FOSTERING CONCEPTUAL UNDERSTANDING IN STUDENTS THROUGH THE USE OF PHYSICS DEMONSTRATIONS

Ning Hwee Tiang
Raffles Girls Secondary School
Singapore

R. Subramaniam
National Institute of Education
Nanyang Technological University
Singapore

Abstract

The topic of pressure in Physics was used to study the effectiveness of demonstrations in promoting conceptual understanding among secondary school students. Two classes of secondary school students were used for the test group while another two classes of students served as the control group; the latter group was taught the topic via the conventional chalk-and-talk approach. Analyses of students' responses to survey instruments as well as of another instrument to gauge content acquisition and conceptual understanding show that the use of demonstrations promotes a learning climate which is conducive for the acquisition of key concepts and also helps to scaffold students' thinking in a more pronounced manner as compared to the traditional approach. Some implications of this study are also discussed.

Introduction

Tell me, I forget
Show me, I remember
Involve me, I understand

~ Confucius

Traditional physics instruction, predominantly based on lectures and manipulation of formulae, has largely been ineffective (Welzel, 1997, Pfundt & Duit, 1994). In a typical classroom setting, if students are involved in only such passive learning, it would lead to limited knowledge retention, let alone engaging them in thinking or promoting conceptual understanding. Research has shown that involving students directly and actively in the learning process promotes meaningful learning. The constructivist teaching approaches encourage teachers to recognize the views and ideas that students bring to the class so as to provide experiences that will help them build on their current knowledge of the world (Duit & Confrey, 1996). Of the many teaching approaches proposed as a direct consequence of research into students' conceptions, one feature/strategy that draws our attention is the use of demonstrations in the Physics classroom.

As Physics teachers, we want our students to develop valid ideas about Physics in the spirit of inquiry and investigation, and this can be triggered off by interactive demonstrations in their lessons. The demonstrations are led by the teacher who is well prepared with trials before executing them in front of the students. This is often accompanied with a list of prompting questions to entice students and constantly have the cognitive objectives checked. Its interactivity is upheld by inviting students to predict, observe and finally propose an explanation for the demonstration/phenomenon observed.

Conceptual understanding is a worthwhile goal of science teaching. It is promoted by using concepts to explain observations and make predictions as well as by representing the concepts in multiple ways. Conceptual understanding must be given time to be entrenched by establishing connections, forming linkages and exploring issues in greater depth.

Scientific demonstrations are often used in science classrooms (Glasson, 1989). It has been recognized as a complimentary approach to traditional teaching approaches. There is a need for demonstrations to assume a more important role in science education. However, there has been little research on the effectiveness of the use of demonstrations in helping pupils to construct meanings of concepts and promote conceptual understanding. Studies done by Roth et al (1997) and Shepardson (1994) have recognized the varying degrees of impact that science demonstrations can have on student learning and its success has also been thought to be dependent on variables such as social interaction, instructional practice, organizational mechanics and other physical factors.

In this study, we aim to investigate the effectiveness of demonstrations to promote conceptual understanding in physics among secondary school students. Little research in this area has been done in Singapore and, in particular, at the secondary level. The topic of air pressure was chosen because of the availability of several demonstrations that can illustrate its multifarious concepts. Moreover, the apparatus for demonstrations can be easily fabricated or assembled using everyday materials. .

Research Design

<u>Sample</u>

The participants in this study were 100 pupils (all girls) attending a secondary school. They are enrolled in the Secondary 3 level and take Pure Physics as one of their science subjects. Intact classes were engaged so as not to disrupt their normal schedules. Two classes were chosen and taught various concepts on the topic of Pressure by the traditional chalk-and-talk approach, these made up the control group. The other two classes were taught the topic only via a demonstration session, and constituted the test group.

The demonstration sessions were conducted by an experienced teacher. Each session consisted of 18 demonstrations that illustrated various aspects of pressure in a holistic manner. A number of these demonstrations have everyday life relevance and applications. The demonstrations were fabricated using simple and easily available materials. Students were invited to predict and observe at the beginning of each demonstration, posed questions to test their understanding or clarify doubts on the demonstrated phenomenon during each demonstration. The teacher then presented a clear and explicit explanation to the students before starting the next demonstration. A few demonstrations were presented to the students as discrepant events so as to foster cognitive dissonance or jolt their thinking about the concepts being taught.

<u>Design of Evaluation instruments</u>

Three evaluation instruments were used in the study. Their design is addressed in this section.

The first instrument was developed in order to obtain a quantitative assessment of the students' conceptual understanding of the topic of pressure. It comprised a cognitive test made up of ten multiple-choice questions. Attempts were made to formulate items that were relevant to the concepts illustrated in the demonstration session and which are within the framework of the syllabus but does not require a great deal of isolated factual knowledge. In assessing and measuring students' understanding of science concepts, Esiobu and Soyibo (1995) have suggested that test items must test beyond the comprehension level on the Bloom's taxonomy. The distribution of test items revealed that all questions were at least at the comprehension level (Table 1). Two experienced Physics colleagues confirmed that the content and validity of the instrument were appropriate for use in this study. Their minor feedback was incorporated into the final version of the test.

Table 1 Distribution of multiple choice questions based on Bloom's Taxonomy

Cognitive level	**Description**	**No. of Questions**
Knowledge	Exhibits previously learned material by recalling facts, terms, basic concepts and answers	-
Comprehension	Demonstrating understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions and stating main ideas.	4
Application	Solving problems by applying acquired knowledge, facts, techniques and rules in a different way.	1
Analysis	Examining and breaking information into parts by identifying motives or causes; making inferences and finding evidence to support generalizations.	5
Synthesis	Compiling information together in a different way by combining elements in a new pattern or proposing alternative solutions.	-
Evaluation	Presenting and defending opinions by making judgments about information, validity of ideas or quality of work based on a set of criteria.	-

The second instrument was a survey form. The statements in the survey form were crafted by using ideas from the survey literature as well as by drawing on the authors' experiences. Statements were drafted for five categories: *learning climate, learning behaviour, about the session, learning outcomes, and about demonstrations.* They were edited for clarity, ambiguity and redundancy, before trimming them down to an adequate number. The instrument was validated by two university professors and a school teacher who had expertise in survey construction. Their comments were taken into consideration before finalizing the list of statements in the survey form. A space was provided in each survey form to capture respondents' general comments. The survey form used for the control group differed slightly from that administered for the test group - the difference can be seen from Tables 4 and 5. Each statement in the survey instrument used a five-point Likert-type scale, ranging from Strongly Agree (SA) to Strongly Disagree (SD). The corresponding numerical measures ranged from 5 for SA to 1 for SD. For negatively worded statements, the numerical measures were reversed.

The third instrument was a qualitative survey of the students' feelings/experiences on the demonstrations, and this was collected through entries in a learning journal. All participating students were encouraged to write, giving their reflections and providing comments on their learning experience.

Procedure

The cognitive ability of the students from the four participating classes was ascertained in a common Physics examination. Table 2 illustrates their mean score and how they were grouped in this study.

Table 2 Mean scores of students in common examination

Class	Mean score (%)	Group
Sec 3A	66.3	Control Group 1
Sec 3B	60.0	Test Group 1
Sec 3C	58.0	Control Group 2
Sec 3D	59.0	Test Group 2

The grouping of the classes for the purpose of this study shows that the pupils in Secondary 3 C and 3 D are of about the same academic standing as far as their Physics competency is concerned – one formed the control group while the other formed the test group. The Secondary 3A pupils were slightly better than the Secondary 3B pupils, but it was felt that their competency levels in Physics are such that one can be the control group and the other be the test group.

The two classes forming the test group were invited to a 75-minute demonstration session in a well-equipped science laboratory over two different timings on a Saturday morning. Prior to this, the students were not exposed to any formal teaching on the topic but were merely informed of the title of the session. After the demonstration session, the students were required to complete the MCQ questionnaire in 20 minutes, followed by the survey instrument. The 20 minutes allocated for the completion of the MCQ paper follow the norms used by the Cambridge University Examination Syndicate's General Certificate Examination (Ordinary Level), where each MCQ item is given 90 seconds for answering.

As for the two classes forming the control group, they were exposed to the syllabus requirements of the topic and this includes all related concepts, mathematical treatment, experiments (theoretical) and problem-solving. The teacher did not show them any demonstrations in the two weeks of lessons, though they could try any one as suggested in the textbook themselves. They completed the same MCQ questionnaire after being taught the topic. In order to provide all participants with equitable learning experiences, the control groups were then invited to the same demonstration session during one normal lesson. After this, they completed the survey form.

20 minutes was allocated for survey form completion, and all students were encouraged to respond freely. This was done so as to elicit as much information as possible from the students' thoughts and insights on the sessions.

Both groups were also invited to reflect on the session, write entries in their learning journal, and hand this within a week of attending the demonstration session.

Discussion

An assessment framework based on a multitude of instruments – content testing, survey form and learning journal, has been found to be useful in gauging the effectiveness of demonstrations in the teaching of physics. These instruments have permitted a holistic perspective of the various research issues to be obtained.

(a) MCQ questionnaire

Cognitive assessment in the MCQ test seeks to examine the level of conceptual understanding attained by the control and test groups. The correct answer to each question in this instrument requires conceptual understanding rather than a memorized response. The maximum score is 10 and the mean is obtained by averaging the scores of the group. Table 3 shows the distribution of scores for the various groups.

Table 3 Distribution of scores for MCQ test

Group	**Test Group 1**	**Test Group 2**	**Control Group 1**	**Control Group 2**
Mean score /10	6.9	6.4	6.9	5.8

It can be seen that the mean scores for the test group compares favourably with those of the control group, who have been taught the lesson in the traditional manner. Though the mean scores for the MCQ test are relatively similar, the control group has not given better performance in comparison despite the fact that the students in this group have been given the full treatment of the topic of Pressure. A possible reason for this could be that the students in the control groups have not had the opportunity to develop sound conceptual understanding of the topic. In the demonstration session, providing explanations in an enrichment setting helps to develop the conceptual understanding of students. In fact, one of the test group has top scored over both the control group as well as the other test group.

(b) Evaluation of effectiveness of demonstrations

For the purpose of our study, we aimed to assess the effectiveness of demonstrations in contributing towards the development of students' conceptual understanding in Physics. In this context, the emphasis has been only on the use of simple statistical analyses and reliability analysis of the data captured by the survey forms. The use of more sophisticated analyses as well as the study of other factors are not the focus of this study, and are thus not addressed

Internal consistency of the evaluation instrument was obtained by extracting the Cronbach Alpha coefficient (Cronbach, 1951). For all groups, the coefficient exceeds the norm of 0.70 recommended by Nunnaly (1978), and thus indicates good reliability of the survey instrument developed (Table 4)

Table 4 Means and Cronbach Alpha Coefficient for various groups

Group	**Number of students**	**Overall mean of instrument**	**Cronbach Alpha coefficient**
Demo group 1	21	4.19	0.97
Demo group 2	25	4.32	0.98
Traditional group 1	28	4.53	0.91
Traditional group 2	26	4.46	0.88

Descriptive statistics for the data for the survey instruments are shown in Tables 5 and 6.

Table 5 Descriptive statistics for Test Groups 1 and 2

No.	Item	Min Gp 1	Min Gp 2	Max Gp 1	Max Gp 2	Mean Gp 1	Mean Gp 2	Standard deviation Gp 1	Standard deviation Gp 2
Learning Climate									
1	This mode of lesson delivery created a classroom climate conducive for my learning.	4.00	4.00	5.00	5.00	4.24	4.56	0.436	0.507
2	The pace and sequence of the lesson was appropriate for me.	3.00	2.00	5.00	5.00	4.19	4.40	0.512	0.764
Learning Behaviour									
3	The session (a) captured my attention,	4.00	4.00	5.00	5.00	4.67	4.76	0.483	0.436
	(b) focused my thinking and	4.00	3.00	5.00	5.00	4.38	4.32	0.498	0.627
	(c) maintained my interest.	4.00	3.00	5.00	5.00	4.61	4.60	0.498	0.577
4	The demonstrations enhanced my understanding of the key concepts in *Pressure*.	3.00	3.00	4.00	5.00	4.52	4.28	0.602	0.737
About the Session									
5	The probing questions raised during the session had helped me to (a) scaffold my thinking and	3.00	3.00	4.00	5.00	3.71	4.12	0.463	0.526
	(b) foster my conceptual development.	3.00	3.00	5.00	5.00	3.80	4.12	0.402	0.526
6	The session was fun and engaging in terms of lesson delivery.	4.00	3.00	5.00	5.00	4.57	4.60	0.507	0.577
7	The number of demonstrations in the session was just nice.	3.00	2.00	5.00	5.00	4.24	4.04	0.700	0.790
Learning Outcomes									
8	During the session, I (a) felt challenged to make calculated predictions, and	3.00	3.00	5.00	5.00	3.76	4.20	0.625	0.707
	(b) was encouraged to explain / account for each demonstration / phenomenon.	3.00	2.00	5.00	5.00	4.00	3.68	0.547	0.852
9	I had this strong feeling to participate and handle the demonstrations myself to reaffirm the concepts and skills that I have learnt in Physics.	3.00	2.00	4.00	5.00	3.76	3.92	0.625	0.702

No.	Item	Min Gp 1	Min Gp 2	Max Gp 1	Max Gp 2	Mean Gp 1	Mean Gp 2	Standard deviation Gp 1	Standard deviation Gp 2
10	The session built up the confidence in me in learning and explaining the scientific concepts in Physics.	3.00	3.00	5.00	5.00	3.76	3.96	0.436	0.455
No.	**Item**	**Min**		**Max**		**Mean**		**Standard deviation**	
		Gp 1	**Gp 2**	**Gp 1**	**Gp 2**	**Gp 1**	**Gp 2**	**Gp 1**	**Gp 2**
11	Through this session I am made more aware of my own thinking and learning.	3.00	3.00	5.00	5.00	3.81	4.16	0.512	0.688
	About Demonstrations								
12	Demonstrations are a waste of time.	2.00	4.00	5.00	5.00	4.42	4.76	0.746	0.436
13	Demonstrations should not be integrated into traditional physics teaching.	2.00	2.00	5.00	5.00	4.57	4.64	0.746	0.700
14	Use of simple items in the demonstrations made the concepts easier to understand.	3.00	3.00	5.00	5.00	4.19	4.24	0.512	0.523
15	Live demonstrations are better than 'video' demonstrations.	3.00	4.00	5.00	5.00	4.42	4.64	0.598	0.490

Table 6 Descriptive statistics for Control Groups 1 and 2

No.	Item	Min		Max		Mean		Standard deviation	
		Gp 1	Gp 2	Gp 1	Gp 2	Gp 1	Gp 2	Gp 1	Gp 2

Learning Climate									
1	In comparison to traditional teaching, demonstrations during a lesson created a classroom climate more conducive for my learning.	3.00	4.00	5.00	5.00	4.79	4.62	0.499	0.496
Learning Behaviour									
2	Comparing to traditional teaching, this session (a) captured my attention more,	4.00	4.00	5.00	5.00	4.89	4.77	0.315	0.430
	(b) focused my thinking more and	4.00	3.00	5.00	5.00	4.71	4.46	0.460	0.582
	(c) maintained my interest more.	4.00	4.00	5.00	5.00	4.86	4.77	0.356	0.430
3	The demonstrations provided me **better** understanding of the key concepts in *Pressure*.	4.00	4.00	5.00	5.00	4.64	4.58	0.488	0.504
No.	**Item**	**Min**		**Max**		**Mean**		**Standard deviation**	
		Gp 1	**Gp 2**	**Gp 1**	**Gp 2**	**Gp 1**	**Gp 2**	**Gp 1**	**Gp 2**
About the Session									
4	Compared to traditional teaching, the demonstration session raised probing questions that helped me to (a) scaffold my thinking more and	3.00	2.00	5.00	5.00	4.14	4.15	0.525	0.613
	(b) foster my conceptual development better.	4.00	2.00	5.00	5.00	4.21	4.15	0.418	0.613
5	The demonstration session was more fun and engaging than traditional teaching.	4.00	4.00	5.00	5.00	4.89	4.73	0.315	0.452

6 The number of demonstrations in the session was just nice.	3.00	3.00	5.00	5.00	4.54	4.31	0.576	0.679
Learning Outcomes **7** In comparison to traditional teaching, this demonstration session encouraged me **more** to explain/account for each phenomenon.	3.00	3.00	5.00	5.00	4.21	4.31	0.499	0.549
8 The demonstration session gave me greater confidence in learning and explaining the scientific concepts in Physics.	3.00	3.00	5.00	5.00	4.21	4.15	0.499	0.464
9 Through this demonstration session, the awareness of my own thinking and learning was further heightened compared to that in traditional teaching.	3.00	3.00	5.00	5.00	4.21	4.31	0.499	0.549
About Demonstrations **10** Demonstrations are a waste of time.	4.00	4.00	5.00	5.00	4.71	4.62	0.460	0.496
11 Demonstrations should not be integrated into traditional teaching.	4.00	4.00	5.00	.00	4.79	4.81	0.418	0.402
12 Use of simple items in the demonstration made the concept easier to understand.	3.00	3.00	5.00	5.00	4.21	4.15	0.499	0.543
13 Live demonstrations are better than ‘video’ demonstrations.	3.00	4.00	5.00	5.00	4.43	4.50	0.690	0.510

Some of the important findings emerging from this study

- The interactive and active environment involving the use of demonstrations in teaching the topic of pressure has promoted understanding of these concepts among students, as reflected by the mean of about 4.1 for Items 4 and 5 (Test Groups) and that of 4.4 for Items 3 and 4 (Control Groups). The fostering of understanding through structured questioning and teacher scaffolds pitched at appropriate level for each of the demonstrations does play a role in this regard. Such meta-cognitive strategies encourage reflective practice as well as promotes scientific inquiry in students. It also facilitates conceptual inter-relatedness as well as develops thinking skills among students.

- Students perceived that the learning climate in the demonstration teaching session is better than that in the traditional teaching session as it is less threatening and more fun and engaging. With regards to the learning climate, the means for Items 1, 2 and 6 are 4.2 for Test Group 1 and 4.5 for Test Group 2 while the mean for Items 1 and 5 is 4.8 for the Control Group – thus testifying to the perception of the efficacy of the use of demonstrations.

- The mean of at least 3.7 for all items in the Learning Outcomes segment suggests that better learning outcomes have been achieved with demonstration teaching as it has set up an active learning environment where students are presented with opportunities to question and challenge themselves on their ideas and concepts. This articulation and construction of deeper understanding have enhanced their level of confidence in learning and explaining scientific concept as well as promoting awareness of their own thinking.

- The overall mean value of at least 4.2 for all groups (Table 4) clearly illustrate students' positiveness towards the use of demonstrations in the lesson. The participants in the control groups have shown greater appreciation of the session than those in the test groups.

- All groups have unanimously agreed that demonstrations should be integrated into normal science teaching and that it has created an environment that is conducive for their learning through the invoking in them of positive learning behaviours such as high interest levels and attention spans, as well as scope for focusing on their own thinking Item 3 (Test Group) and Item 2 (Control Group) refers.

(c) Learning journal entries

The form of feedback leveraging on learning journal entries has been found to be very productive and insightful. There does not appear to be references in the literature reporting the use of learning journals. It was chosen over interviews since it posed little inhibition on the students' responses/feedback and also plays down the time factor and physical set up necessary for setting up interviews. The learning journal was not compulsory for all, but many chose to hand it in, which goes to show that the session that they had has affected them to a certain extent. All reported having enjoyed the session and had found it 'interesting, challenging and fun' and 'captivating and engaging'. It is evident from the entries in the learning journal that students are thinking more confidently, critically and creatively.

Echoed Shiqi: *"Especially when interesting and captivating demonstrations that capture our attention are shown, we are inclined to find out more or watch on, and also think about further aspects of the Physics laws."*

Clearly, the students are motivated and the demonstrations had set them thinking, searching for a plausible explanation to the immediate situation as well as triggering their critical thinking skills.

The 'live-ness' of demonstrations in the class affords a sense of authenticity and credibility - students are inclined to subscribe more readily to the lesson/concept. Said another student*: 'seeing is believing'*. Besides being convincing, it impacted them with a long lasting effect, as Michelle highlighted: *"It helped me remember the concepts better as I've a greater impression of the demonstration, hence enforcing my learning and understanding of the topic"*. And chorused Yuxin:
"Seeing the spectacle occur before our very own eyes strengthened the impact it had on us."

Wrote Zhaojing: 'The use of ordinary everyday materials like cups, … was also effective in demonstrating the application of pressure and such physics concepts in our daily lives'. . The students generally appreciated the everyday context provided in most of the demonstrations. Many others reiterated the notion that this could improve their observation of everyday phenomena. The use of common materials gave them confidence to want to try the demonstrations themselves, as Karen remarked: *"What struck me most was that his demonstration did not require fanciful or high tech equipment but on the contrary, could be applied in day-to-day situations."*

The quality and characteristics that the teacher demonstrator contributes to the session significantly enhances the effectiveness of the demonstration, too. Yuxin wrote: *'the occasional trick here and there did not have much to do with physics but served to amuse and enthrall and keep our attention focused.''* and added Sara *'there was clarity in his explanations and he has quite a sense of humour.'*

These anecdotal student accounts further indicate that the approach used in this study was successful in increasing students' conceptual understanding of the topic of Pressure as well as increasing their interest and positive-ness towards the study of Physics.

The following selected entries from the students' learning journal further reiterates the effect that the session had on them:

Control Group

Michelle: *The experiments conducted were all highly interesting and captivating, serving as a better alternative learning medium to the traditional theory lessons.*

Zhern Ling: *The live demonstration was a welcome change from normal teaching methods and effectively it managed to capture my attention and focus my thinking, helping me maintain interest in the topic, as well as encouraging me to ponder over the concepts causing each phenomenon.*

Mindy: *(name of teacher) is a very humorous man who manages not only to inform, but also entertains with his demonstrations.*

Fang Ying*: I believe that visual aid accompanied by explanations is definitely a lot more effective compared to normal classroom teaching. I think that this method should be employed as often as possible especially for complex concepts.*

Test group

Geraldine*: The demonstrations provided me with a better understanding on the concept.*

Sara: *(name of teacher) made all the concepts so easily understandable.*

Janice: *The simplicity of most of the demonstration also makes them more appealing and may encourage us to try out for ourselves after seeing them.*

Shiqi: *The lecture was extremely amusing and his method of demonstration helps because he managed to create suspense, wonder and invoke an immense interest and had us questioning ourselves in a search for an explanation for the seemingly miraculous trick he performed.*

Linette: *These 'magic tricks' helped make the concepts more visual and easier to understand and grasp.*

Implications

Through this study, we have identified a number of contributing factors that can aid in the development of conceptual understanding in students when using demonstrations for teaching.

The role played by the teacher is rather important. He/She is the stimulator of curiosity, an attribute that is important for capturing students' attention through suspense or mystery. Students are thus motivated to see the real purpose of the demonstration. The teacher challenges the students with ideas, encouraging them to think critically about their explanations. Being the resource person, he/she assembles the demonstration materials , practice these before hand and has cognizance of the limitations of time within the framework of curricular considerations. A dose of humour when presenting demonstrations is certainly not out of place as it can enrich the flavour of the session!

Consideration must also be given to the choice of demonstrations. In this context, the following remarks are pertinent:

- If a series of demonstrations are to be used, then these demonstrations should revolve around a single concept (Shepardson, Moje & McClelland, 1994). For example, there were three demonstrations in our study that focused on the movement of fluid due to a pressure difference; the students were able to make the appropriate conclusions on their own through observation and without any teacher guidance. No conceptual confusion arose as they predicted correctly the outcome of the third demonstration.

- Inclusion of discrepant event starts the process that induces students to think more deeply about the phenomenon or process under study, particularly when their predictions differ from the observation. Though there is little evidence that using discrepant events promote conceptual understanding in itself, this powerful strategy does help students to analyze their thought processes.

- Roth et. al. (1997) have identified several influences that mediate what and how students learn from demonstrations. Our study was able to shed some light on three of them which include:

(a) students having difficulties separating ‘signal’ from noise: they do not know which aspects of the demonstration they need to focus on in order to understand what is happening,

(b) when students see a particular demonstration, they develop their explanations and understanding based on their prior experiences and discourses, which may or may not be appropriate in the construction of knowledge for the current situation; and

(c) interference from other seemingly similar demonstrations that affect their learning.

There were three demonstrations in the session that have exactly identical effects but the underlying principles are fundamentally different. These three demonstrations have been found to stir a number of queries in students. They were alerted to the fact that they need to carefully process what they see in order to match the intent of the demonstration rather than just constructing their understanding on the basis of their existing mental models. Thus, it is important for demonstrations to explicitly and concretely communicate the attributes of the concept in relation to the construction of scientific knowledge.

The need to provide a conducive environment for demonstration teaching needs no reiteration. This includes cognizance of the following factors:

- the physical set-up of the classroom, which allows all students to have both visual and audio access to the demonstration event, and

- good pacing of the session, as is reflected in the smooth flow of different demonstrations interlaced with teacher-students sharing and questioning.

We are not advocating that demonstrations should replace traditional teaching, but that it could be judiciously incorporated into normal lessons so that it could further assist students in making sense of certain concepts in more depth. This helps to reduce the cognitive load required to understand concepts in the traditional manner.

Conclusion

It might be hasty to conclude that demonstration teaching has effectively developed the students’ conceptual understanding based on this study. However, we believe that this method has effected some useful conceptual changes in our students as viewed through the lens of constructivism. In the context of probing student understanding, observation of the outcome of the demonstration is crucial as it formed the link between the prediction and explanation stages, and the process requires interpretation arising from one’s prior experiences. Hence, this provides a window into the students’ own personal views and ideas through which they can be challenged to construct meaningful learning.

The demonstration teaching session promotes peer interaction where students are free to argue, make mistakes, and challenge each other. According to Piaget (1994) this peer interaction plays an important role in the equilibration process whereby students are motivated to resolve the discrepancies between what they already know and what they observe. Thus, demonstrations afford opportunities for students to work on a task, co-constructing knowledge by building on each other’s ideas and, in doing so, they gain a greater conceptual clarity for themselves as well as arriving at a shared understanding.

Also, this study suggests the potential for the development of a teaching strategy which incorporates demonstrations. The teacher must be mindful of various considerations when it comes to the integration of various teaching strategies with demonstrations to make the combination productive to promote student learning. Science teaching, therefore, needs to develop conceptual understanding in students, rather than encouraging rote memorization or avoiding conceptual issues in favour of procedures and activities. It is also apparent that the use of demonstrations aid in surfacing alternative conceptions in students' scientific knowledge.

Teachers need to recognize the availability of many demonstrations for science teaching as well as the potential of this instructional tool to generate positive learning outcomes in students' learning. There are strengths and some weaknesses in adopting this approach for teaching, which awaits each teacher's discovery. Though the session described an apparent teacher-centric activity, carefully planned timings were allocated for construction of understanding through predictions, question and answers, and explanations.

In summary, this study shows that demonstrations can be an important vehicle for promoting conceptual understanding in physics among students. Its potential for fostering cognitive gains when allied with traditional teaching is significant!

References

M Welzel, (1997). Student-centred instruction and learning processes in Physics. Research in Science Education, 27(3), 383-394

Pfundt, H., & Duit, H. (1994). Students' a;ternative frameworks and science education. Kiel: IPN.

Duit, R. & Confrey, J. (1996). Reorganising the curriculum and teaching to improve learning in science and mathematics. In D.F. Tresagust, R. Duit, & B.J. Fraser (Eds.), Improving teaching and learning in science and mathematics (pp. 79-93). New York and London: Teachers College Press.

Glasson, G. (1989). The effects of hands-on and teacher demonstration laboratory methods on science achievement in relation to reasoning ability and prior knowledge. Journal of Research in Science Teaching, 26, 121-131.

Esiobu, G.O. & Soyibo, K. (1995). Effects of concept and vee mappings under three learning modes on students' cognitive achievement in ecology and genetics, Journal of Research in Science Teaching, 32, 971-995.

Nunnaly, J. (1978). Psychometric Theory, New York: McGraw Hill

Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests, Psychometrika 16, 297-334.

Piaget, J. (1964) Cognitive development in children: Development and learning, Journal of Research in Science Teaching, 2, 176-186.

Shepardson, D.P., Moje, E.B., & Kennard-NmcClelland, A.M. (1994). The impact of a science demonstration on children's understandings of air pressure. Journal of Research in Science Teaching, 31, 243-258.

Roth, W.-M., McRobbie, C.J., Lucas, K.B. & Boutonne, S. (1997). Why may students fail to learn from Demonstrations? A social practice perspective on learning in Physics, Journal of Research in Science Teaching, 34, 509-533.