Effects of Peer Tutoring on Learning Outcomes of High School Science Students

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ABSTRACT

This experimental study determined the differences between learning outcomes of Assamese high school science students who were exposed to peer tutoring or traditional instruction. Results indicated better learning outcomes in terms of achievement in science with peer tutoring. It also emphasised two important aspects: Together we (students) can achieve better; and learning by teaching.

PEER tutoring is a method of teaching in which one student (or a small group of students) receives personalised and individualised instruction (Medway, 1995). In tutoring, the teaching is called a tutor, while the student is called a tutee. Tutoring most often supplements traditional classroom instruction, which is typically conducted in large groups for those students who require remedial help and those who have difficulty learning by conventional methods. Being closer in knowledge and status, the tutee in a peer relation feels freer to express opinions, ask questions, and risk untested solutions. The interaction between instructor and pupil is more balanced and more lively when the tutor is a peer (Damon and Phelps, 1989).

A theoretical grounding for peer tutoring can be found in L.S. Vygotsky's idea of the Zone of Proximal Development. Vygotsky wrote that problem-solving in collaboration with more

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capable peer could enable children to enter into new areas of potential (Vygotsky, 1978). These new areas, which Vygotsky called the leading edge of children's intellectual growth constitute the zone of proximal development (ZPD); it is created when a child interacts with a more experienced mentor in intellectually productive ways. Vygotsky argues that it is not only information that is internalised, but also fundamental cognitive processes that are implicit in the communication. Accordingly, both parties of the communication stand to benefit. The tutee profits from the very acts of questioning, challenging and providing feedback to the tutor. The tutor profits from the act of reformulating knowledge for transmittal to the tutee, from answering the tutee's questions and from responding to the tutee's challenges. This is what is meant by the old axiom that one never really knows a subject until one tries to teach it (Damon, 1995).

Webb (1991) found that when students did not understand a teacher's explanation, peers were often able to provide explanations in words that were more easily understood. Othman (1997) conducted a study to gain understanding of significant mechanisms of Peer Tutoring (PT) with respect to the balance between enhancing tutees' learning, while maintaining tutors' own achievement. Data analysis revealed that enhancing tutees' learning required tutors and tutees each to perform roles that were individually relevant. For example, at a cognitive level, tutees had to think aloud, verbalise what they learn, and pay attention. On a behavioural level, students had for example, to listen, cooperate, and compromise explaining, repeating and providing cues. At the affective level, tutors had to reinforce, praise, and encourage successful responses from the tutees.

Koh's (1998) study revealed that more than half of the respondents perceived small group discussion, case study, student presentation, cooperative learning, PT and role play to be useful active learning strategies for helping students to attain all the higher levels of Benjamin Bloom's taxonomy of cognitive learning outcomes.

Nazzal (2000) recommended the use of peer tutoring as an alternative means of lessening the potential effects of several factors that put low socio-economic students at risk for dropping out of school. Peer Tutoring reinforced perceptions of students towards the school and decreased feelings of alienation.

Brown (2001) reported that mathematics teachers were adopting new teaching strategies such as cooperative learning, hands on activities, computer labs, one-to-one teaching, lecturing, peer tutoring, and guided practice in Alabama High Schools and the teachers' major concerns were student retention, covering of all the course material, student concentration and student attendance.

Rational for the Study

In most Indian classrooms, the existing teacher student ratio limits the teacher's ability to instruct with each learner's Zone of Proximal Development (ZPD). Some educators argue that increased small-group discussions may enable greater student participation and growth (Webb, 1992), providing opportunities for peers to assist one another in their learning. Implementation of peer tutoring programme can increase the learning opportunities offered to students, where peers provide individualised help to their underachieving classmates at no extra cost. Although a number of researches have been conducted on peer tutoring abroad, few empirical studies have been conducted in this area in India. So, the authors proposed to study the effectiveness of peer tutoring with the following objectives in mind.

- To determine the effect of peer tutoring and traditional instruction on learning outcomes, viz., achievement in science of students with high and low intelligence.
- To compare learning outcomes in science of high and low intelligence groups of students.
- To study the learning outcomes of students in science at knowledge and comprehension category of objectives.
- To study the interaction effects of the instructional treatments, intelligence and categories of objectives for the two types of learning outcomes as mentioned above.

Null hypotheses were developed as few empirically sound studies have been conducted on peer tutoring in India.

H_1 The two instructional treatments yield comparable mean gain on achievement scores in science.

H_2 The high and low intelligence groups yield equal mean gain on achievement scores.

H_3 Comparable gain on achievement scores are yielded by the students at knowledge and comprehension categories of objectives.

H_4 There is no significant interaction between instructional treatment and levels of intelligence.

H_5 There is no significant interaction between instructional treatments and categories of objectives.

H_6 There is no significant interaction between levels of intelligence and categories of objectives.

H_7 The two instructional groups attain comparable mean gain on achievement scores with both the levels of intelligence at knowledge and comprehension categories of objectives.

Sample

One of the authors belonged to Dhubri District of Assam and had great concern for the low achievement exhibited by students from middle and low socio-economic status, which hampered their future progress. Peer Tutoring seemed to be a promising strategy for providing individual help to all students and thereby improving their learning outcomes.

Raven's Advanced Progressive Matrices was administered to 200 students of Class IX from the Kalapani Higher Secondary School of Dhubri District in Assam. Ninety five per cent of the students were from middle and low socio-economic status Muslim families and their average age was 13 years. On the basis of their intelligence scores, 54 high intelligence and 54 low intelligence group of students were selected. So, finally 108 students were selected for the study and the students were randomly allocated to two groups as shown below :

Sample Distribution

Group	*High Intelligence*	*Low Intelligence*	*Total*
Experimental Group	27	27	54
Control Group	27	27	54
Total	54	54	108

Tools

Raven's Advanced Progressive Matrices (APM) was used to determine the intelligence of the students. Achievement test was developed on 6 units from the Science syllabus of Class IX of SEBA, Guwahati, Assam, viz., organisation of the living body at different levels, population and community, our universe, periodic classification of elements and chemical bonding. The

final draft of the achievement test comprised 115 items; 53 items were developed at knowledge category and 47 items were developed at comprehension category. Reliability of the test was 0.88. The test was used as pre-test and post-test. Lesson plans were developed on the above mentioned topics for teacher directed instruction. Six unit tests were developed on the units mentioned above for formative evaluation and formed the basis for peer tutoring.

Design of the Study

The present experimental study employed a pre-test/post-test control group with one experimental group design. The 2×2×2 factorial design was employed for analysing the data of the present study. The 2×2×2 factorial design was computed by ANOVA for mean gain on achievement scores. Here, instructional treatment, intelligence and category of objectives were the independent variables. Gain on achievement scores was the dependent variable which was computed as the difference in post-test and pre-test scores for each student. The variable of instructional treatment was studied at two levels namely; experimental group (T_1) which was taught by teacher directed instruction followed by peer tutoring and control group (T_2) was taught by traditional instruction. The variable of intelligence was studied at two levels viz., high intelligence (I_1) and low intelligence (I_2) levels. The third variable of categories of objectives was studied at knowledge (O_1) category and comprehension (O_2) category.

Treatment Procedure

Firstly, the students were provided orientation regarding the different instructional treatments. Experimental group students were explained about the procedure involved in peer tutoring. Next, achievement test was administered to the students of the experimental group and control group which indicated the previous knowledge possessed by the students.

The instructional treatment was implemented for about 50 days. Students of experimental group were motivated to learn through the novel method of instruction and were explained the steps of instructional treatment as follows:

Unit 1 was taught by the teacher directed instruction; Administration of unit test 1; Feedback to all students; Formation

of peer groups followed by peer tutoring; Administration of unit test 1 again to determine the level of mastery of the tutors and the tutees; Feedback and retutoring by peers, if essential. Similarly, the remaining units were taught by teacher directed instruction followed by the above mentioned activities. Teachers in the peer tutoring sessions performed the role of facilitator as they formed groups, assigned roles, monitored, evaluated and intervened when necessary.

The students who were selected to be peer tutors (on the basis of their mastery in the unit test) were given specific instructions such as :

At each tutoring session

- Get started with your tutees as quickly and quietly as possible: Greet the tutees by their first names and let them call you by your first name.
- Smile : the fastest ice-breaker.
- Orient the tutees to the task for the day.
- Always try to proceed by asking questions, rather than making statements. Do not prompt your tutees with subtle clues or cues.
- Praise your tutees when they are doing well or give correct answers.
- Do not punish your tutees. If they give incorrect answers, just go on asking questions until they give the right answer, then repeat the right answer with them.
- If your tutees are restless or indisciplined, ask them what is the matter : do not shout at them or order them about. In case of serious indiscipline, call the teacher.
- Do not expect too much from your tutees. Try to get the feel of an appropriate rate of learning.
- Reinforce the tutees' learning.
- Be prepared to be flexible. Try to assess how much of the earlier work needs to be reinforced before progressing further.
- Try to use illustrative examples which draw on your tutees' interest, e.g. sports, TV programmes, pop, etc and/or examples with which they will be familiar such as incidents in the kitchen.
- Do not discriminate or show favouritism. And be aware of your tutees' sensitivities – ethnic or social class background, gender, religious beliefs.

- Do not assume that the tutees' secondary behaviour (such as shifting on the stools, drumming fingers, unwillingness to make eye-contact, tendency to giggle and gossip) is an indication that they dislike you; they may just be shy or somewhat embarrassed by their lack of proficiency in the subject (some children, for example, may have difficulty in reading).
- Towards the end of the lesson, go over the points learned.
- Having 'broken the ice', ask about their interests in science. If they say it is all boring, try sympathetically to unearth the source(s) of their dislike. Gradually, and without pushing too hard, stress the interest, excitement, and importance of systematic enquiry as the basis of science.
- Consult the teacher before going off on a new track or departing in any significant way from the syllabus.
- Try to build around the teacher's demonstrations, worksheets, etc.
- Do not be afraid to ask the teacher's advice on how to approach a problem with a particular child.
- Take things into lessons (games/books/photos/objects) which illustrate the content being covered.

The control group was taught the same content for the same period by traditional instruction. Immediately after the instructional treatment of 50 days was over, achievement test was administered to the students for post-testing.

Data Analysis and Results

Data were analysed using Analysis of Variance (ANOVA) to explore the differences among the groups. F-ratio for the pre-test scores of the two treatment groups was found to be 2.42 which was not found to be significant even at 0.05 level of confidence. This revealed that before the implementation of the instructional programme, the two treatment groups were comparable with respect to their entry behaviour in science.

Next, the gain as measured by the difference of post and pre-test scores was calculated for each student. These obtained gains were subjected to ANOVA. Data was treated according to the specifications of Winer (1971). The summary of the $2 \times 2 \times 2$ ANOVA for gain scores in achievement have been presented in Table I.

TABLE 1
Summary of 2 × 2 × 2 ANOVA for Gain Scores on Achievement in Science

Source of Variation	*SS*	*df*	*MSS*	*F*	*Level of Significance*
Between Subjects	9140.76	107	85.427	10.612	S (.01)
Treatment (T)	3716.74	1	3716.740	461.707	S (.01)
Intelligence (I)	4500.90	1	4500.900	616.472	S (.01)
T × I	85.62	1	85.620	10.636	S (.01)
Error between	837.50	104	8.050		
within Subjects	1447.00	108	13.398	2.028	S (.01)
O (Categories of Objectives)	498.07	1	498.070	75.408	S (.01)
T × O	77.95	1	77.950	11.802	S (.01)
I × O	163.63	1	163.630	24.774	S (.01)
T × I × O	20.17	1	20.170	3.053	NS
Error within	686.89	104	6.605		

S : Significant
N.S. : Not Significant

Main Effects

Treatment (T) : The F-ratio for the difference in the mean scores of the two treatment groups was found to be significant at 0.01 level of confidence for achievement (Table 1) leading to the inference that the two instructional treatments yielded different mean gains on achievement in science. Thus Hypothesis 1 was rejected as students exposed to peer tutoring exhibited better gain in achievement as compared to those taught by traditional instruction.

Intelligence (I) : F-ratio for difference in the mean gain in achievement scores (Table 1) of the two intelligence groups was found to be highly significant at 0.01 level of confidence. Hypothesis 2 was rejected as high intelligence group exhibited better achievement in science than their low intelligence counterparts.

Categories of Objectives (O) : F-ratio for the difference in mean of the two students at the two categories of objectives for achievement scores (Table 1) was found to be significant at 0.01 level of confidence. Hypothesis 3 was rejected as students performed better at knowledge category of objectives than at comprehension category of objectives.

Interaction Effects

Treatment × Intelligence (T × I) : F-ratio for the interaction between Treatment and Intelligence was found to be significant at 0.01 level of confidence (Table 1) for achievement scores. Thus, Hypothesis 4 was rejected. The investigation was further investigated with the help of t-ratios for mean gain in achievement scores as shown in Table 2.

TABLE 2
t-ratios for Different Combinations of T × I for Mean Gain in Achievement Scores

Group	T_1I_1 *M = 36.44 n=54*	T_1I_2 *M = 26.056 n=54*	T_2I_1 *M = 26.889 n=54*	T_2I_2 *M = 19.019 n=54*
T_1I_1 M=36.44 n=54	—	2.56*	17.50**	31.92**
T_1I_2 M=26.056 n=54	—	—	1.53	12.90**
T_2I_1 M=26.889 n=54	—	—	—	14.42**
T_2I_2 M=19.019 n=54	—	—	—	—

* Significant at 0.05 level
** Significant at 0.01 level

For high intelligence group, students taught by teacher directed instruction followed by peer tutoring yielded better mean gain scores on achievement than those taught by traditional instruction (t=17.50). For low intelligence group, students taught by teacher directed instruction followed by peer tutoring attained better mean gain scores on achievement than those taught by the traditional instruction (t=12.90). When taught by teacher directed instruction followed by peer tutoring, the high intelligence students performed better than the low intelligence students (t=2.56).

When taught by traditional instruction, the high intelligence students performed better than the low intelligence students (t=14.42). The high intelligence group taught by teacher directed instruction followed by peer tutoring performed better than the low intelligence group taught by traditional instruction (t=31.92). The low intelligence group taught by teacher directed instruction followed by peer tutoring performed comparably with the high intelligence group taught by traditional instruction (t=1.53).

Treatment and Categories of Objectives (T × O)

The F-ratio for the interaction between treatment and categories of objectives (Table 1) was found to be significant at 0.01 level of confidence, leading to the inference that the two variables interact with each other. Thus, Hypothesis 5 was rejected. t-ratios were computed for further analysis and have been placed in Table 3.

TABLE 3
t-ratios for Different Combinations of T × O for Mean Gain in Achievement Scores

Group	T_1O_1 *M=32.167 n=54*	T_1O_2 *M=30.333 n=54*	T_2O_1 *M=25.074 n=54*	T_2O_2 *M=20.833 n=54*
T_1O_1 M=32.167 n=54	—	3.72**	14.36**	22.94**
T_1O_2 M=30.333 n=54	—	—	10.65**	19.23**
T_2O_1 M=25.074 n=54	—	—	—	8.59**
T_2O_2 M=20.833 n=54	—	—	—	—

* Significant at 0.05 level
** Significant at 0.01 level

At knowledge category of objectives, the students taught by teacher directed instruction followed by peer tutoring attained better mean gain scores than their counterparts taught by traditional instruction (t=14.36). At comprehension category of objectives, the students taught by teacher directed instruction

followed by peer tutoring performed better than those taught by traditional instruction (t=19.23). Students taught by teacher directed instruction followed by peer tutoring yielded more mean gain scores at knowledge than at comprehension category of objectives (t=3.27). Students taught by traditional instruction yielded better gain scores at knowledge than at comprehension category of objectives (t=8.59). Students taught by teacher directed instruction followed by peer tutoring at knowledge category of objectives performed better than those taught by traditional instruction at comprehension category of objectives (t=22.94). Students taught by teacher directed instruction followed by peer tutoring yielded better mean gain scores at comprehension category than their counterparts taught by traditional instruction at knowledge category of objectives (t=10.65).

Intelligence and Categories of Objectives (I × O)

F-ratio for the interaction between intelligence and categories of objectives was found to be significant at 0.01 level of confidence (Table 1) leading to the inference that the two variables interact with each other. Thus, Hypothesis 6 was rejected. t-ratios were computed for further analysis and have been placed in Table 4.

TABLE 4
t-ratios for Different Combinations of T × O for Mean Gain in Achievement Scores

Group	I_1O_1 *M=34.056 n=54*	I_1O_2 *M=29.278 n=54*	I_2O_1 *M=23.185 n=54*	I_2O_2 *M=21.888 n=54*
I_1O_1 M=34.056 n=54	—	9.67**	22.00**	24.63**
I_1O_2 M=29.278 n=54	—	—	12.33**	14.96**
I_2O_1 M=23.185 n=54	—	—	—	2.63**
I_2O_2 M=21.888 n=54	—	—	—	—

* Significant at 0.05 level
** Significant at 0.01 level

At knowledge category of objectives, the high intelligence group attained better mean gain scores than low intelligence group (t=22). At comprehension category of objectives, the high intelligence group attained better mean gain scores than low intelligence group (t=14.96). High intelligence group performed better at knowledge than at comprehension category of objectives (t=9.67). Low intelligence group performed better at knowledge than at comprehension category of objectives (t=2.63).

Treatment, Intelligence and Categories of Objectives (T×I×O)

The F-ratios for the interaction among the three variables was not found to be significant even at 0.05 level of confidence (Table1). This indicates that treatment, intelligence and categories of objectives do not interact with each other for achievement scores. Hypothesis 7 was thus retained.

Discussion of Results

The present study revealed that there is a difference in the mean gain scores of the two treatment groups. Students taught science by teacher directed instruction followed by peer tutoring exhibited better gain in achievement scores as compared to those taught by traditional instruction. Thus, H_1 was rejected.

This finding was supported by Cloward (1967) who found that peer tutoring improved reading skills of 16-year-old New York school children, Klosterman (1970) who reported that elementary school students made significant gains when tutored individually or in groups; Delquadri et al. (1986) and Greenwood, Carta and Hall (1988) who found this strategy effective for low achievers. Peers were often able to provide explanations in words that were more easily understood was Webb's (1991) finding. Peer tutoring improved achievement of Class IX and X Geography students was reported by Pahuja (1992). Further peer tutoring facilitated learning of fifth graders in a basal reading programme (McMohan and Goatley, 1995); spelling performance of Class IX students (Gyanani, 1996); learning of basic multiplication facts of third graders (Slaughter, 1997); mastery gains in mathematics of ninth graders (Carroll, 1998) and elementary school mathematics urban students (Ginsburg-Block, 1998). Peer tutoring was found to be an effective instructional strategy by Bevington and Wishart (1999) for improving academic achievement of 9-14 years students; Bergeron (1999) for

improving reading achievement of second grade students. Mumford (2000) reported that peer tutoring was effective for college students' success in an anatomy and physiology class. This strategy was found to be effective for promoting mathematics achievement at the eighth grade level (White, 2000); improvement in writing skills of fourth graders (Gray, 2000); learning multiplication facts by special education students (Drew, 2000); improving elementary students' reading achievement (Kang, 2000) and spelling performance (Li, 2000). Peer tutoring was reported to improve technological competence and skills of elementary school girls (Jenson, 2001) and English language skills of sixth grade students (Arquette, 2001).

The means of high intelligence group were superior to that of low intelligence group. Thus, H_2 was also rejected. The findings were supported by Khare (2000).

The means for learning at knowledge and comprehension categories lead to the inference that performance at knowledge category was superior to that at comprehension category. Thus, H_3 was rejected. The finding was in contrast to Khare's (2000) finding, where students attained more at comprehension category of objectives than at knowledge category, but was supported by Mehra (1992) in Biology and Neeru (2001) in Maths.

Treatment and intelligence were found to interact with one another, which lead to the rejection of H_4. Further analysis revealed that, for high intelligence group, students taught by teacher directed instruction followed by peer tutoring yielded better mean gain scores in achievement than those taught by traditional instruction. For low intelligence group, students taught by teacher directed instruction followed by peer tutoring attained better mean gain scores on achievement than those taught by traditional instruction. When taught by teacher directed instruction followed by peer tutoring, the high intelligence students performed better than the low intelligence students. When taught by traditional instruction, the high intelligence students performed better than their low intelligence counterparts. The high intelligence group taught by teacher directed instruction followed by peer tutoring performed better than the low intelligence group taught by traditional instruction. The high intelligence group taught by teacher directed instruction followed by peer tutoring performed comparably with the high intelligence group taught by traditional instruction. This was an important finding, as it revealed the importance of instructional strategy in improving the performance

of the low intelligence group, who needed more help than their high intelligence counterparts.

The interaction between treatment and categories of objective was found to be significant which led to rejection of H_5. Further investigations revealed that at knowledge category of objectives, the students taught by teacher directed instruction followed by peer tutoring attained better mean gain scores than their counterparts taught by traditional instruction. At comprehension category of objectives, the students taught by teacher directed instruction followed by peer tutoring performed better than those taught by traditional instruction. Students taught by teacher directed instruction followed by peer tutoring yielded better mean gain scores at knowledge than at comprehension category of objectives. Students taught by traditional instruction yielded better mean gain scores at knowledge than at comprehension category of objectives.

Students taught by teacher directed instruction followed by peer tutoring at knowledge category of objectives performed better than those taught by traditional instruction at comprehension category of objectives.

Students taught by teacher directed instruction followed by peer tutoring yielded better mean gain scores at comprehension category than their counterparts taught by traditional instruction at knowledge category of objectives.

The variables intelligence and categories of objectives interacted with one another. Thus, H_6 was rejected. Further analysis lead to the results that at knowledge category of objectives the high intelligence group attained better mean gain scores than the low intelligence group. At comprehension category of objectives, the high intelligence group attained better mean gain scores than low intelligence group. High intelligence group performed better at knowledge than at comprehension category of objectives. Low intelligence group performed better at knowledge than at comprehension category of objectives. The present study revealed that treatment, intelligence, and categories of objectives do not interact with one another with regard to achievement scores.

Educational Implications

Peer tutoring helps to individualise instruction at no extra cost. Finance is of great importance to students who belong to poor

families, especially in Dhubri district of Assam. It is difficult for parents to provide tuitions for their wards. Peer tutoring is a blessing for these children where their higher achieving classmates help them to achieve better. Otherwise, with continuous failures in studies, students tend to drop out, never to enter back into the educational system. Using peer tutoring as a method of instruction, can improve the learning outcomes of under achievers. Peer tutoring is usually effective when tutees are tutored in groups or individually. A tutoring session could also include recreation, games, refreshments etc. for making it more effective. Ultimately the participants of peer tutoring sessions, both tutors and tutees, begin to take control of their own learning. When students do not understand a teacher's explanation, peers are often able to provide explanation in words that are more easily understood, i.e., they are able to communicate in comprehensible words. Although teacher has an important role in monitoring student discourse and planning instruction that meets emerging needs, students are encouraged to work together, build social skills and develop friendships, adopt leadership role, participate in discussions, facilitate each other's learning and engage in problem-solving.

Peer tutoring can be used as a supplement to large group classroom teaching. Peer tutoring could reinforce the tutor's perceptions of the importance of school, improve their perception of how well they thought they were doing in school and decrease feelings of alienation. This will lead to decline in drop-out rate especially in primary schools. Truly, one never really knows a subject until one tries to teach it. There are no alternative techniques that will replace the need for classroom teachers and the traditional approach to instruction. However, in a classroom of upto 35 students with diverse academic and social needs, viable techniques must be available to teachers who seek the best education for their students, whether they are regular or learning disabled students. Peer tutoring is one such technique that has been supported by many areas of research. The traditional model for peer tutoring has employed two students, with an older student tutoring a younger student. Variations on role-taking between tutor and tutee have been demonstrated in recent years, particularly with special education students. Previously, learning disabled students were used only to fill the tutee's role. Recently, however, learning disabled students have been found to be as successful as other peers in the tutor's role.

Some researchers found learning disabled students to be successful tutors of non-handicapped peers, and many others also found success with younger disabled students.

Positive outcomes can be obtained with learning disabled students acting as either tutors or tutees, as long as training and supervision are adequate. Mainstreamed or integrated classroom settings are ideal locations for the implementation of peer tutoring. Classrooms that use peer tutoring can facilitate the integration process for both the teachers and the students. Furthermore, it is clear that we should not assume that teacher-directed instruction has no merits nor that child-centred teaching (in its most liberal form) can do no wrong. Rather we should appreciate that teacher-directed and child-centered teaching are neither all bad nor all good. Finally, based on the present findings and prior research, it is evident that differing instructional approaches have differential effects on diverse groups of children. Two slogans of advocates of peer tutoring are:

"TOGETHER WE CAN" AND "LEARNING BY TEACHING"

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