The Use of Datalogging to Raise Achievement in Science in Rural Tanzanian Schools

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Abstract

Tanzania was the first country in the East African region to propose universal primary education in the early eighties under the Nyerere regime [1]. The educational system was based around the extended family (or ujumaa), found in traditional African cultures. After the introduction of school fees in 1984, there has been a steady decline in primary school participation to around 60% [1] although numbers of children with access to basic education in sub-Saharan Africa (SSA) have steadily increased again over the last two decades [2]. Concerns about the decline in science education are not exclusive to the sub-Saharan region. The lack of uptake of science in secondary schools (high schools, in USA and post-primary schools in Ireland) has been a cause for concern for governments worldwide [3]. Therefore, this research sought to identify if the use of datalogging by secondary students raised enthusiasm for and understanding of science, compared to students who were taught without datalogging using the same curriculum. The pilot study adopted a mixed-methods approach using quantitative data collected from pre- and post-examination results with teacher and student questionnaires, followed by semi-structured interviews with two teachers. The study looked at two schools in the Mwtara and Lindi regions of Tanzania, and sough to establish if through the use of datalogging:

- *students could achieve a better understanding and knowledge of concepts of motion and motion graphs and problem solving than a control group taught using inquiry methods but without the technology;*
- *there would be a measurable increased level of enthusiasm about science and hence a greater desire to continue studies in science to tertiary level education;*
- *the performance of students in post-test examinations was higher as compared to the control group.*

The main findings of the research demonstrated that using data logging had a small positive influence on understanding of scientific concepts, which in turn led to higher achievement in the post–study examination. Additionally, students also demonstrated a higher propensity to consider taking a career in a scientific discipline, although only two schools in the same region of Tanzania participated. The study showed that data logging can underpin the development of scientific enquiry skills in rural Tanzania. Students who used data-logging equipment generally performed up to 8% higher in the end of study examination in both enquiry skills and ability to interpret graphs than those that did not use the technology.

Data logging and Inquiry

There is increasing awareness of the need to de-emphasise the rote learning of “de-contextualised scientific facts” [4], and a recognition of the need to place a greater emphasis on developing deeper understanding through inquiry [5]. Moreover, inquiry has always been strongly espoused as an important aspect in teaching science [4]. Scholarly studies conducted in the UK and Australia have recognised that data loggers can facilitate students’ understanding of science and increased process skills when used in an inquiry-based context [6], [7], [8], [9], [10], [11]. Although data-logging shows great promise in the classroom [12], the potential goes unrealised because of the lack of teacher support and professional development, where traditional transmission ways of teaching are still practised to the detriment of student inquiry [13]. Using a design-based methodology, MacDonald (ibid) posed the research problem to teachers: that of integrating data loggers to possibly improve levels of science inquiry. The research was guided by teachers in a community of practice (CoP) who influenced the search for new theories in the research design phase. The corpus of the data was fourteen 60-minute interviews and eight, 60-minute focus group interviews. The data was gathered from the numerous CoP group meetings, data-logging presentations, teacher-researcher collaborative lesson planning/teaching and online collaborative communications.

A number of studies have shown that impact by the use of ICT and datalogging in the classroom is most effective when students are allowed to take control of the learning context [14],[15], [13, 16]. Due to restraints on teachers such as training, time limitations and limited resources, datalogging is often performed by the teacher in front of the classroom, transmitting information while students watch [17], [16]. While traditional transmission pedagogy (such as experiment demonstrations and science talk) is still important [13], datalogging can act as a catalyst for further student inquiry [14], [15].

Methodology

A baseline examination of 1 hour duration was set at the start of the pre-study phase, and again at the end of the post-study phase. For purposes of validity and to reduce pre-study bias, the teachers and students were unaware of the specific details of the research programme at the time of pre-test examination, but were informed that the study would involve innovative ways to teach science over the period of the pilot study. Two secondary schools were involved with a control group (CG) and a datalogging group (DG). Both schools were in rural regions, and were regarded at average performing schools in the national Tanzanian school tables. The CG was instructed in science over a 12 week period through inquiry-based methods alone, whilst the DG group were taught exclusively using dataloggers scaffolded by a similar inquiry-based pedagogy. Eight teachers took parts – four in each school and a total of 40 students over both schools. The participating teacher had no prior experience of either inquiry-based teaching methods or any knowledge of the existence of dataloggers.

The examination questions were based on both factual knowledge and interpretative (graph) questions. The categories covered physics, chemistry and biology and students were given 4 possible answers from which to choose. The questions were designed to test the students' tacit knowledge of science and also their cognitive ability to understand and manipulate data presented in graphical form. A post-study examination was also set of a similar standard to test the scientific knowledge of both CGs and the DGs at the end of 12 weeks.

Results

There was a notable difference in the ability of students to better understand graphs and to decipher the information contained in them. In the case of School 1, data-logging showed a positive influence on students' understanding of questions based on graphical representations, with the CG average of 69.3% (SD = 12.95), whilst the DG showed a higher overall average of 77.1% (SD = 8.97). The mean examination test score increased from 63.6% to 69.3% in the control groups compared with an increase of 61.5% to 71.1% in the data-logging group. The increases represented 6% and 10% respectively. In the case of School 2 the differences were much starker. The mean value of the test scores fell from the pre-study (50%, SD = 27) to the post study (36%, SD = 22) representing a significant fall of 14%. However, the opposite was true for the data-logging groups where there was a significant jump of 20% between the pre-study (39%, SD = 32) and post study (59%, SD = 14).

In the case of problem solving, there were clear differences between the average score attained by the DGs (88.24%; SD = 5.88) and the CGs (57.65%, SD = 31.79) in School 1. This was also mirrored by School 2, with DG scores substantially higher in group problem solving activities (90.2%, SD = 6.79) against the CG (67.6%, SD = 4.16). This test was only carried out post-study in both schools.

For School 1 the paired-sample t-test was conducted to evaluate the impact of data-logging on the performance of students sitting an examination at the end of a pilot study. The levels of attainment in the final examination increased 4.72% whilst the DG group showed a higher increase of 6.33%. This is not surprising that the levels of attainment increased in the control group since the teachers were trained in inquiry-based learning techniques and that there was a positive effect on science learning by virtue of this. The effect size on the group was calculated at .119 showing that the inquiry based methodology exerted some influence. The greater increase was ascribed to DG which showed a more significant increase from 6.33% between pre and post-study examinations with also a correspondingly bigger affect size of .25, which, presumably, is due to using data-logging. School 2 showed a similar trend, although not so defined. The mean result (52.5%) between pre- and post-study groups increased just 1% for the control group and 1.14% for the data-logging group (61.4%). Although the analysis shows that the results could not have occurred by chance, the effect sizes are also corresponding low (control group .003 and the data-logging group .002).

Conclusion

In conclusion, data-logging has a positive influence on the attitudes of students towards science and their approach towards problem solving. The results show that the data-logging has the potential to provide a platform for motivating students to study science, look for a deeper meaning in scientific concepts, stimulate inquiry-based learning and better understand the concept of graphing together with graph matching. The study has also shown suggested that datalogging can provide a surrogate to the science laboratory in the medium term, whilst little prospect exists of fully equipped science laboratories in Tanzania at the moment. The potential for data-logging in Tanzanian schools has been demonstrated in principle and the enthusiasm it inspired in the students to progress to university to study science can only benefit Tanzania.

The study could have benefited from a longer pilot study with more participating schools, but nonetheless, the potential for further research in Tanzania is obvious. It was clear from the study that teachers also need targeted technical and pedagogical support to maximise the learning benefits for students.

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