A WEB-BASED MODEL FOR INTERACTIVE DISTANCE LEARNING OF PHYSICS

J. J. A. Smit*, G. A. Stringer** & P.J. Enslin ***

INTRODUCTION

The quality of science teaching in South African high schools is extremely low as reflected in the annual Grade 12 (matric) results and the results of the Third International Mathematics and Science Study (Howie, 1997). The main factor causing this state of affairs is the low level of development of science teachers (Smit *et al*, 1997; Taylor & Vinjevold, 1999). The obvious solution to the problem is in-service training of science teachers. This is not an easy task as most teachers are established in a community with family and other responsibilities, distances to tertiary institutions are large and the population density where two-thirds of the population resides is low. Distance education is the only option for many teachers who wish to upgrade themselves. Effective distance education in Physics is restricted by two factors: practical work and the opportunity to communicate on a regular basis with peers and lecturers. The web-based model described in this presentation attempts to eliminate the aforementioned factors to a large extent. The key question addressed in the research was: can Internet technology provide effective in-service physics training for the target group of teachers?

A WEB-BASED MODEL FOR PHYSICS LEARNING

Physics education research has proven that peer learning is an effective learning strategy (Mazur, 1997). Studies of interactive engagement (IE) methods in introductory physics courses showed normalized learning gains of 0.3 - 0.6 compared to traditional instruction at one-third of this level (Hake, 1998). Thus peer interaction became an integral part of the model. A schematic outline of the Asynchronous Peer Response Database Model, facilitating Interactive Engagement (IE) is displayed in Fig. 1.

APRDM facilitates IE and includes other useful/needed features:

Every learner response is documented in time-stamped written form in the database.
The development of each learner's conceptual framework is available for educational research and analysis.
Remediation on persistent misconceptions is possible in the HTML course materials.
The APRDM promotes self-paced mastery learning.

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* School of Science, Mathematics and Technology Education, Potchefstroom University for Christian Higher Education, Potchefstroom, South Africa.

** Department of Physics, Southern Oregon University, United States.

*** Information Technology and Management, Potchefstroom University for Christian Higher Education, Potchefstroom, South Africa.

A Model for Implementing Effective Telematic Education

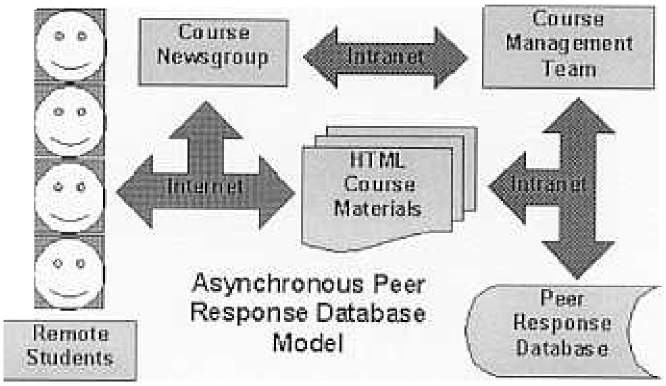

Figure 1: The asynchronous peer response database model (APRDM) stores the naive responses generated by remote asynchronous learners in their interaction with the HTML course materials. The learner is then encouraged to edit and resubmit their responses after reviewing earlier responses from their peers.

A constructivist Outcomes-Based Education (OBE) approach (Matthews, 1997) was used in accord with South African educational goals (National Department of Education, 1997). Practical work, which is essential for effective conceptualization in introductory physics courses (Celliers, 1999) was included even though most high schools currently lack adequate laboratory facilities to implement (Smit *et al,* 1997; Celliers, 1999).

A minimum set of peer responses, preloaded into the database is an important prerequisite for the use of APRDM. There are several possibilities on how to create the minimal set of peer responses: students can be hired to enter naive responses into the database or experts can create a set of pseudo peer responses including common student misconceptions. The purpose with the minimal set of peer responses is to provide students with a number of peer responses they can critically review and analyze as they evaluate their own responses.
In practice a student at a remote computer would log in on the website http://www.puk.ac.za/activelearning/, study the text on one of the units in electricity, perform the associated experiment and then answer the questions on the unit. Students could respond in English, Afrikaans or Tswana. A written response had to be entered in each text area. Naive responses had to be entered sequentially for each question or problem in the module. Questions previously answered could be revisited at any time to refine a response, but the program did not permit skipping ahead.

THE PROJECT

The project called the Telematic Teacher Training Project (TTTP) was conducted at the University of Potchefstroom to assess the feasibility and effectiveness of the APRDM. It used an outcomes-based electricity module developed to coincide with the syllabus for the July 1999 contact session in the second year of the SEDIBA physics course. The telematic module contained three units on basic electricity (Table 1).

1. Electric Current (33)	**2. DC Circuits (40)**	**3. Application (35)**
A. Prerequisites (9)	A. Prerequisites (4)	A. Prerequisites (5)
B. Outcomes (4)	B. Outcomes (4)	B. Outcomes (7)
C. Background (3)	C. Introduction (2)	C. Electronic Parts Kit (4)
D. Circuit Building Blocks (3)	D. Schematic diagrams (2)	D. Resistors in Series and Parallel (2)
E. Current Basics (2)	E. Resistance, Voltage, Current, Power (3)	E. Cells in Series and Parallel (2)
F. Necessary Conditions (1)	F. Series and Parallel Circuits (4)	F. DC Circuit Analysis (2)
G. Precise Definition (1)	G. Ammeters and Voltmeters (1)	G. Energy and Power (3)
H. Exercises (6 + 4)	H. Exercises (16 + 4)	H. Exercises (3 + 7)

Table 1. The 3-unit module in basic electricity used in the TTTP pilot study. The number of responses required in each section of the module is enclosed by parentheses.

An experimental group of twelve students was selected from a class of 43 second year physics students. Each student was issued an apparatus kit. Pre- and post-testing utilized the electricity test instrument DIRECT developed and tested at North Carolina State University (Vetter, 1997). It was simultaneously administered to the experimental and control groups. The study was executed in three phases (Table 2).

Student ID	*Phase 1a 17 July 99*	*Phase 1b 23 July 99*	*Phase 2 25 Sept 99*	*Phase 3 28 Sept 99*
15	1 - D – 3	2 - F - 4	2 - F - 4	2 - F - 4
16	1 - F – 1	2 - F - 4	2 - F - 4	2 - F - 4
17	1 - F – 1	2 - H - 12	2 - H - 16	3 - C - 3
18	1 - A – 2	2 - G - 1	2 - G - 1	3 - A - 3
19	1 - A – 2	2 - H - 1	2 - H - 6	2 - H - 6
20	-	1 - E - 2	1 - E - 2	1 - E - 2
21	1 - A – 1	1 - H - 6	1 - H - 6	2 - G - 1
22	1 - D – 2	2 - H - 11	2 - H - 11	2 - H - 11
24	1 - D – 3	2 - H - 10	2 - H - 10	2 - H - 12
25	1 - C – 3	2 - E - 1	2 - H - 2	3 - B - 4
26	1 - E – 2	2 - H - 14	3 - A - 5	3 - H - 1
27	1 - C – 3	2 - C - 1	2 - C - 1	2 - C - 1
% done =	12%	47%	49%	58%
Responses =	158	608	637	753

Table 2: Progress through the module at key points in the pilot study. The ending date for each phase is shown. Notation used = unit number - section - response number. Shaded cells indicate that no database entries were made during that time interval.

OUTCOMES OF THE PROJECT

DIRECT was used again for post-test assessment. The results are summarized in Table 3.

	Pre-test	*Post-test*	*t-test ⇔*	*<gain>*
TTTP group	47.4%	53.1%	0.346	0.10
Control group	40.5%	50.0%	0.006	0.12
t-test ⇕	0.108	0.582		
Correlation	0.83	0.78		

Table 3: Average scores on DIRECT (shaded), t-test values, normalized learning gains, and correlation coefficients. T-test values measure the likelihood that the average scores could be from the same population. Correlation coefficients approach unity, as the average responses between the TTTP and control groups become proportional question-by-question. The normalized learning gains are typical of traditional instruction according to Hake (1998).

It is apparent in both the pre- and post-tests that the TTTP group outperformed the control group. Both groups show modest learning gains. The t-test results indicate that the learning gains were significant for both groups. Normalized learning gains for the TTTP group did not reach the values expected for IE (Hake, 1998). This can be attributed to the fact that the TTTP group on average completed only 58% of the course before the post-test was administered. The slow progress was due to lower than expected computer literacy in the TTTP group. In an attitude test at the beginning of the project 70% of the group rated themselves as highly computer literate. This dropped to 33% at the end of the project.

It was assumed that the low English language skills of the groups would effect the performance. No clear correlation of language fluency with performance was identified.

The average scores on the regular course examinations in electricity, given to both groups are shown in Table 4. From the November scores it is evident that the TTTP group slightly outperformed the control group.

	April 99	*July 99*	*September 99*	*November 99*
TTTP group	54.3	44.4	58.8	57.5
Control group	55.6	56.6	52.2	53.8

Table 4: Average scores for examinations on electricity administered around the time of the pilot study provide comparative information on the performance of the TTTP group and the control group.

CONCLUSIONS

1 There is reason to be optimistic about this approach to telematic teaching of a discipline like physics. The study proved that the learning gains obtained by this strategy matches that obtained by conventional contact strategies.
2. Technical problems for example due to limited bandwidth at rural sites and breakdown in telephone lines were a handicap. It is however expected that due to technological advances these problems will disappear in the near future.
3. Students need to be computer literate before embarking on web-based studies.

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References

Celliers, J.A. (1999). *First year physics practicals in distance Education in South Africa.* Ph.D. thesis. UNISA, Pretoria.

Hake, Richard R. (1998). Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses, *Am. J. Phys. 66,* pp. 64-74.

Howie, S. (1997). *Mathematics and science performance in the middle school years in South Africa.* HSRC, Pretoria.

Matthews, M.R. (Ed.),(1997). Philosophy and constructivism in science education. *Science & Education.* 6.

Mazur, Eric (1997). *Peer Instruction: A User's Manual,* NJ:Prentice Hall. See also http://galileo.harvard.edu/home.html

National Department of Education. (1997). *Curriculum 2005. Lifelong Learning for the 21st century.* Pretoria, CTP Books.

Smit, J.J.A., Selvaratnam, M., Nel, S.J., Taole, S.H., du Toit, C.J., Selvaratnam, H. & Vreken, N. (1997). *The Training of Physical Science Teachers in the North West Province.* Report to FRD. Potchefstroom.

Taylor, N. & Vinjevold, P. (1999). Curriculum 2005: finding balance between school and everyday knowledge. In Nick Taylor and Penny Vinjevold (Ed.), *Getting learning right* (pp.105-130). South Africa: WITS, The Joint Education Trust.

Vetter, Paula V. (1997). Examining students' understanding of electrical circuits through multiple-choice testing and interviews, Ph. D. Thesis at North Carolina State University (abstract). See also http://www2.ncsu.edu/ncsu/pams/physics/Physics_Ed/