International Journal of Research in Social Sciences
Vol. 10 Issue 09, September 2020
ISSN: 2249-2496 Impact Factor: 7.081
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Effect of internalization as evincive on academic achievement in science

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Abstract: Concept internalization is conceived as the pre-requisite condition for achievement through the agency of self-regulation of learning science. Internalization is the individualway of structural and functional transformation of external relations into internal reconstruction of conception leading to task mastery with ease in appropriation of cultural mediational tools. It establishes a shift from inter-psychological plane to intra-psychological plane of consciousness even functional with automatization in the absence of concrete external links.It minimizes the probability of rote memorisation in higher order science learning objectives.The on hand study is committed to disclose the effective circumstantial outcome of internalization upon science achievement through the selection of specific experimental manipulation. Eighty 6th standard learners from an HS rural govt.-aided school following the state board (WBBSE) curriculum of study serve as participants of the experimental study – divided into two equivalent halvesthrough randomisation after the administration of entry level pre-test of the dependent variable – impartially for one (40) is treated by problem solving method (PSM) of teaching and the rest half (40) by play way method (PWM) of teaching for the transaction of selected science lessons in three units. Internalization and achievement data are obtained by the application of SLIQ scale and SAT in three units respectively after the instructions of nearly two months duration. PSM is found to the predictor of science achievement in higher order cognitive levels for all the three units. But no efficiency of PSM over PWM is established in terms of learner's concept internalization scores. The two-way 3 (Unit I vs Unit II vs Unit III) x 2 (PSM vs PWM) ANOVA revealed the significant main effect of only teaching method on achievement. Concept internalization exerts significant effect on Unit I achievement for the learners instructed by PSM of teaching. But no effect evinced for average and low level internalized group on Unit II and Unit III achievement for PSM group. The effect was overall significant except average and low level internalized group of learners instructed by PWM of teaching in all the three units. The analysis for total sample follows the trend yielded by the learners instructed by PSM of teaching. Finally, we sum up our analysis cum discussion through some educational implications about science teaching learning in line with our major research findings.

Keywords: Internalization, Achievement, Science lessons, Teaching method, Experimental manipulation.

Introduction

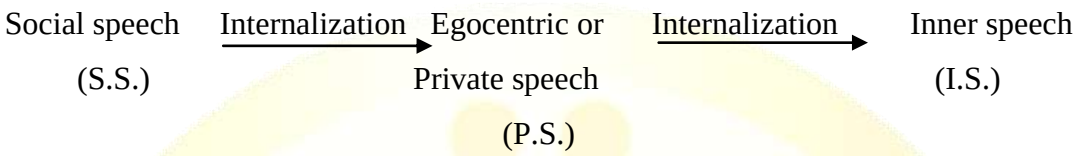
Constructivism is a theoretical approach for processing 'How' aspect of learning rather than 'What' aspect of gain in learning. It lays great emphasis on how the knowledge is constructed by the learners through their active participation in their own learning tasks. Prior to the individual construction of knowledge, the learners have to involve in on-going co-construction of knowledge through social interaction with others as envisaged by social constructivism. Thus, it deals with the constructive mechanism of learning. This internal reconstruction of knowledge from outward interaction is termed as internalization (Vygotsky, 1978a). As a social constructivist, L. S. Vygotsky was the forerunner to convey the term internalization.

Internalization refers to the individual's external part of being internal higher mental functions. It involves the shift of external activity from inter-psychological plane to the mediated activity at intra-psychological plane. That is the outward physical activity now takes the form of inward psychological activity as a result of internalization (Lantolf, 2003) and without the immediate presence of concrete objects or peripheral situation, one can gradually develop the ability for mental representation, action with automatization after the mastery in task and verbal formattained (Galperin, 1967; Clowes, 2006). The transition from material object dependent activity to material independent psychological activity occurs through the mediation of psychological tools, signs, symbols establishing the bridge between external and internal affairs of relation. This process of mediation gradually replaces the real incidence; material means of activity becomes subordinate or secondary to mental activity (Zinchenko, 1985; Kozulin, 1999).

Language functions as the potential mediator for the centre of various activities(Vygotsky, 1987; Bodrova& Leong, 2007; van der Veer, 2007; Pritchard, 2009).It is a means for communication among people participating in a social activity, formal and informal discussion. It bears messages from one orator to other, thereby, facilitating the transition of message from social plane to individual plane and viceversa. Thus, it converts content of message into thought and viceversa accommodating the acquisition of new information. But children's early form of speech serves communicative function rather than intellectual function (Vygotsky, 1987; Guerrero, 2005). It is termed as social speech pertinent to the interaction with animate creatures or inanimate objects. Exchange of information at inter-mental level occurs both by formal and informal way of talking. It is vital for adaptation to establish a first-hand immediate connection with surroundings. At this stage of infancy, there is no trace of thought in language rather infant satisfy his/her

need through creating unique sound, speech, body gesture, inclining body parts to desired objects.The child imparts the function of asking, conveying information, demanding, begging with the help of this kind of speech. Social speech undergoes the process of internalization developing to inner speech through the agency of private speech with the increase in age. Speech internalization follows the developmental trajectory as below.

 Process of internalization



Thought and speech start to get merged at nearly age 3 onwards. Speech is gradually going to become mature due to the attachment of thought process. When there is an attempt for in search of a solution of problem, then speech becomes a tool to find mediational means of the task performance. This kind of intermediary speech is private speech directed to the self only. Although directed to self, this kind of intermediary private speech retains social character due to its origination from social speech.It is dialogic in character only within the capacity of self. Thus, it is sometimes termed as self-talk, self-verbalization. One who talks about a situation interprets possible alternatives of a situation only selfly.The querist and the respondent are same – the self. Thus, it is self-directed acommunicative speech. It has self-regulatory functions like planning, critiquing. It helps to organize behaviours, perceive situations and surmount difficulties of emerging situations. It emerges in greater proportion on facing with problematic task.

As child grows, private speech does not disappear but goes 'underground', called inner speech(Vygotsky, 1987). It is cent percent internal, inaudible. Self-directed private speech when gradually loses its audible character to whispered speech it appears like silent lip movements in on-going thought process. Representation of social behaviour now takes the inner form of ideas in conscious thought fully inside one's head (Winsler, 2009). It is fragmentated, condensed, abbreviated with predominance of sense over meaning in covert form. By nature, it is a function of thought connected with words – it 'involves the evaporation of speech into thought' (Vygotsky, 1987, p. 257, 280). It helps in children's writing process. It can be accessible to psychologist through think aloud method, introspection (Bakhurst, 1991).

Thus, Vygotsky highlighted the process of mediational means being instituted in individuals, shrinking in inner speech towards inward transition. It is not a simple direct

transfer of external operation rather the formation of internal plane of consciousness (Leont'ev, 1981). James V. Wertsch (1998) introduces the construct from two different angles – internalization as mastery and that as appropriation. The first one is the mastery or expertising ability of using cultural tools through mediated action i.e. how one handles with ease in dealing the acquired cultural tools with an emerging problem solving task. He also termed it as 'an image' of external operation in internal plane of consciousness. Next, internalization as appropriation means employing of cultural tools within the limit of available resources after ignoring the some sort of perceived constraints between mediational means and unique use in mediated action. Thus, internalization is the transformation of external operation into internal intra-personal psychological process rather than only transmission (Vygotsky, 1978a; Wertsch& Stone, 1985; Raven, 2003; Guerrero,2005; Clowes, 2006; Gillespie, 2006; Susswein, Bibok&Carpendale, 2007). It accompanied the structural and functional developmental changes in emerging social behaviour (Guerrero,2005). Learners thought expressed in speech attributed not to the chance factor rather their judicious choice of words. There must be personal meaning making of natural phenomena, not verbatim learning of repetition of exact words or phrases as instructed by science teachers. It is the process of reconstruction of conceptual foundation for accommodating objective and subjective interpretation of scientific facts, concepts. Thus, internalization can be regarded as the prolonged extended processes of developmental events (Vygotsky, 1978a).

As language shapes one's behaviour, decision making in response to other's social stimuli and becomes a tool for thought (Vygotsky, 1997; Kozulin, 1998; Bertau, 2007), we consider speech internalization as respective thought internalization as speech and thought are intertwined with each other as an inseparable entity at age 3 onwards (Vygotsky, 1987). We manipulate the selection of teaching methods (PSM & PWM) to exert science lesson internalization effectively in line with Vygotsky's interpretation that problem solving situation evokes to elicit private speech (Vygotsky, 1987) and his acknowledgement of play in child development during school age (Vygotsky, 1978b).

Research literature

A growing body of research literature on Vygotsky's tenets of internalization is basically focused on the investigation of intermediary private speech in the developmental trajectory of speech internalization for its observable properties facilitating assessment (Zivin, 1979; Berk, 1992; Diaz & Berk, 1992; Winsler, 2009; Winsler, Fernyhough& Montero, 2009). In

contrast, there is little research evidence for higher level more mature covert form of speech i.e. inner speech due to its complication in operational measure and complex psychometric properties. Research related documentation on children's private speech extensively conducted in problem solving situation. A handsome of study encompasses through the classroom discourse analysis in social settings where social interaction receives considerable weightage. Classroom discourse analysis studies of internalization of scientific concepts in terms of sign (symbol) and language system adopt the qualitative research methodology while most quantitative researchers consider only the speech internalization (Berk, 1992; Scott, 1996, 1997; Mortimer & Scott, 2000; Winsler, 2009).

The relation between private speech and task performance varies as a function of learner's expertising ability, age, grade, gender, intelligence, form of speech, type of task etc. More competent learners are susceptible to use more private speech during problem solving task than novices (Roberts, 1979) and expert children's private speech got diminished across the four sessions supports the internalization of private speech over time (Azmitia, 1992).Azmitia's (1992) sample evinced substantial self-verbalization about the different aspect of problem solving task when sufficient knowledge about the task remains within their reach of perception and the speech performance relation as significant for both age-appropriate and difficult task consisting with the study of J. Beaudichon (1973), D. A. Behrend, K. Rosengren and M. Perlmutter (1989), F. Smolucha (1992), P. Feigenbaum (1992) and in contradictory to the study of P. P. Goudena (1992). But private speech elicitation was optimum in case of task of medium difficulty regardless of parental scaffolding (Behrend et al., 1989; Fernyhough& Fradley, 2005). The performance of cognitively challenging academic task other than non-academic task were accompanied with the overall incidence of private speech specifically for describing own activity, reading aloud, inaudible muttering form of private speech (Berk & Garvin, 1984). In addition goal-directed activity found the better predictor of learner's private speech (Winsler& Diaz, 1995). On-task task relevant private speech correlated with the increase in task difficulty that specifically in reading aloud form from past experience of successful task completion and gender effect favours the girls for private speech internalization (Roberts, 1979). Less competent learners found to engage in task irrelevant speech irrespective of the imposed difficulty on task during task performance while more capable counterparts used this form of speech after task completion. Less capable learners tended to evaluate task before its completion. Thus, more difficult the task the greater the amount of elicitation of private speech (Kohlberg, Yaeger &Hjertholm 1968). Here, intelligence

was found to be the predictor of private speech internalization. Bright children being at cognitively more advanced level demonstrated private speech internalization at early years of age i.e. reflected in task execution. But J. H. Flavell and A. A. Wong (2009) found no significant age difference in executing overt and covert speech operated task. The data analysis from their follow-up study acknowledged the role of covert speech in task performance.

C. S. White and M. Daugherty (2009) were interested in examining private speech in relation to creativity for challenging problem solving task. Their three studies revealed strong positive correlation of solving, task-relevant and self-directed category of private speech with fluency and originality components of creativity. High creative children used private speech for task orientation, task execution with high incidence of task-relevant, coping/reinforcing, solving speech.

On contrary, high incidence of private speech was observed for consistently lower performance in problem solving task (Frauenglass& Diaz, 1985). Also, overall no relation between private speech and task performance evinced except positive association for inner speech (Winsler&Naglieri, 2003). For whispered and muttered speech during task performance children possessed more academic achievement. That ringed true for younger children in case of overt private speech. Private speech exerted no effect on high achievers in addition to the poor performance of high achievers with overt private speech, but low achievers with partially covert speech did better on the task assigned. But high achievers all reported their covert use of speech. Thus, speech-performance relationship is complex and dynamic in nature. J. A. Bivens and L. E. Berk (1990) found the relation as linear and significant at several condition in moderate level strength in correlation. But first graders task relevant external speech positively and significantly related to second graders achievement as quadratic correlation. Only externalized inner speech established significant association with achievement at grade 2 for concurrent task performance in consistent with the study of L. E. Berk (1986), C. Fernyhough and E. Fradley (2005). Task relevant speech found to better predictor of future task performance than concurrent task performance (Azmitia, 1992; Gaskill & Diaz, 19991). Again, learner's private speech found better predictor of task performance cum improvement in case of label and description of classification task (Gaskill & Diaz, 1991). Here the speech performance relation found for controlling the task difficulty. For concurrent classwork performance, private speech failed to reach at significance level to correlate (Berk, 1986). Although task relevant external speech and externalized inner speech positively related to task facilitating

and no movement behavior respectively, the more mature form of speech showed greater task predictive. High off-task children tended to engage in more private speech to exert attention after being unsuccessful in task completion consisting with the study of M. H. Frauenglass and R. M. Diaz (1985). The same findings reflected in the study of F. Deutsch and A. H. Stein (1972) that personal failure in task completion evoked to elicit more private speech. S. H. Goodman (1981) also reported the occurrence of private speech with task failure in spite of the overall association of task success with private speech.

Language as cultural mediational tool shapes the form of personal meaning making, individual interpretation in science classroom discourse (Mortimer & Scott, 2000). Spontaneous dissolution and diffusion of potassium per-manganate ($KMnO_4$) in water leading to the change in colour reached to the particle level explanation of the natural phenomenon. P. H. Scott (1996) demonstrated the gradual decontextualization of mediational means (speech) from a particular air pressure experiment to a generalisation that differential air pressure can exert a net force. All are the transformation of student teacher talk (social speech) on inter-mental plane to learner's intra-mental plane of thought. On the way, the present study deals with this application of Vygotsky's psychological principle in science education and hence strives to disclose the form of manipulated condition to be effective for concept internalization as well as achievement in science.

Objectives of the study

O_1. To identify the more effective teaching methods in terms of concept internalization of selected science lessons for 6th standard learners.

O_2. To identify the more effective teaching methods in terms of achievement in science for 6th standard learners.

O_3. To estimate the effects of concept internalization of selected science lessons on the achievement of the 6th standard learners in higher order cognitive levels as per revised Bloom's taxonomy.

Assumptions

A_1. The learners can construct knowledge during the classroom discourse of selected science lesson.

A_2. 6th standardscience learner's lesson internalization occurs through speech internalization regarding science activity, phenomena, concepts.

Hypotheses

$^0H_1$. There is no significant difference in concept internalization of selected science lessons between the students instructed by problem solving and play way method of teaching.

$^{0}H_{2.1.}$There is no significant difference in achievement of Unit I between the students instructed by problem solving and play way method of teaching.

$^{0}H_{2.2.}$ There is no significant difference in achievement of Unit II between the students instructed by problem solving and play way method of teaching.

$^{0}H_{2.3.}$ There is no significant difference in achievement of Unit III between the students instructed by problem solving and play way method of teaching.

$^{0}H_{3.1.}$ There are no significant differences among the means for three content areas of achievement (Unit I, Unit II & Unit III) in higher order cognitive levels among the 6th standard learners having different levels of concept internalization.

$^{0}H_{3.2.}$ There is no significant difference between the means for achievement (Unit I, Unit II & Unit III) in higher order cognitive levels among the 6th standard learnershaving different levels of concept internalization;instructed by two types of teaching method (PSM & PWM) conditions.

$^{0}H_{3.3.}$ There is no significant content areas (units) by teaching methods interaction at their respective conditions.

$^{0}H_{3.PSM.}$ There are no significant difference in Unit I, Unit II and Unit III achievement of higher order cognitive levels among the learners of high, average and low levels internalized groups instructed by problem solving method of teaching.

$^{0}H_{3.PWM.}$ There are no significant difference in Unit I, Unit II and Unit III achievement of higher order cognitive levels among the learners of high, average and low levels internalized groups instructed by play way method of teaching.

$^{0}H_{3.TOTAL.}$ There are no significant difference in Unit I, Unit II and Unit III achievement of higher order cognitive levels among the learners of high, average and low levels internalized groups for whole sample.

METHODOLOGY OF THE STUDY

Research Method

The main objective of the study is to find out the effect of internalization on achievement in science. In order to satisfy the need, post-test only two randomised equivalent groups factorial research design under experimental research method has been adopted due to the involvement of more than one independent variable.

Sample and sampling

All the 6th standard students of KamdevpurSnehabala Milan Vidyapith, a higher secondary rural govt.-aided WBBSE run school in South 24 Parganas district of W. B. constitute the sample of the study.

Formation of equivalent group

An entry level general science achievement pre-testin relation to the dependent variablemostly at knowledge level objective is administered on all the sample for the formation of two equivalent group through randomisation from each hierarchical level. The group equivalence is established in the following way –

TABLE – 1
Group equivalence: Random assignment of students between two groups

Pre-test score level	Section A_2 (Strength – 71)	Group A (PSM)	Section A_1 (Strength – 71)	Group B (PWM)
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

Problem solving method (PSM) for science lesson transaction is impartially applied on one group and the rest group is treated by play way method of teaching (PWM).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 two groups were made statistically equivalent 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
PSM Pre-test score	40	26.93	7.13	1.13	78	0.19	0.85	Not Significant at 0.05 level
PWM Pre-test score	40	27.25	7.80	1.23				

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

Thus, the mean score of pre-test achievement score for PSM group does not significantly differ from that of PWM group. So, there is no significant difference between the two

groups i.e. equivalence between the two groups is established in terms of achievement, the dependent variable of the study. The gender distribution of the group members isas below.

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 – Internalization.
2. Dependent variable – Achievement.

Tools of the study

A compiled version of Science Lesson Internalization Questionnaire (SLIQ) for assessing internalization and three self-made tools of Science Achievement Test (SAT) to assess achievement in science are administered for data collection.

Description of Science Lesson Internalization Questionnaire (SLIQ)

The dimensional adaptation of hierarchical level of private speech internalization from Kohlberg et al.'s study (1968) is integrated in SLIQ as an operational measure of the the construct internalization. The tool cover the spectrum of five point Lickert scale responses ranging from strongly agree to be awarded 5 to strongly disagree to be awarded 1 with some negatively worded items of reverse scoring, thereby, reporting the scores of positively worded versions of negatively worded items through data analysis.

TABLE – 4 Summary of SLIQ

Measuring Variable	Level/Dimension	Initial try-out item	Item analysis technique	Final item	Reliability	Validity
Internalization (I)	Level I: Presocial self-stimulating speech or Social speech; Leve II: Outward-directed private speech or Task irrelevant speech; Level III: Inward- directed private speech or Task relevant speech; Level IV: External manifestations of inner speech or Condensed inner speech; Level V: Silent inner speech or Inner speech or thought.	119	Popularity test	68	0.726	0.852

Description of Science Achievement Test (SAT)

6th standard WBBSE science book (2014) 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.

As Internalization of knowledge level objective is meaningless i.e. information can be retrieved from memory while needed, according to our research objective we exclude the knowledge level objective from the achievement test. The test is prepared according to the higher order cognitive levels of revised Bloom's taxonomy of educational objective under the dimension of Understanding, Application and Skill level where analyzing, evaluating and creating objectives are merged into Skill level. The achievement test is 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

Unit I Science Achievement Test					
Content	**Objective**			**Total**	**Weightage**
	Understanding	**Applying**	**Skill**		
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%	

After exclusion of the knowledge level objective, the test appears like criterion referenced test (CRT) or mastery test for which item analysis is tough task as measurement experts acknowledged the fact that item analysis for CRT is meaningless or unimportant (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.

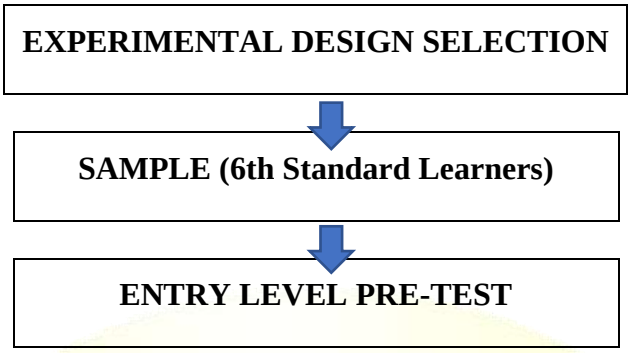
TABLE – 6
Summary of SAT

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 group equivalence is established on the basis of entry level pre-test, one group is impartially selected for lesson transaction by PSM of teaching as private speech elicitation occurs in problem solving situation by greater amount (Vygotsky, 1987) and the remaining group by PWM of teaching as children's play behaviour exerts the psychological capacity of imagination development, rule-governed practice in performance and 'internal transformations' in child development during schooling age (Vygotsky, 1978b). The duration of the experiment was for a period of two months. The execution of whole experimentation can be represented as –

RESEARCH DESIGN SELECTION



EQUIVALENT GROUP I (40)	EQUIVALENT GROUP II (40)
TREATMENT I **PROBLEM SOLVING METHOD**	**TREATMENT II** **PLAY WAY METHOD**

Unit I	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 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 Science Lesson Internalization Questionnaire		

Achievement score for High Level Internalized Group	Achievement score for Average Level Internalized Group	Achievement score for Low Level Internalized Group	Achievement score for High Level Internalized Group	Achievement score for Average Level Internalized Group	Achievement score for Low Level Internalized Group
Upper 30% achievement sample response w.r.t. internalization i.e. 12	Middle 40% achievement sample response w.r.t. internalization i.e. 16	Lower 30% achievement sample response w.r.t. internalization i.e. 12	Upper 30% achievement sample response w.r.t. internalization i.e. 12	Middle 40% achievement sample response w.r.t. internalization i.e. 16	Lower 30% achievement sample response w.r.t. internalization i.e. 12

DATA ANALYSIS AND RESULTS

The sample responses are organised in tabular form by Microsoft Excel 2016 software and IBM SPSS Statistics (Version 25) software to test the hypotheses framed according to the research objectives. The statistical techniques and tests of bar diagrams, descriptive statistics, both one-way and two-way ANOVA followed by t-test for mean difference are performed on the tabulated data in Excel worksheets and SPSS spreadsheets for data analysis with interpretation.

TABLE – 7
t-test: Comparison of Internalization between PSM and PWM groups

Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
Internalization of PSM group	40	238.85	26.69	78	0.49	0.63	Not Significant at 0.05 level
Internalization of PWM group	40	236	25.29				

$t(78) = 0.49, p > 0.05$

Thus, the mean score (238.85) of concept internalization for problem solving method instructed group does not significantly differ from that (236) for play way method instructed group.

TABLE – 8
t-test: Comparison of Unit I, Unit II and Unit III Achievement between PSM and PWM groups

$^0H_{2.x.}$	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	4.12	0.00	Significant at 0.05 level
	Unit I Achievement of PWM	40	12.33	3.83				
$^0H_{2.2.}$	Unit II Achievement of PSM	40	14.85	4.36	78	3.03	0.00	Significant at 0.05 level
	Unit II Achievement of PWM	40	12.10	3.74				
$^0H_{2.3.}$	Unit III Achievement of PSM	40	17.33	4.59	78	4.02	0.00	Significant at 0.05 level
	Unit III Achievement of PWM	40	12.98	5.08				

$^0H_{2.1.}$ – $t(78) = 4.12, p < 0.05$; $^0H_{2.2.}$ – $t(78) = 3.03, p < 0.05$ and $^0H_{2.3.}$ – $t(78) = 4.02, p < 0.05$.

Thus, the 't' value 4.12 for $^{0}H_{2.1.}$ is significant at 0.05 level meaning, thereby, both Unit I of PSM and Unit I of PWM groups differ significantly in their Unit I achievement in science i.e. Unit I of PSM group gains more Unit I achievement in terms of mean score. Similarly, the 't' value 3.03 for $^{0}H_{2.2.}$ is significant at 0.05 level suggesting that the teaching methods exert significant effect on Unit II achievement in differentiating the equivalent groups after the treatment in favour of PSM. Again, the 't' value 4.02 for $^{0}H_{2.3.}$ is significant at 0.05 level reveals the same trend in case of Unit III achievement.

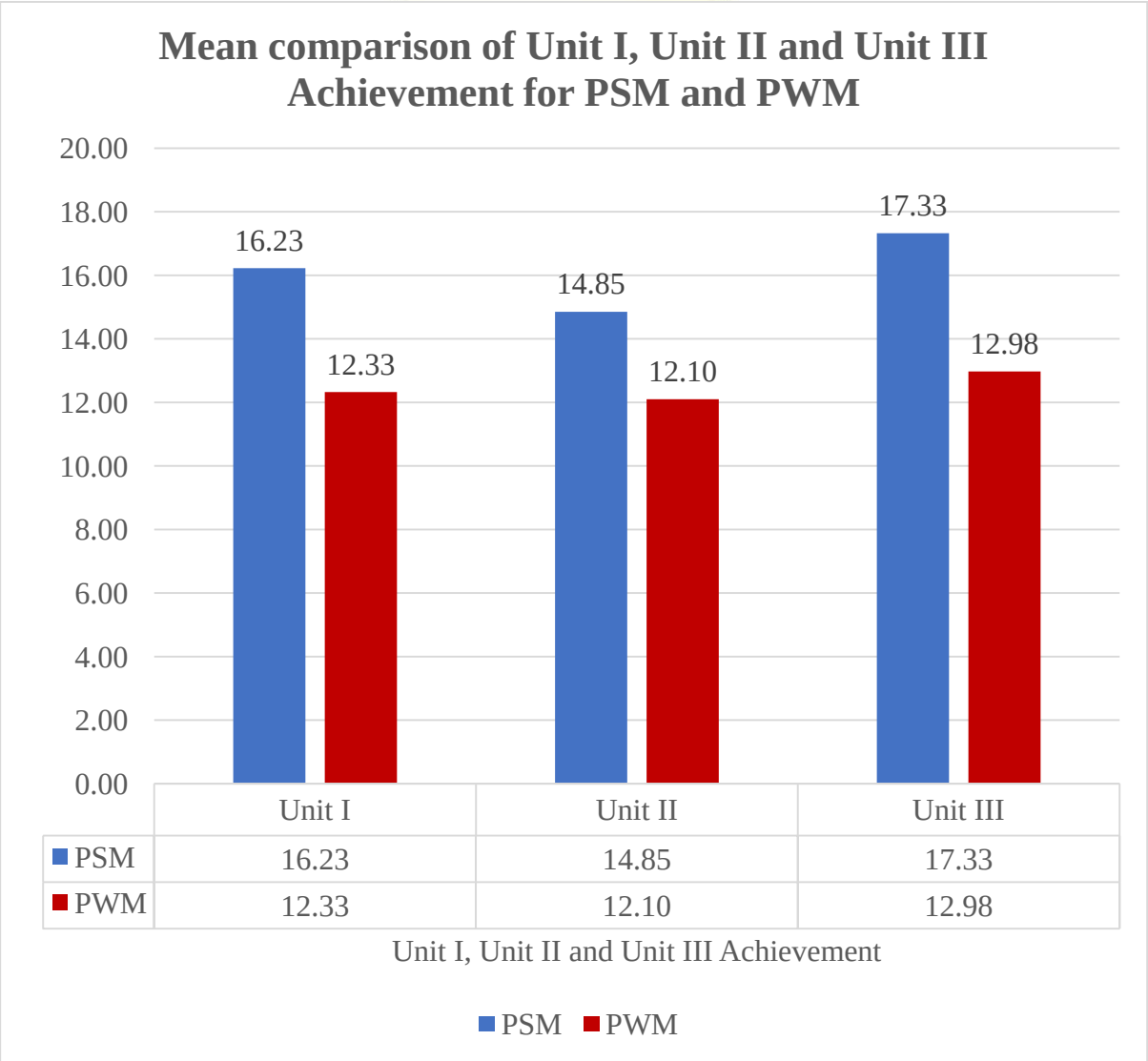


TABLE – 9
Two-way ANOVA: Main effects with interaction effects of contents and teaching methods

Sources of Variation	Degrees of Freedom (df)	Sum of Squares (SS)	Mean Sum of Squares (MSQ)	F-ratio	P value	Significance Status	Partial η^2
Among Units	2	112.30	56.15	2.914	0.056	Not Significant at 0.05 level	0.24
Between Teaching Methods	1	806.667	806.667	41.870	0.000	Significant at 0.05 level	0.152
Interaction (Units X Teaching Methods)	2	27.233	13.617	0.707	0.494	Not Significant at 0.05 level	0.006
Within Treatments (Errors)	234	4508.20	19.266				
Total	240	54532.00					
Corrected Total	239	5454.400					

$F(2, 234) = 2.914$, $p > 0.05$; $F(1, 234) = 41.87$, $p < 0.05$; $F(2, 234) = 0.707$, $p > 0.05$.

TABLE – 10
Estimated marginal means for Units
Dependent Variable: Achievement

Unit	Mean	Standard Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Unit I	14.275	0.491	13.308	15.242
Unit II	13.475	0.491	12.508	14.442
Unit III	15.150	0.491	14.183	16.117

TABLE – 11
Estimated marginal means for Teaching Methods
Dependent Variable: Achievement

Teaching Method	Mean	Standard Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PSM	16.133	0.401	15.344	16.923
PWM	12.467	0.401	11.677	13.256

TABLE – 12
Estimated marginal means for Units by Teaching Methods interaction
Dependent Variable: Achievement

Unit	Teaching Method	Mean	Standard Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Unit I	PSM	16.225	0.694	14.858	17.592
	PWM	12.325	0.694	10.958	13.692
Unit II	PSM	14.850	0.694	13.483	16.217
	PWM	12.100	0.694	10.733	13.467
Unit III	PSM	17.325	0.694	15.958	18.692
	PWM	12.975	0.694	11.608	14.342

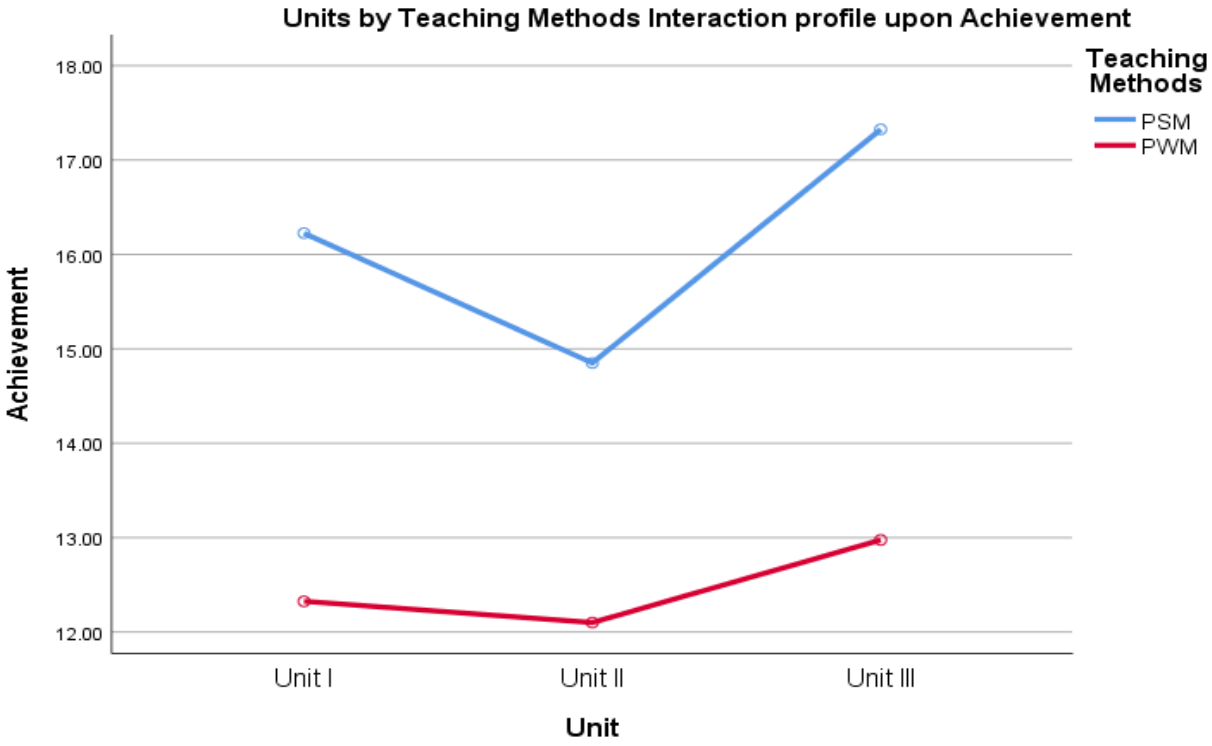
The 2nd row of Table 9 shows that the calculated F-ratio value 2.914 is less than the critical value 3.02 required for 0.05 level of significance and accordingly 'p' value 0.056 is greater than 0.05 i.e. $F(2, 234) = 2.914$, $p = 0.056$, partial $\eta^2 = 0.24$. Thus, the F-ratio 2.914 is not significant at 0.05 level meaning, thereby, there is not a significant units effects on achievement score. Therefore, the three content areas of units, averaged over the applied two conditions of teaching methods, are not producing the significant difference in the

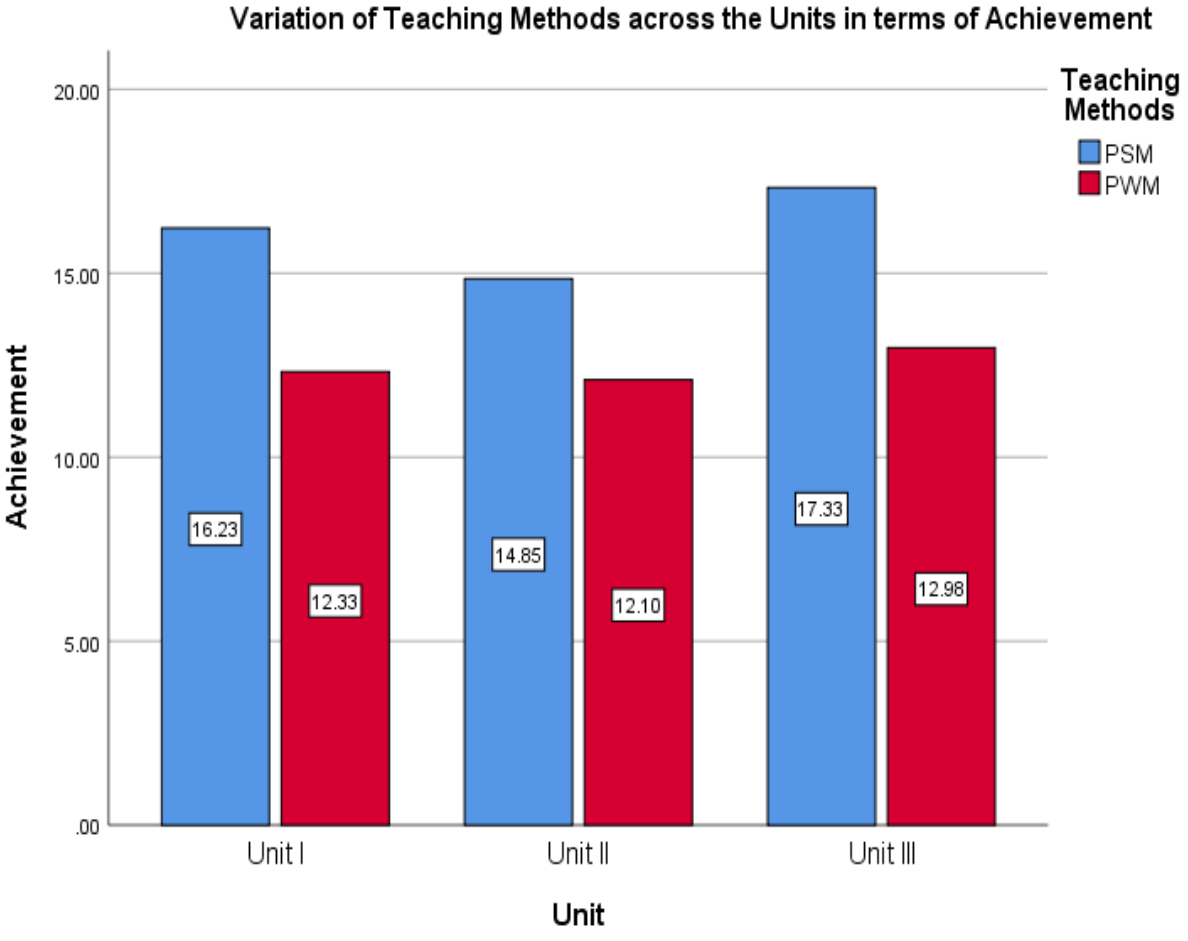
achievement of higher order cognitive levels. Thus, the obtained mean differences (0.80 between Unit I and Unit II, 0.875 between Unit I and Unit III & 1.675 between Unit II and Unit III as per Table 10) among the means for three content areas of achievement (Unit I, Unit II & Unit III) are due to the chance factor.

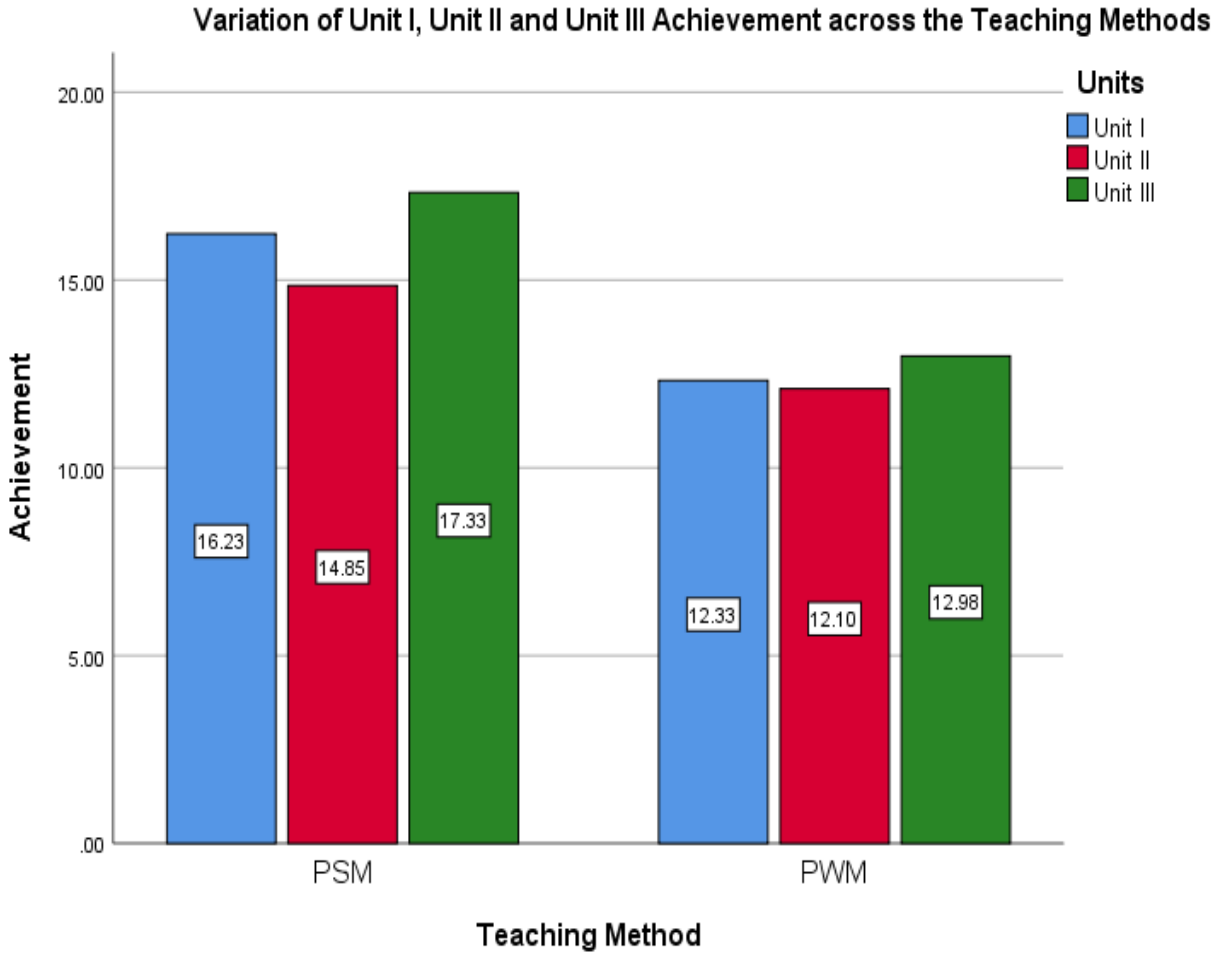
The 3rd row of Table 9 shows that the calculated F-ratio value 41.87 is greater than the table value 3.86 required for 0.05 level of significance and accordingly 'p' value 0.000 is less than 0.05 i.e. F(1, 234) = 41.87, p = 0.000, partial η^2 = 0.152. Thus, the F-ratio 41.87 is significant at 0.05 level meaning, thereby, there is a significant teaching methods effects on achievement score. Therefore, the two types of teaching methods conditions, averaged over the three content areas of units, produce a significant difference in the achievement of higher order cognitive levels. Thus, the obtained mean difference (3.666 between PSM and PWM as per Table 11) between the means for the two teaching methods conditions is due to the existing real mean difference and hence can not be attributed to the chance factor.

The 4throw of Table 9 shows that the calculated F-ratio value 0.707 is less than the critical value 3.02 required for 0.05 level of significance and accordingly 'p' value 0.494 is greater than 0.05 i.e. F(2, 234) = 0.707, p = 0.494, partial η^2 = 0.006. Thus, the F-ratio 0.707 is not significant at 0.05 level meaning, thereby, there is not a significant content areas (units) by teaching methods interaction effects on achievement score. Therefore, the difference among the three content areas of units is not dependent upon the applied two conditions of teaching methods.

Thus, there is approximately the same difference among the means for three content areas of achievement (Unit I, Unit II & Unit III), irrespective of the imposed two conditions of teaching methods (Vide Table 12). So, the achievement in three different content areas is not affected by the applied variation in teaching method. The non-significant first-order interaction is graphically shown below. It represents non-significantly parallel lines. Actually the lines are nearly parallel for this first-order interaction, as there is negligible interaction of magnitude 0.707 in terms of F-ratio i.e. not significant and closed to zero (Edwards, 1972; Broota, 1999). In this regard, it can be noted that non-parallel lines on the interaction graph do not always reflect significant interaction effects among the variation in conditions of contents and teaching methods rather it depends on how non-parallel the lines are (Field, 2016).


Units by Teaching Methods Interaction profile upon Achievement
Teaching Methods
PSM
PWM
Achievement
18.00
17.00
16.00
15.00
14.00
13.00
12.00
Unit I
Unit II
Unit III
Unit


Variation of Teaching Methods across the Units in terms of Achievement
Teaching Methods
PSM
PWM
Achievement
20.00
15.00
10.00
5.00
.00
16.23
12.33
14.85
12.10
17.33
12.98
Unit I
Unit II
Unit III
Unit



That is the difference in Unit I achievement of 3.90, Unit II achievement of 2.75 and Unit III achievement of 4.35 for the variation in problem solving and play way teaching methods do not significantly differ. Similarly, the difference between Unit I and Unit II achievement of 1.38, Unit II and Unit III achievement of 2.48, Unit I and Unit III achievement of 1.10 do not significantly differin case of problem solving method while also the difference between Unit I and Unit II achievement of 0.23, Unit II and Unit III achievement of 0.88, Unit I and Unit III achievement of 0.65do not significantly differfor play way method i.e. the difference in achievement for the variation in units is not significant for any applied teaching method.

At last, we find thatthere is no significant interaction between the two independent variables i.e. between content areas (units) and teaching methods at their respective conditions. The non-significant interaction indicates that the main effects are of much interest. That calls for further tests on main effects. The test comprises the test on

differences between means within the same profile. The analysis would be like running a one-way ANOVA within a same profile (Field, 2016). In order to understand better the nature of concept internalization, each profile is sub-divided into three groups as high, average and low levels internalized group. Thus, we run t-test to find out the main effects of lesson internalization on corresponding achievement in science.

TABLE – 13
t-test: Comparison of Unit I, Unit II and Unit III achievement in higher order cognitive levels among High, Average and Low levels Concept Internalized groups for PSM

$^0H_{3.x.}$	Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
$^0H_{3.4.}$	Unit I Achievement of High level Internalized group for PSM	12	20.75	4.61	26	3.87	0.00	Significant at 0.05 level
	Unit I Achievement of Average level Internalized group for PSM	16	15.81	1.94				
$^0H_{3.5.}$	Unit I Achievement of High level Internalized group for PSM	12	20.75	4.61	22	5.37	0.00	Significant at 0.05 level
	Unit I Achievement of Low level Internalized group for PSM	12	12.25	2.96				
$^0H_{3.6.}$	Unit I Achievement of Average level Internalized group for PSM	16	15.81	1.94	26	3.85	0.00	Significant at 0.05 level
	Unit I Achievement of Low level Internalized group for PSM	12	12.25	2.96				
$^0H_{3.7.}$	Unit II Achievement of High level Internalized group for PSM	12	19.33	3.92	26	4.97	0.00	Significant at 0.05 level
	Unit II Achievement of Average level Internalized group for PSM	16	13.19	2.64				
$^0H_{3.8.}$	Unit II Achievement of High level Internalized group for PSM	12	19.33	3.92	22	4.56	0.00	Significant at 0.05 level
	Unit II Achievement of Low level Internalized group for PSM	12	12.58	3.32				

$^0H_{3.9.}$	Unit II Achievement of Average level Internalized group for PSM	16	13.19	2.64	26	0.54	0.60	Not Significant at 0.05 level
	Unit II Achievement of Low level Internalized group for PSM	12	12.58	3.32				
$^0H_{3.10.}$	Unit III Achievement of High level Internalized group for PSM	12	22.42	4.40	26	4.99	0.00	Significant at 0.05 level
	Unit III Achievement of Average level Internalized group for PSM	16	15.88	2.50				
$^0H_{3.11.}$	Unit III Achievement of High level Internalized group for PSM	12	22.42	4.40	22	5.85	0.00	Significant at 0.05 level
	Unit III Achievement of low level Internalized group for PSM	12	14.17	2.12				
$^0H_{3.12.}$	Unit III Achievement of Average level Internalized group for PSM	16	15.88	2.50	26	1.90	0.07	Not Significant at 0.05 level
	Unit III Achievement of low level Internalized group for PSM	12	14.17	2.12				

$^0H_{3.4.}$ – $t(26) = 3.87$, $p < 0.05$; $^0H_{3.5.}$ – $t(22) = 5.37$, $p < 0.05$; $^0H_{3.6.}$ – $t(26) = 3.85$, $p < 0.05$; $^0H_{3.7.}$ – $t(26) = 4.97$, $p < 0.05$; $^0H_{3.8.}$ – $t(22) = 4.56$, $p < 0.05$; $^0H_{3.9.}$ – $t(26) = 0.54$, $p > 0.05$; $^0H_{3.10.}$ – $t(26) = 4.99$, $p < 0.05$; $^0H_{3.11.}$ – $t(22) = 5.85$, $p < 0.05$; $^0H_{3.12.}$ – $t(26) = 1.90$, $p > 0.05$.

If there is significant difference between the achievement (Dependent variable) of high and average, high and low, and average and low internalized group, then it is inferred that the significant effect of internalization on achievement exists. From the above table, the effect of internalization on achievement is significant in case of Unit I achievement for the learners instructed by PSM of teaching. Although the difference in achievement between average and low level internalized group in case of Unit II and Unit III achievement exists but attributed to chance factor i.e. not significant.

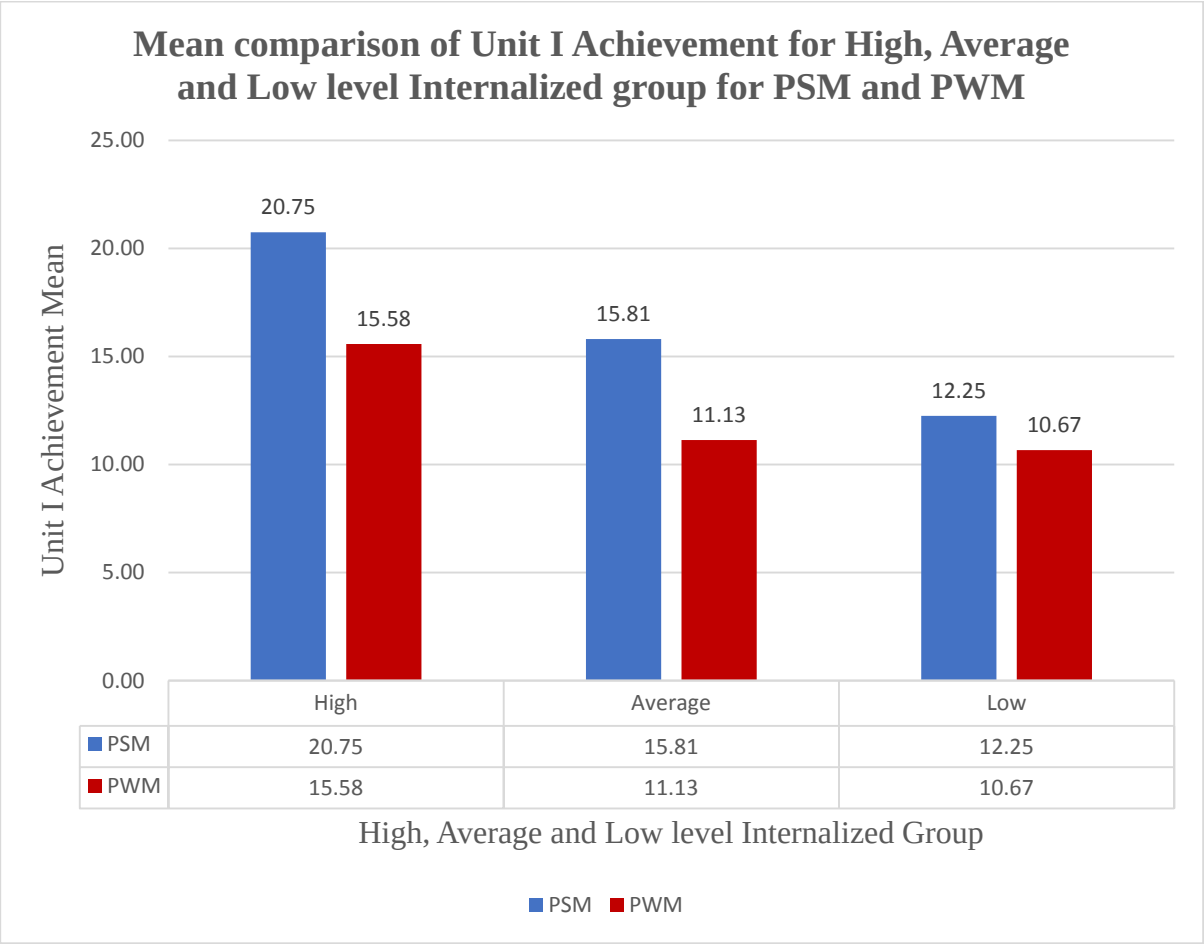


TABLE – 14

t-test: Comparison of Unit I, Unit II and Unit III achievement in higher order cognitive levels among High, Average and Low levels Concept Internalized groups for PWM

$^0H_{3.x.}$	Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
$^0H_{3.13.}$	Unit I Achievement of High level Internalized group for PWM	12	15.58	4.38	26	3.29	0.00	Significant at 0.05 level
	Unit I Achievement of Average level Internalized group for PWM	16	11.13	2.78				
$^0H_{3.14.}$	Unit I Achievement of High level Internalized group for PWM	12	15.58	4.38	22	3.43	0.00	Significant at 0.05 level
	Unit I Achievement of Low level Internalized group for PWM	12	10.67	2.35				
$^0H_{3.15.}$	Unit I Achievement of Average level Internalized group for	16	11.13	2.78	26	0.46	0.65	Not Significant at 0.05 level

	PWM							
	Unit I Achievement of Low level Internalized group for PWM	12	10.67	2.35				
$^{0}H_{3.16.}$	Unit II Achievement of High level Internalized group for PWM	12	14.42	3.55	26	2.20	0.04	Significant at 0.05 level
	Unit II Achievement of Average level Internalized group for PWM	16	11.38	3.67				
$^{0}H_{3.17.}$	Unit II Achievement of High level Internalized group for PWM	12	14.42	3.55	22	2.67	0.01	Significant at 0.05 level
	Unit II Achievement of Low level Internalized group for PWM	12	10.75	3.17				
$^{0}H_{3.18.}$	Unit II Achievement of Average level Internalized group for PWM	16	11.38	3.67	26	0.47	0.64	Not Significant at 0.05 level
	Unit II Achievement of Low level Internalized group for PWM	12	10.75	3.17				
$^{0}H_{3.19.}$	Unit III Achievement of High level Internalized group for PWM	12	16.83	5.24	26	2.65	0.01	Significant at 0.05 level
	Unit III Achievement of Average level Internalized group for PWM	16	11.63	5.08				
$^{0}H_{3.20.}$	Unit III Achievement of High level Internalized group for PWM	12	16.83	5.24	22	3.59	0.00	Significant at 0.05 level
	Unit III Achievement of low level Internalized group for PWM	12	10.92	2.27				
$^{0}H_{3.21.}$	Unit III Achievement of Average level Internalized group for PWM	16	11.63	5.08	26	0.45	0.66	Not Significant at 0.05 level
	Unit III Achievement of low level Internalized group for PWM	12	10.92	2.27				

$^{0}H_{3.13.}$ – t(26) = 3.29, p < 0.05; $^{0}H_{3.14.}$ – t(22) = 3.43, p < 0.05; $^{0}H_{3.15.}$ – t(26) = 0.46, p > 0.05; $^{0}H_{3.16.}$ – t(26) = 2.20, p < 0.05; $^{0}H_{3.17.}$ – t(22) = 2.67, p < 0.05; $^{0}H_{3.18.}$ – t(26) = 0.47, p > 0.05; $^{0}H_{3.19.}$ – t(26) = 2.65, p < 0.05; $^{0}H_{3.20.}$ – t(22) = 3.59, p < 0.05; $^{0}H_{3.21.}$ – t(26) = 0.45, p > 0.05.

The above table exhibits that the mean score of all the Unit I, Unit II and Unit III achievement for average level internalized group does not significantly differ from that of low level internalized group treated by play way method of teaching. But the real mean difference of all the achievement scores exists between the high and average, and high and low level internalized group.

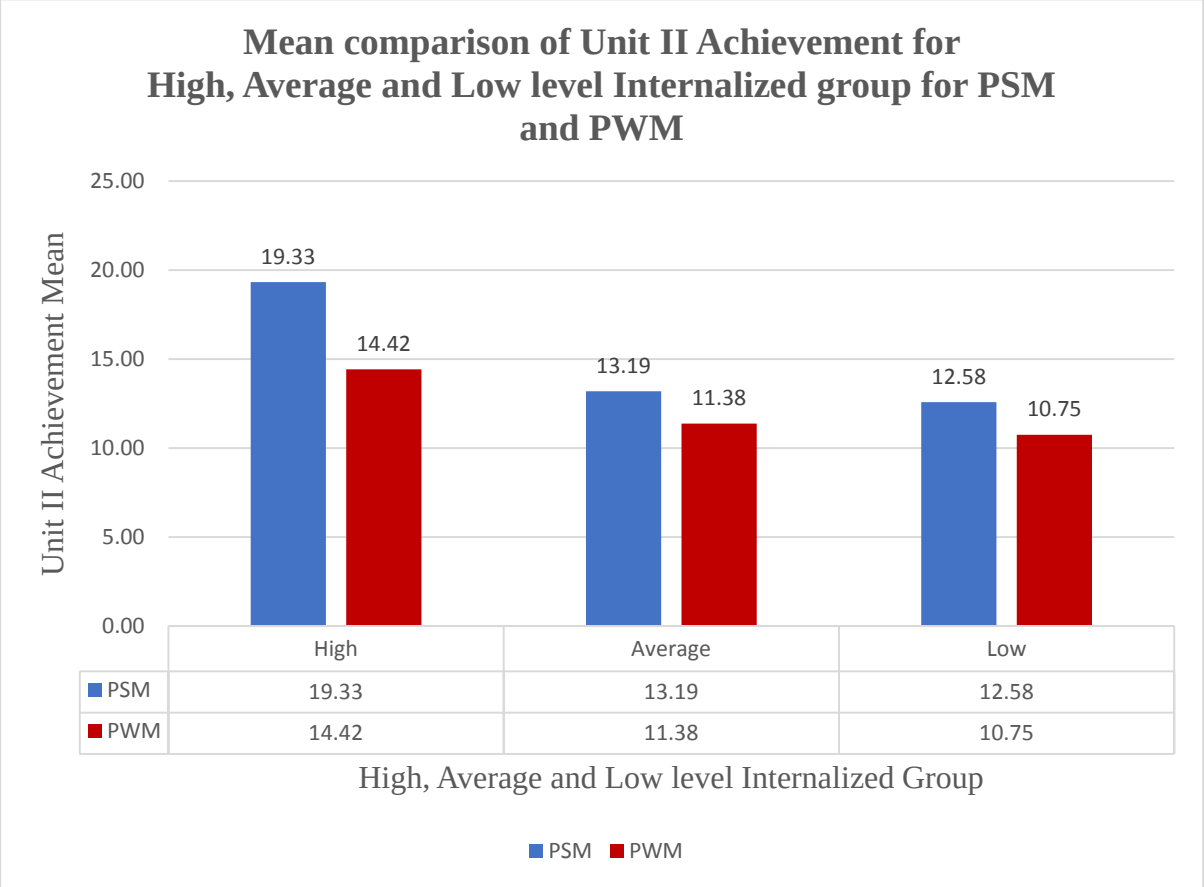


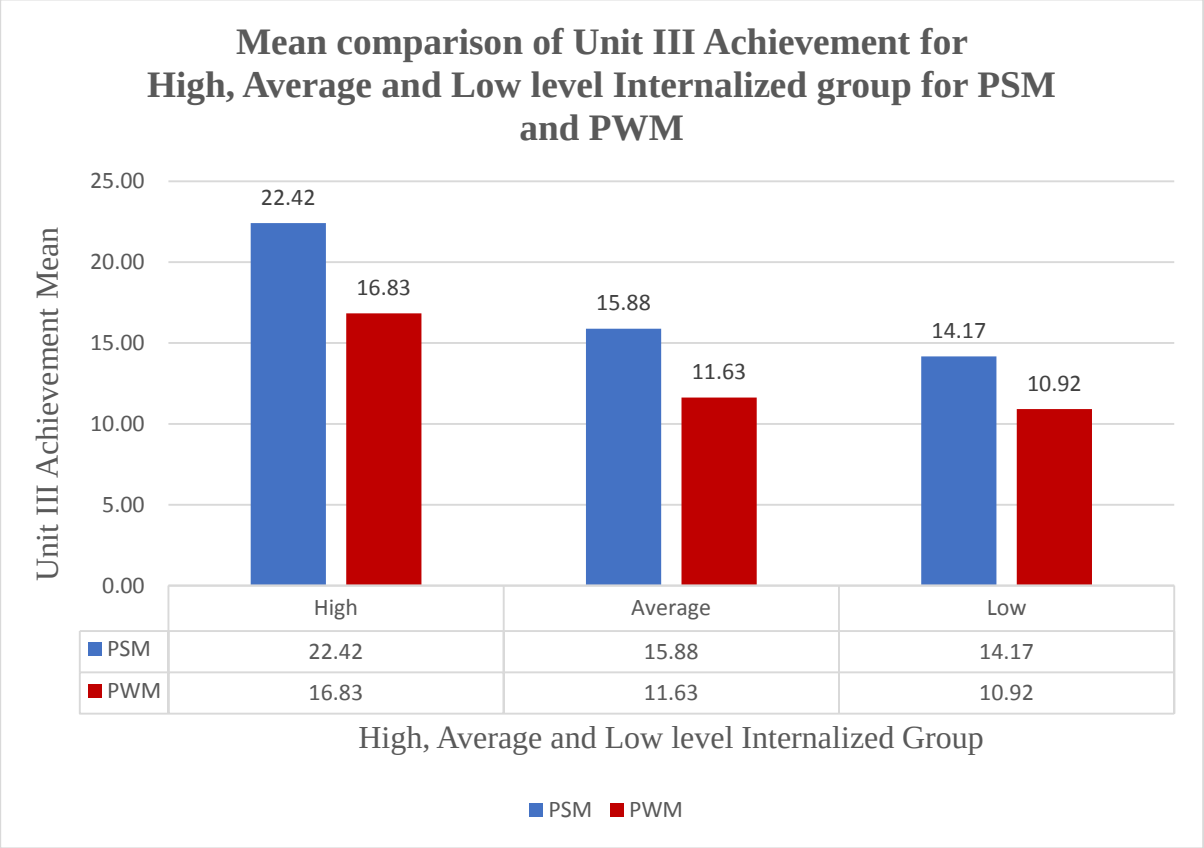
TABLE – 15
t-test: Comparison of Unit I, Unit II and Unit III achievement in higher order cognitive levels among High, Average and Low levels Concept Internalized groups for total sample

$^{0}H_{3.x.}$	Variables	Sample (N)	Mean (M)	Standard Deviation (SD)	Degrees of Freedom (df)	't' Value	'p' Value	Significance Status
$^{0}H_{3.22.}$	Unit I Achievement of High level Internalized group for all sample	24	18.50	4.83	54	4.73	0.00	Significant at 0.05 level
	Unit I Achievement of Average Internalized group for all sample	32	13.44	3.17				
$^{0}H_{3.23.}$	Unit I Achievement of High level Internalized group for all sample	24	18.50	4.83	46	6.49	0.00	Significant at 0.05 level
	Unit I Achievement of Low level Internalized group for all sample	24	11.17	2.71				
$^{0}H_{3.24.}$	Unit I Achievement of Average level Internalized group for all sample	32	13.44	3.17	54	2.82	0.01	Significant at 0.05 level
	Unit I Achievement of Low level Internalized group for all sample	24	11.17	2.71				
$^{0}H_{3.25.}$	Unit II Achievement of High level Internalized group for all sample	24	17.04	4.36	54	4.72	0.00	Significant at 0.05 level
	Unit II Achievement of Average level Internalized group for all sample	32	12.38	3.03				
$^{0}H_{3.26.}$	Unit II Achievement of High level Internalized group for all sample	24	17.04	4.36	46	5.02	0.00	Significant at 0.05 level
	Unit II Achievement of Low level Internalized group for all sample	24	11.38	3.40				
$^{0}H_{3.27.}$	Unit II Achievement of Average level Internalized group for all sample	32	12.38	3.03	54	1.16	0.25	Not Significant at 0.05 level
	Unit II Achievement of Low level Internalized group for all sample	24	11.38	3.40				

$^{0}H_{3.28.}$	Unit III Achievement of High level Internalized group for all sample	24	19.83	5.35	54	4.61	0.00	Significant at 0.05 level
	Unit III Achievement of Average level Internalized group for all sample	32	13.81	4.42				
$^{0}H_{3.29.}$	Unit III Achievement of High level Internalized group for all sample	24	19.83	5.35	46	6.25	0.00	Significant at 0.05 level
	Unit III Achievement of low level Internalized group for all sample	24	12.25	2.59				
$^{0}H_{3.30.}$	Unit III Achievement of Average level Internalized group for all sample	32	13.81	4.42	54	1.54	0.13	Not Significant at 0.05 level
	Unit III Achievement of low level Internalized group for all sample	24	12.25	2.59				

$^{0}H_{3.22.}$ – $t(26) = 4.73$, $p < 0.05$; $^{0}H_{3.23.}$ – $t(22) = 6.49$, $p < 0.05$; $^{0}H_{3.24.}$ – $t(26) = 2.82$, $p < 0.05$; $^{0}H_{3.25.}$ – $t(26) = 4.72$, $p < 0.05$; $^{0}H_{3.26.}$ – $t(22) = 5.02$, $p < 0.05$; $^{0}H_{3.27.}$ – $t(26) = 1.16$, $p > 0.05$; $^{0}H_{3.28.}$ – $t(26) = 4.61$, $p < 0.05$; $^{0}H_{3.29.}$ – $t(22) = 6.25$, $p < 0.05$; $^{0}H_{3.30.}$ – $t(26) = 1.54$, $p > 0.05$.

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



Discussion

Concept internalization of selected science lessons evinces both of the applied teaching methods to be indiscriminately effective in science learning but achievement score in all the three units significantly differentiate problem solving method (PSM) from play way method as impactful teaching method whereas the possibility is in either of the direction (Two-tailed test). Thus, only the achievement data satisfactorily explains the effectiveness of PSM over PWM of teaching (Duncan &Tarulli, 2009). It can be ascribed to the lessons, tasks based various activities they experienced in their problem solving situation. That, in turn, become successful to develop strategy based critical thinking reflected in achievement (Moss, 1990; Duschl&Erduran, 1996; Scott, 1996; White & Daugherty, 2009; Winsler, 2009). It also appears learning by playing conditions in PWM of teaching somehow to be the effective impression at lower primary level supervision of learning as far as particularly when the higher order learning objective as per revised Bloom's taxonomy is concerned in the on-hand study. Moreover, the indistinguishable manifestation of concept internalization score towards the applied variation in the teaching methods on contrary to achievement data may call for the attention to the degree of both accuracy and precision level of the assessment of concept internalization.

The two-way ANOVA revealed the significant main effect of the applied teaching methods on achievement in higher order cognitive levels, but no significant main effect found for the three units. Also, the first order interaction effect of units by teaching methods can not reach upto its significance level i.e. the achievement in the three content areas is not affected by the applied variation in teaching method. The non-significant interaction thus suggests the main significant effect of the applied teaching method on achievement in higher order cognitive levels is of our key interest. Thus, the analysis evinces that the problem solving situation influences higher order achievement (Behrend et al., 1989; Azmitia, 1992; Winsler,Diaz, McCarthy,Atencio, &Chabay, 1999; Duncan & Cheyne, 2002; Fernyhough& Fradley, 2005;Carlson & Beck, 2009). So,PSM is found to the predictor of science achievement in higher order cognitive levels for all the science contents. After carrying out the main effect of teaching method on achievement, the follow-up analysis revealed overall a significant effect of concept internalization on science achievement in higher order cognitive levels (Beaudichon, 1973; Goodman, 1981; Berk 1986). But no or little effect for average and low level internalized group on achievement is found except Unit I achievement for PSM instructed and total learners. Thus, internalization satisfactorily explains the gain in achievement for higher level group or more competent learners (Roberts, 1979; Azmitia, 1992).

Educational implication

[i] As problem solving method of teaching is found to the predictor of achievement, lesson plan should be designed through this method of instructions for effective science learning. Play way teaching method should also be applied as far as practicable.

[ii] As social speech at inter-psychological plane is the pre-requisite condition for concept internalization, the different types of social speech that science teacher's formal lecture, discussions, interactive speech activities should be used in a judicious way in classroom talk, conversation, discourse during lesson transaction. That demands the need to create rich opportunities, experiences in science learning for learners arguably to judge acquired knowledge into new situations.

[iii] Learner's use of private speech should be encouraged during problem solving situation as speech or thought internalization occurs through the developmental continuum of private speech to inner speech.

[iv] Read aloud of problem solving strategies can be modelled and gradually developed in learners particularly for difficult tasks.

[v] The teacher should foster a bridge between qualitative understanding and quantitative reasoning during a teaching of problematic content in order to reinforce gain in achievement in higher order cognitive levels.

[vi] Learner's personal interpretation, meaning-making as conversational outcome of science concepts should be encouraged as it does not imply lesson transmission rather ensures the transformation of information for concept formation.

Conclusion

The study overall establishes the causal effect of internalization on achievement in science discipline through the experimental research design in West Bengal. That supports the socio-cultural theoretical position of Vygotsky covering mediational means of language, sign, symbols, higher mental function of deliberateness, focused attention, logical thinking, abstract reasoning, seeking alternative way of problem solving. Vygotsky devoted pedagogical resources imposed during science lessons transaction. The study itself is the adaptation and hence application of Vygotsky's principle in science education. It is the piecemeal work of the whole experimental research. Its highlighting feature is that creating problem solving situation becomes an worth strategies for the fruitful outcome of learning science. Thus, the on-hand study demonstrated that problem solving way of instructions maintains a better predictor of learner's achievement in science rather than the instructions exerted by play way method.

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