010). A comparative study of peer and teacher feedback and of various peer feedback forms in a secondary school writing curriculum. *British Educational Research Journal,* 36(1), 143-162. doi:10.1080/01411920902894070
29. Gnadinger, C. M. (2008). Peer-mediated instruction: assisted performance in the primary classroom. *Teachers and Teaching: theory and practice,* 14(2), 129-142. doi:10.1080/13540600801965945
30. Gronlund, N. E., & Linn, R. L. (1985). *Measurement and evaluation in teaching* (6th ed.). New York: Macmillan Publishing Company.
31. Harlen, W., & Elstgeest, J. (1997). *UNESCO sourcebook for science in the primary school: A workshop approach to teacher education*. New Delhi: National Book Trust.
32. Hogan, K., & Pressley, M. (1997). Scaffolding scientific competencies within classroom communities of inquiry. In K. Hogan & M. Pressley (Eds.), *Scaffolding student learning Instructional approaches and issues* (pp. 74-107). Cambridge, Massachusetts: Brookline Books.
33. Hovardas, T., Tsivitanidou, O. E., & Zacharia, Z. C. (2014). Peer versus expert feedback: An investigation of the quality of peer feedback among secondary school students. *Computers & Education,* 71, 133-152. doi:10.1016/j.compedu.2013.09.019
34. Hsin, C.-T., & Wu, H.-K. (2011). Using scaffolding strategies to promote young children's scientific understandings of floating and sinking. *Journal of Science Education and Technology,* 20(5), 656-666. doi:10.1007/S10956-011-9310-7
35. Kanter, D. E., Honwad, S., Adams, J. D., & Fernandez, A. (2011). Guided play for

science learning in middle school. *Children, Youth and Environments*, 21(2), 360-382.
36. Kim, N. J., Belland, B. R., & Axelrod, D. (2019). Scaffolding for optimal challenge in K-12 problem-based learning. *The Interdisciplinary Journal of Problem-based Learning*, 13(1). doi:10.7771/1541-5015.1712
37. Kollar, I., & Fischer, F. (2010). Peer assessment as collaborative learning: A cognitive perspective. *Learning and Instruction,* 20(4), 344-348. doi:10.1016/j.learninstruc.2009.08.005
38. Konings, K. D., van Zundert, M., & van Merrienboer, J. J. G. (2019). Scaffolding peer-assessment skills: Risk of interference with learning domain-specific skills? *Learning and Instruction,* 60, 85-94. doi:10.1016/j.learninstruc.2018.11.007
39. Landry, S. H., Miller-Loncar, C. L., Smith, K. E., & Swank, P. R. (2002). The role of early parenting in children's development of executive processes. *Developmental neuropsychology,* 21(1), 15-41. doi:10.1207/S15326942DN2101_2
40. Lin, S. S. P., & Samuel, M. (2013). Scaffolding during peer response sessions. *Procedia – Social and Behavioral Sciences,* 90, 737-744. doi:10.1016/j.sbspro.2013.07.147
41. Lu, J., & Law, N. (2012). Online peer assessment: effects of cognitive and affective feedback. *Instructional Science,* 40(2), 257-275. doi:10.1007/s11251-011-9177-2
42. Martin, N. D., Gnesdilow, D., & Puntambekar, S. (2015). Peer scaffolding to learn science in symmetrical groups collaborating over time. In O. Lindwall, P. Häkkinen, T. Koschman, P. Tchounikine, & S. Ludvigsen (Eds.), *Exploring the Material Conditions of Learning: Vol. 1. The Computer Supported Collaborative Learning* (pp. 340-347). doi:10.22318/cscl2015.320
43. Morgan, K., & Brooks, D. W. (2012). Investigating a method of scaffolding student-designed experiments. *Journal of Science Education and Technology,* 21(4), 513-522. doi:10.1007/s10956-011-9343-y
44. Newson, J., & Newson, E. (1975). Intersubjectivity and the transmission of culture: On the social origins of symbolic functioning. *Bulletin of the British Psychological Society*, 28, 437-446. Abstract retrieved from https://psycnet.apa.org/record/1979-03234-001
45. Panagiotis, P., & Panagiotis. K. Discourse analysis as a tool for the transformation of teacher's talk companion meanings about NOS, NOT and NOL.
46. Parten, M. B. (1932). Social participation among pre-school children. *The Journal of Abnormal and Social Psychology,* 27(3), 243-269. doi:10.1037/h0074524
47. Pata, K., Lehtinen, E., & Sarapuu, T. (2006). Inter-relations of tutor's and peer's scaffolding and decision-making discourse acts. *Instructional Science,* 34(4), 313-341. doi:10.1007/s11251-005-3406-5
48. Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *The Journal of The Learning Sciences,* 13(3), 423-451. doi:10.1207/s15327809jls1303_6
49. Pishghadam, R., & Ghadiri, S. (2011). Symmetrical or asymmetrical scaffolding: Piagetian vs. Vygotskyan views to reading comprehension. *Journal of Language and Literacy Education,* 7(1), 49-64.
50. Pratt, M. W., Kerig, P., Cowan, P. A., & Cowan, C. P. (1988). Mothers and fathers teaching 3-year-olds: Authoritative parenting and adult scaffolding of young children's learning. *Developmental psychology,* 24(6), 832-839. doi:10.1037/0012-1649.24.6.832
51. Puntambaker, S., & Kolodner, J. L. (2005). Toward implementing distributed scaffolding: Helping students learn science from design. *Journal of Research in Science Teaching,* 42(2), 185-217. doi:10.1002/tea.20048
52. Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E., Duncan, R. G., Kyza, E., Edelson, D., & Soloway, E. (2004). A scaffolding design framework for software to support science inquiry. *The Journal of The Learning Sciences,* 13(3), 337-386. doi:10.1207/s15327809jls1303_4
53. Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *The Journal of The Learning Sciences,* 13(3), 273-304. doi:10.1207/s15327809jls1303_2
54. Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. Oxford, UK: Oxford University Press.
55. Rojas-Drummond, S., Torreblanca, O., Pedraza, H., Velez, M., & Guzman, K. (2013). 'Dialogic scaffolding': Enhancing learning and understanding in collaborative contexts. *Learning, Culture and Social Interaction,* 2(1), 11-21. doi:10.1016/j.lcsi.2012.12.003
56. Saleh, M., Lazonder, A. W., & de Jong, T. (2005). Effects of within-class ability grouping on social interaction, achievement, and motivation. *Instructional Science,* 33(2), 105-119. doi:10.1007/s11251-004-6405-z
57. Saleh, A., Yuxin, C., Hmelo-Silver, C. E., Glazewski, K. D., Mott, B. W., & Lester, J. C. (2020). Coordinating scaffolds for collaborative inquiry in a game-based learning environment. *Journal of Research in Science Teaching*, 57(9), 1490-1518. doi:10.1002/tea.21656
58. Sax, G. (1974). *Principles of educational measurement and evaluation*. California: Wadsworth Publishing Company.
59. Schwieter, J. W. (2010). Developing second language writing through scaffolding in the ZPD: A magazine project for an authentic audience. *Journal of College Teaching and Learning,* 7(10), 31-46. doi:10.19030/tlc.v7i10.154
60. Sherin, B., Reiser, B. J., & Edelson, D. (2004). Scaffolding analysis: Extending the scaffolding metaphor to learning artifacts. *The Journal of The Learning Sciences,* 13(3), 387-421. doi:10.1207/s15327809jls1303_5
61. Shin, S., Brush, T. A., & Glazewski, K. D. (2020a). Examining the hard, peer, and teacher scaffolding framework in inquiry-based technology-enhanced learning environments: impact on academic achievement and group performance. *Educational Technology Research and Development*, 68(5), 2423-2447. doi:10.1007/s11423-020-09763-8
62. Shin, S., Brush, T. A., & Glazewski, K. D. (2020b). Patterns of peer scaffolding in technology-enhanced inquiry classrooms: application of social network analysis. *Educational Technology Research and Development*, 68(5), 2321-2350. doi:10.1007/s11423-020-09779-0
63. Simons, K. D., & Klein, J. D. (2007). The impact of scaffolding and student achievement levels in a problem-based learning environments. *Instructional Science,* 35(1), 41-72. doi:10.1007/s11251-006-9002-5
64. Tabak, I. (2004). Synergy: A complement to emerging patterns of distributed scaffolding. *The Journal of The Learning Sciences,* 13(3), 305-335. doi:10.1207/s15327809jls1303_3
65. Tharp, R. G., & Gallimore, R. (1988). *Rousing minds to life Teaching, learning, and schooling in social context.* Cambridge: Cambridge University press.
66. Trif, L. (2015). Training models of social constructivism. Teaching based on developing a scaffold. *Social and Behavioral Sciences,* 180, 978-983. doi:10.1016/j.sbspro.2015.02.184
67. Vygotsky, L. S. (1978). The role of play in development. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), *Mind in society: The development of higher psychological processes* (pp. 92-104). Cambridge: Harvard University Press.
68. Vygotsky, L. S. (1987). Thought and word. In R. W. Rieber & A. S. Carton (Eds.), *The collected works of L. S. Vygotsky: Vol. 1 Problems of general psychology* (pp. 243-285). New York: Plenum press.
69. Webb, N. M., Baxter, G. P., & Thompson, L. (1997). Teachers' grouping practices in fifth-grade science classrooms. *The Elementary School Journal,* 98(2), 91-113. doi:10.1086/461886
70. Wertsch, J. V. (1984). The zone of proximal development: Some conceptual issues. In B. Rogoff & J. V. Wertsch (Eds.), *Children's learning in the "Zone of Proximal development" New directions for child development,* 23, 7-18. San Francisco: Jossey-Bass. doi:10.1002/cd.23219842303
71. West Bengal Board of Secondary Education (2014). পরিবেশ ও বিজ্ঞান। Park Street, Kolkata: WBBSE.
72. White, C. S., & Manning, B. H. (1994). The effects of verbal scaffolding instruction on young children's private speech and problem-solving capabilities. *Instructional Science,* 22(1), 39-59. doi:10.1007/BF00889522
73. Winsler, A., Diaz, R. M., & Montero, I. (1997). The role of private speech in the transition from collaborative to independent task performance in young children. *Early childhood research quarterly,* 12(1), 59-79. doi:10.1016/S0885-2006(97)90043-0
74. Wood, D. J., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry,* 17 (2), 89-100. doi:10.1111/j.1469-7610.1976.tb00381.x