Investigating Peer Scaffolding in Learning and Transfer of Learning Using Teaching Interviews*

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Abstract. We conducted teaching interviews with nine groups of students enrolled in an introductory level algebra-based physics course and consisted of two sessions–a learning session and a transfer session. The students were engaged in hands-on activities to learn various physics ideas in the learning session. We expected the students apply the physics learning to understand positron emission tomography (PET) in a transfer session. After providing worksheets, we asked the students to write their responses before and after the group discussion. To present the dynamics of group learning and the influence of peer scaffolding we compared the results of this study with our prior study [3] where students were individually engaged with a similar set of activities. Results suggest that peers were effective in activating and challenging each other's conceptual resources as well as facilitating transfer of learning. The results of this study also showed that students' performance was better when they were provided the direct hint instead of graduated hints. However, we found that the students gave the right answer with the wrong reasoning when a direct hint was provided, and they gave wrong answer with relatively better reasoning when the hints were graduated.

Keywords: Positron emission tomography, scaffolding, conceptual resources.
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INTRODUCTION

The research presented in this paper concentrates on revealing the nature of social influences to dynamics of learning. It discusses students' achievements in both learning and transfer of physics learning through group interaction with the aid of the hands-on activities. The instructional goal of the activities is to help students learn a range of physics ideas and apply those ideas in understanding the technology of positron emission tomography. A group teaching interview method [1], where students discuss with peers and respond to the questions, is used to collect data.

We describe the details of the students' activation of resources and the facilitation of transfer of learning through peer interaction. A resource-based transfer framework [2] is used to analyze qualitative data. To discuss the students' achievements in group learning we compare some of the results with that of our previous study [3] where the students of similar physics backgrounds participated individually using the same set of teaching activities.

The goal of research presented in this paper was to answer the following questions.

1. What is the effect of scaffolding provided to facilitate learning?
2. What is the effect of group interactions on activation of students' cognitive resources and facilitation of learning transfer using the physical models?

LITERATURE REVIEW

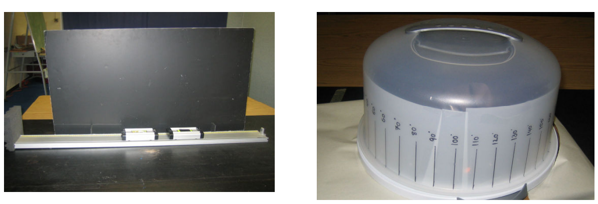
Literatures in psychology and education document the difference between the individual and group learning [4]. It is accepted that students' learning accomplishment is greater through group interaction than the individual efforts [5]. Various cognitive developmental and behavioral theories consider learning a social process and regard the role of social interaction in construction of knowledge. Vygotsky's [6] cognitive theory emphasizes the role of scaffolding in the cognitive development by introducing a notion of Zone of Proximal Development (ZPD). In a peer interaction context, the scaffolding comes from the cumulative efforts among the students of more or less equal capability. The group teaching interviews used in the research are based on Vygotsky's idea of learning within the ZPD.

One way to describe students' learning performance and ZPD is by counting the number of problem steps, number of hints provided and strength of hints [7]. In this study we count the number of hints, problem steps as well as the time required to complete the task to describe students' achievements in learning and transfer of learning.

METHODOLOGY

The participants of this study were students enrolled in an algebra-based physics course and were exposed to kinematics in their physics course. Nine groups were formed from 21 students (10 females and 11 males). They participated in two sessions of the teaching interview each about one hour long. A peer instruction format [8] was adapted in the interviews with minimal interviewer intervention.

The first session of teaching interview used series of hands-on activities where students learn physics through active engagement. One activity of the session involved the collision carts on a track. A barrier was placed in front of the track so that students were able to see the end of the track but not the location where the carts were released (Figure 1 (a)). They were asked to discuss the location where they started, both qualitatively and quantitatively. Another activity of the first session simulated a series of simulated explosions using the light activity (Figure 1(b)). The result of each "explosion" produced two light spots on the wall of the cylindrical enclosure. Students were asked to deduce the explosion location that produced the light pulses. Students observed several pairs of lights, recorded the positions of light on a circular graph paper, and noted any pattern or trend in a graph.



1(a) 1(b)

Figure 1: Activities used in the teaching interview

The interviewer guided a discussion of general ideas about positron emission tomography (PET) at the beginning of the second session. Students engaged in a series of problems related to the physics PET technology such as building a model of locating the exact position of electron-positron annihilation in a brain. Finally, they were asked to complete activities that enabled them to find the region of a tumor in which the annihilations were occurring.

The interviews were video and audio taped. The data analysis followed most of the steps with Colaizzi's [9] phenomenological analysis technique. Six physics education researchers independently analyzed several samples of interview data for the inter-rater reliability test. An agreement of 67% or above was established among the researchers in different categories.

RESULTS AND DISCUSSION

Peer Scaffolding in Learning

Expansion of ZPD Through Peer Scaffolding:

In a task of locating hidden events using the cart activity students' performance was categorized into three levels. The students at the 'quantitative' level could use the appropriate variables and put them in an equation to come up with the numerical results. The students at the 'qualitative' level used the appropriate reasoning identifying the correct variables without being able to use the variables in an equation and the students in the 'unsuccessful' group could not come up with a correct reasoning.

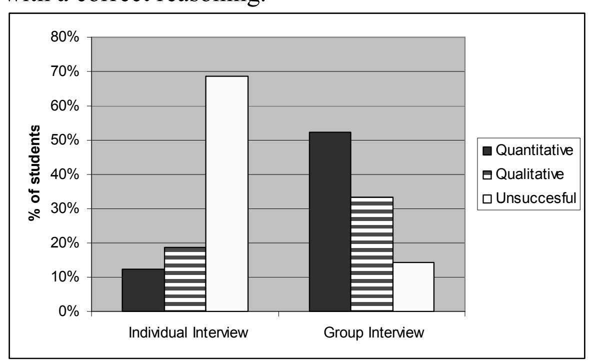


Figure 2: Students Performance in Locating Cart Release

Figure 2 indicates that student performance in the group teaching interviews was significantly better than that in individual teaching interviews. During group teaching interviews 11 out of 21 (52%) students were successful in quantitative task, 33% were successful in qualitative and 15% students were not able to use an appropriate reasoning. In our prior study [3] we had conducted the individual teaching interviews with 16 students where 11 students (68.75%) were not successful in making any kind of approach to solve the problem. Only two students (12.5%) were able to complete the task quantitatively and the remaining three students (18.75%) could complete the task with qualitative reasoning successfully.

Students' performance difference in different contexts can be explained on the theoretical basis of Vygotsky's zone of proximal development. The interviewer in the individual interviews scaffolded almost 69 % of the students to enable them to use appropriate reasoning whereas during the group interviews 72% of the students make appropriate reasoning through peer interaction. More students were successful through peer scaffolding than through interviewer scaffolding to do the quantitative task (53% versus 13%). The students constructed their knowledge socially with the help of others in both the cases the peers were more effective than the interviewer.

Activation of Appropriate Reasoning by Peers

Peers were capable of challenging each other's symmetry argument. For example, the students were asked to deduce the location of an explosion that produced lights on the wall of the cylinder. They used symmetry reasoning to predict locations of the hidden events where this type of reasoning was not relevant. This "central tendency" was more prominent during individual teaching interviews. The students who participated in the group interviews also held a similar idea but they changed it easily through peer scaffolding.

Most of the students (87%) who participated individually held the central tendency. Similarly, most of the student groups (7 out of 9 groups) who participated in the group interviews started out with the central tendency but with the completion of their discussion six groups (15 students) did not indicate central tendency. Only three groups (6 students) still had the central tendency.

In the context of the light activity we expected students to make the association of 'time' with 'location' to find the origin of explosion in the light activity. We noted that students transferred the idea of the cart activity to the light activity to associate 'time' with the 'location'. Six out of nine groups (14 out of 21 students) relied on time to deduce event location in the light activity. Two groups (5 students) relied on intensity of light and the last group (2 students) inferred the location based on the size of the light spot of the wall of the cylinder.

The peer scaffolding was found effective in activation of 'time' resource to locate events. Peer helped to suppress the association of 'location' with 'intensity' through several examples. They helped each other to transfer the idea of the cart activity to facilitate the association of the 'time' with 'location' in the light activity.

Effect of Sequencing Hints

Students described the cart motion by either associating the cart behavior with kinematics or magnetic terms. Before asking them to describe the motion of the carts they were asked if they had either seen the carts before and if so in what context. Or they were provided information that the carts were magnetic. The association of the carts motion with kinematics idea was dominant (12 out of 16 students) among the students who were asked if they saw the carts before. The association of the cart's motion with magnetic interaction was more popular (12 out of 21 students) among those students who were provided with the information that the carts were magnetic.

It is reasonable to argue that the students activated resources of different domains based on the types of scaffoldings. Activation of students' resources from a prior physics class was facilitated when they were asked if they saw the carts before. On the other hand the information of magnetic carts helped to trigger the students' prior experiences of magnetism, and they associated magnetic interaction with the cart's behavior.

We investigated the effect of direct hint versus indirect graduated hint. Students were asked to describe the least number and direction of gamma rays produced in the electron-positron annihilation process. None of the students applied the idea of momentum conservation themselves when the initial hint was phrased as 'momentum of system is zero' and several hints followed afterwards. To the other groups of students the question in the worksheet was phrased like the following: "When an electron and positron annihilate how many gamma rays in the least should be produced in order to conserve the momentum (hint: momentum of the electron-positron system was zero just before annihilation)". The result was that 15 out of 21 students (72%) of different groups individually came up with the idea immediately and wrote that there must be at least two gamma rays produced in the process to conserve momentum.

Peer Scaffolding in Transfer of Learning

We classified types of transfer into four categories. A student group is said to make spontaneous transfer if they correctly answer the PET problems and refer to the physical models immediately during their explanation. If they refer back the physical models upon being asked the basis of their answer, this group of students is considered to exhibit semi-spontaneous transfer. If they are successful in solving the PET problem but make the association of the physical models with the PET problem only after being asked if they had previously seen a similar situation, the students are said to be in non-spontaneous transfer class. They are said to be in no transfer class if they are not successful in their task of the PET problem.

A group was considered to transfer spontaneously if every student contributed in the problem solving and made associations with the physical models. If one student started the discussion and other students helped build upon each others' ideas, then we considered that the group as a whole transferred. On the other hand if a student in a group could solve the problem successfully and the other students of the group sought clarification to make sense of it, then the latter ones were considered in either the low level of transfer or no transfer class.

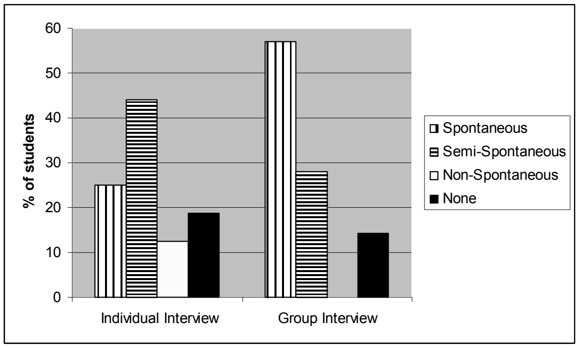


Figure 3: Transfer in individual and group interviews

Figure 3 indicates that the largest student population falls in the spontaneous class and semi-spontaneous comes second when students worked in groups. This is the reverse of our results with the individual interviews.

Students in the groups helped each other in triggering their association of the physical models with the PET problem. This association, which is considered as transfer of learning in this research, is facilitated through peer interaction. We regard that spontaneous and semi-spontaneous transfer are similar in terms of student achievements. The total percentage of these two in the individual interviews was almost 70% whereas that in the group interviews was 85%. This indicates that group interactions have enhanced the transfer of physics learning from the physical models to the PET problems.

CONCLUSION

Group teaching interviews were conducted to investigate the role of peer scaffolding to learning and transfer of learning to the understanding of PET. The results showed that the students' idea progressed significantly when they worked in groups. The students helped each other not only by challenging peer's ideas but also by providing them resources to conduct alternative reasoning. A large majority of the students (69%) could not complete a certain tasks by themselves. Group efforts resulted in the significant improvement in the students' achievements.

The change in students' responses with the change of sequence of hints or information was investigated. Some students were told that the carts were magnetic, and the others were asked if they had prior experience about the 'carts on the track' followed by a common question asking them to describe the motion of 'carts on the track'. The use of the idea of magnetic interaction was dominant in the former group and the use of the kinematics idea was dominant in the latter group while describing the motion of the carts. We also investigated the effect on sequencing of weak hints and strong hints in context of electron-positron annihilation. Students who were given the strong hint before the weak hint came up with the target idea more easily. Many of the students who got the hints in the opposite order could not get the target idea easily.

We discussed peer scaffolding in transferring physics learning to understand PET. The results of this study indicated that the students helped each other facilitate transfer of physics learning from the physical models to the PET problems. The students could trigger each other's ideas to associate the physical models with the related PET problems.

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