ENGAGING SCIENCE EXPERIMENTS FOR STUDENT-CENTRED INSTRUCTION: SHIFTING PARADIGMS AND BUILDING LEARNING COMMUNITIES

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ABSTRACT

Interesting and instructive experiments using data-logging and info-communications technology (ICT) can shift Science learning from the teacher-centred paradigm to the student-centred paradigm and increase the motivation of the learners in the discipline. At the same time, based on projects crafted from these experiments, teachers can build global learning communities through web-based interaction, dialogue, and competitions.

INTRODUCTION

Research has shown that the student-centred paradigm of teaching and learning increases both the motivation and achievement of the learners (McCombs & Whisler, 1997). Today's learners are more sophisticated and demanding. In a knowledge-based society, the social divide continues to widen between the 'haves' and have-nots'. Learners' uniqueness therefore feature dominantly in any instruction. Homogeneity and passive acceptance are no longer the order of today's classrooms. Learners' unique differences including their learning rates, learning styles, stages of development, abilities and other non-academic attributes and needs must be considered. Vatterott (1995) highlighted that ultimately it is the student who makes learning happen. All these point to a pedagogy that calls for a shift in the teaching/learning paradigm from didacticism to constructivism. The p.a.™ Starter Kit is one such attempt to provide engaging scientific experiments for student-centred instruction. "Although there is no one constructivist approach to learning, most emphasize social interaction and adaptability. To view learning through this lens, it is necessary to rethink the traditional idea of what knowledge is" (Silverman & Casazza, 2000, p. 37). This also implies that the 'sage on the stage' position of the 'traditional' teacher is slowly but steadily giving way to the 'guide by the side' facilitative nature of teaching.

The p.a.™ Starter Kit

The p.a.™ Starter Kit is an experimental kit set that can be doubled up as a computer 'game'. "The game nature of the p.a.™ makes it fun and fascinating. At the same time, as an experimental tool, the p.a.™ facilitates a variety of experimentations that can help students gain insights into the abstract ideas of Science" (p.a.™ Starter Kit Manual, Addest Technovation, p. 6). p.a.™ stands for 'Personal Addestation'. The kit set addresses the basics of light and some interesting applications of a light sensor. It contains an interface, a p.a.™ Software CD-ROM, a light sensor, a p.a.™ Starter Kit Manual (comprising 9 self-learning lessons, 8 fully guided activities, 6 semi-guided activities, 5 open-ended projects and 5 suggested games), some accessories for the various experiments and a p.a.™ Starter Kit membership. The membership allows the user on-line access to other web resources and an on-line submission of projects that will be assessed by an international advisory panel. Users can also collect reward points accordingly for a 'trading game'.

The p.a.™ Starter Kit is also a data-logging tool. As such, research has shown that there are tremendous benefits to be derived from it for Science practical lessons. These benefits are listed as follows:

- It offers students new opportunities to explore data in their investigative work (Rogers, 1997).

- In terms of the graphing of data, computer-generated graphs of data can help students appreciate the meaning of data and it is also more advantageous over manual 'pencil and paper' methods (Barton, 1997).

- With respect to the use of data-loggers in Practical Science, research indicates that the opportunity to collect and work on first-hand experimental data offers students authentic scientific experiences (Weller, 1996). Students can use data-loggers to practise skills in scientific inquiry and enhance their understanding and interpretation of graphically presented information.

- In IT-rich environments, students were found to work more independently (Pedretti, Mayer-Smith, & Woodrow, 1998). In our case, the researchers indeed found that the students were less dependent on teachers for instruction, guidance and answers.

- Data-logging methods allow students to take more responsibility in practical work (Newton, 2000). Automatic data collection and graphing reduce the students' need for support from the teachers. The role of the teacher then is to assist students' interpretations of computer generated graphical data through skilful questioning. The identification and explanation of anomalous results are also well supported by data-logging methods.

- The data-loggers can sample large amounts of data. Students are therefore not confronted with insufficient data. Computer generated graphing reduces students' efforts in manual graphing so that they can invest more effort in interpretative activities. The data-logging software allows students to explore data, study trends and patterns and test their hypotheses.

Students engaged in this kind of synthesizing explanations and interpretations are doing higher order cognitive activities (Newton, 1999).

The Study

The p.a. Starter Kit was introduced to a group of 69 primary school teachers with a wide range of teaching experiences. They were attending a three-hour module (on 'Energy' for Primary 4) as part of their in-service course conducted from 6 April 2002 to 4 May 2002 (5 Saturdays in total). At the end of each session, a questionnaire (Appendix 1) was given for the teacher participants to respond and comment on the effectiveness of using p.a.™ Starter Kit as a pedagogical tool. Using a 5-point Likert rating scale, the twelve items in the questionnaire were grouped under three categories; namely, teaching (Items 1, 6, 9 and 10), learning (Items 2, 5, 7 and 8) and thinking (3, 4, 11 and 12). At the same time, three other open-ended questions were included to elicit a qualitative response from the teacher participants.

As part of the 3-hour session, the teachers explored the use of the p.a.™ Starter Kit to investigate the transparency of different materials to light. In this hands-on and minds-on experiment, the teachers worked in small groups of 4 to take readings on the background light intensity and different light intensities for different materials such as cloth, paper, and plastic. They then calculated the resultant light intensity through each material and deduced which materials allow the most and the least amount of light to pass through them. They were also required to suggest as many useful home-based applications as possible. In another experiment, they explored the effect of the triggering of a sound alarm due to the changes in the light intensity.

The Findings

Generally, the feedback from the teacher participants was very positive. They commented that they found the entire experience a very "fun and meaningful" one. Besides, the experimental set-up was extremely user-friendly and easy. "It's fun. Pupils would be very interested in carrying out the experiments. Easy to use," wrote one participant. "The appearance of the p.a. kit set is very appealing. It is very user-friendly – can be set up within a short time. This allows for more time on the experiment," commented another teacher. Considering the limited number of Science lessons in a week and the shortness of time within each class period, the relatively ease of use and set-up was a welcome innovation for the teachers. The teachers also found such an "experiential learning mode with a very hands-on nature" added much variety to their teaching. "Students are able to see for themselves in a concrete way about abstract concepts [sic]," wrote one teacher. They also listed the opportunities the p.a.™ Starter Kit provide for co-operative learning and the development of creative and critical thinking as some ways that will empower them in their teaching. One teacher saw it as allowing him/her to "create problems for pupils to investigate and solve using the p.a. kit set". To summarize the qualitative responses, the p.a.™ Starter Kit is a "fun way to learn and teach" and "it should be useful for all primary schools".

Tabulated below are the quantitative survey ratings in the three categories:

TEACHING

The use of p.a.™ kit set will...		SA	A	N	D	SD
1	interest students towards science learning	29 (42)	39 (57)	1 (1)	0	0
6	cater to different learning styles of students	3 (4)	48 (70)	18 (26)	0	0
9	help students to construct their own learning	6 (9)	47 (68)	16 (23)	0	0
10	help me to teach abstract concepts in a concrete way	9 (13)	53 (77)	7 (10)	0	0
		(17)	(68)	(15)	(0)	(0)

Numbers in brackets indicate percentages

LEARNING

The use of p.a.™ kit set will...		SA	A	N	D	SD
2	enable me to conduct student-centred activities	22 (32)	46 (67)	1 (1)	0	0
5	promote co-operative learning	19 (28)	47 (68)	3 (4)	0	0
7	enhance students' cognitive understanding of scientific concepts	8 (12)	56 (81)	5 (7)	0	0
8	make learning fun and meaningful	32 (46)	37 (54)	0 (0)	0	0
		(30)	(67)	(3)	(0)	(0)

Numbers in brackets indicate percentages

THINKING

The use of p.a.™ kit set will...		SA	A	N	D	SD
3	promote creative/critical thinking	13 (19)	51 (74)	5 (7)	0	0
4	'spark off' further ideas for projects	15 (22)	49 (71)	5 (7)	0	0
11	help students to develop problem-solving skills	4 (6)	55 (80)	10 (14)	0	0
12	trigger in-depth thinking	7 (10)	50 (73)	12 (17)	0	0
		(14)	(75)	(11)	(0)	(0)

Numbers in brackets indicate percentages

It is worthwhile to note that all the ratings were either neutral or positive but not negative. In fact, a very high 97% of the teacher participants agreed or strongly agreed that the p.a.™ Starter Kit catered very much to the learners and learning. A slightly lower but still a very high 89% opined that the use of p.a.™ Starter Kit would enhance students' thinking skills. All except one of the teacher participants was sure that the p.a.™ Starter Kit would interest students towards science learning.

Conclusion

In the classroom of the 21st Century where instructional paradigm and pedagogical practices are navigating towards learner-centredness, the p.a.™ Starter Kit is a timely innovation of a local technopreneur company, Addest Technovation Pte Ltd, that clearly serves the needs and aspirations of today's learners and teachers.

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