

AC 2009-1122: AN EVALUATION OF PEDAGOGICAL GAINS IN A FLUID FLOW CLASS WHEN USING DESKTOP LEARNING MODULES IN AN AFRICAN UNIVERSITY

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**An Evaluation of Pedagogical Gains in a Fluid Flow Class when Using
Desktop Learning Modules in an African University**

Abstract

The modern educational setting is gradually becoming infused with new pedagogical approaches including the use of hands-on active elements. This is particularly important in developing nations where student exposure to industrial equipment is limited. This paper presents results from a study in a Chemical Engineering Fluid Flow class. In contrast to an earlier study where there was only one lecture group and one hands-on group, this study alternates the two groups between lecture based and hands-on activities with one group serving as a control for the other.

As in the previous study, a preliminary analysis of the results shows similar improvement on concept inventory performance for students receiving information through lecture and those participating in the hands-on active exercise. However, a survey reveals that students perceive important long term benefits in the form of conceptual understanding, enlightening discussions with peers and instructors, and overall learning satisfaction with the hands-on active mode in comparison to the traditional lecture mode. A thorough analysis of the new classroom pedagogy and its benefits is presented.

Introduction

The traditional lecture method of dispensing education is gradually becoming outmoded due to its inherent passivity and abstraction. Especially for certain technical courses, a straight run lecture would not guarantee adequate or high conceptual gains for the students, leaving too much to the imagination. According to the Dale retention cone ¹, students tend to retain only 5% of what they hear, 10% of what they read, 20% of what they see, 50% of what they discuss 75% of what they practice and 90% of what they teach. Kolb's ² experiential learning model also reinforces the idea that cooperative, hands-on, active and problem based learning greatly enhance conceptual understanding and retention. Chickering and Erhmann ³ suggest that technology is invaluable in implementing the seven principles of good practice in undergraduate education ⁴. Chi ⁵ hypothesizes that concepts are more difficult to learn when a) they are not directly observable (for instance the onset of turbulent flow in a pipe) and b) when macroscopic patterns arise from unobservable microscopic phenomena (for instance diffusion of mass, momentum and energy).

The attempt to address student learning barriers in Ahmadu Bello University (ABU), Zaria Nigeria using miniaturized industrial process equipment and a novel, concept- driven pedagogy is an innovative effort aimed at addressing some of the challenges facing higher education in developing nations. In this paper we assess the impact of using Desktop Learning Modules (DLMs) to assist in teaching fluid flow principles of relevance to the education of chemical engineers. Furthermore, we assess the impact on conceptual understanding compared to traditional lectures, and survey the students on how a hands-on active learning (HAL) approach impacts their classroom interactions, creating ones own understanding, enhancement of team skills, etc.

Materials & Methods

Equipment Design

The Desktop Learning Modules (DLMs) were designed to be portable and receive interchangeable cartridges some of which are shown in Figure 1. A sealed lead-acid battery provides enough power for a pair of small pumps as well as the pressure transducers, thermocouples and read-out electronics. Run time for the batteries exceeds two hours of normal classroom use. Two four-liter water tanks are built into the DLM footprint, one each for shell and tube side fluids when studying the flow dynamics in shell and tube heat exchangers. This design allows the DLMs to be placed on most classroom desk surfaces without resulting in tripping hazards from power cords or water hoses being run to the module.

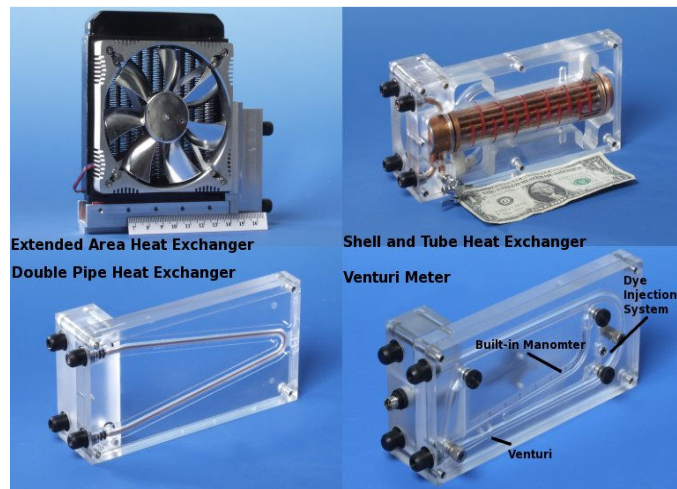


Figure 1. Some Interchangeable cartridges including the Venturi Meter (lower right).

The venturi experiment - a typical fluid flow experiment

In this experiment the students were asked to vary the flow rate of water through the venturi and measure the corresponding pressure drop. They were then asked to reduce the general mechanical energy balance for the case of a venturi and from appropriate plots of the mathematically manipulated model, evaluate the valve coefficient. They are further instructed to compare the experimental value to values reported in the literature and suggest reasons for any significant deviations.

A typical manipulated equation would be:

$$\phi_v = \frac{A_2}{\sqrt{1 - (D_2/D_1)^4}} \sqrt{\frac{2(P_1 - P_2)}{\rho}} C_v \dots \dots (1)$$

Where ϕ_v is the volumetric flow rate, A_2 is the cross-section of the venturi throat constriction, D_1 and D_2 are respectively the pipe and throat diameters, C_v is the venturi coefficient.

Assessment Methods

There were 118 students in the study and they were divided into groups of six students each. Ten groups were exposed to the venturi DLM while the other ten were given a standard active lecture. The groups were then switched in the orifice experiment. To discern whether the HAL or the lecture-based learning offered distinct advantages in terms of conceptual understanding, concept inventory questions were developed (as described below).

The method of convenient sampling was used to split the large class of ca 118 students into two fairly intellectually balanced groups using their previous cumulative GPA as the convenient sorting criteria. Each group was further subdivided into subgroups of 6 students, with an equal mix of “strong”, “average” and “weak” students. A concept inventory pre-test was administered to both the control (lecture) and experimental (HAL) groups. A post-test was then given in order to evaluate the students’ improvement in conceptual understanding. The groups were then switched with the first lecture group now the HAL group in the next experiment for further comparison. After the study, a well designed survey was administered to all the students involved to gauge their receptivity of this new pedagogy compared to the traditional lecture format.

Assessment instruments

Concept Test: A five (5) – question multiple-choice test designed to assess students’ understanding of the concepts of flow in double pipe heat exchanger, venturi meter, orifice meter and pitot tube. The test covered basic theory as well as derived equations of performance parameters and was structured based on the first three levels of Bloom’s⁶ taxonomy. Below is a sample concept question used in our study:

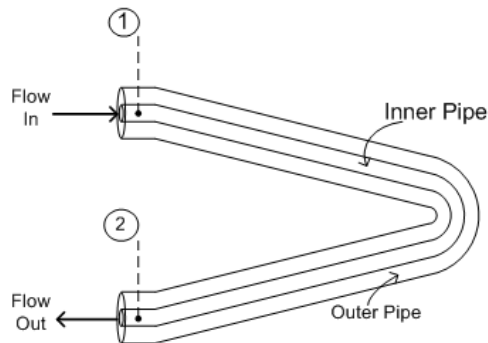


Figure 3: Fluid Flow through inner pipe of a double pipe heat exchanger

For the velocities at points 1 and 2, which is true?

- a) $\langle v_2 \rangle > \langle v_1 \rangle$ because everything accelerates as it flows down hill.
- b) $\langle v_2 \rangle = \langle v_1 \rangle$ because of continuity.
- c) $\langle v_2 \rangle = \langle v_1 \rangle$ because friction forces offset the forces of gravity and differential pressures.
- d) $\langle v_2 \rangle = \langle v_1 \rangle = 0$ because the pump is outside the system.

Flashlight Survey: A survey was developed to assess the HAL experiment therefore and designed based on Chickering’s and Gamson’s⁴ “Seven Principles of Good Practice in Undergraduate Education”. The seven principles include time on task, recognition of students’ diverse approaches to learning, faculty-student contact, student-student contact, faculty’s high expectations, students’ exposure and engagement with diversity, and, finally, students’ opportunities to collaborate. The survey technique and types of questions is referred to as the Flashlight survey (Brown⁷) and in practice uses sets of questions under each of the seven principles. In this we focus only on the conceptual aspects of the survey results.

Results and Discussion

Student survey 2007/2008

A sample of the Flashlight Survey results appears in Figure 2. The most compelling support for the hands-on group learning comes from responses on how the students perceive the method assists them in conceptual understanding. An overwhelming 98% had the opinion that they are better able to remember important facts, while 93% (53% 'strongly agree', 40% 'agree') say they have a more thorough understanding of ideas and concepts, and 93%, (75% 'strongly agree', 18% 'agree') agree that they are better able to visualize ideas. This position is buttressed by a student who said, "The hands-on group learning should be encouraged as it helps the students to interact more and visualize things for themselves". Similarly, another student said, "The hands-on group is (a) very interactive session which should be implemented in other technical courses in order to visualize ideas and concepts in the area of study". This position is in sharp contrast to the Preliminary Concept Inventory results (still under analysis) which show that immediately after a class period both the straight lecture and hands-on active groups showed improvement by the same amount. We note, however, that the Flashlight Survey was given at the end of the semester and that all students had exposure to hands-on active learning as well as lecture throughout the semester. Thus, these results may reflect more on both the long-term persistence of conceptual understanding as well as to the motivation and ability to learn as a result of the hands-on active learning.

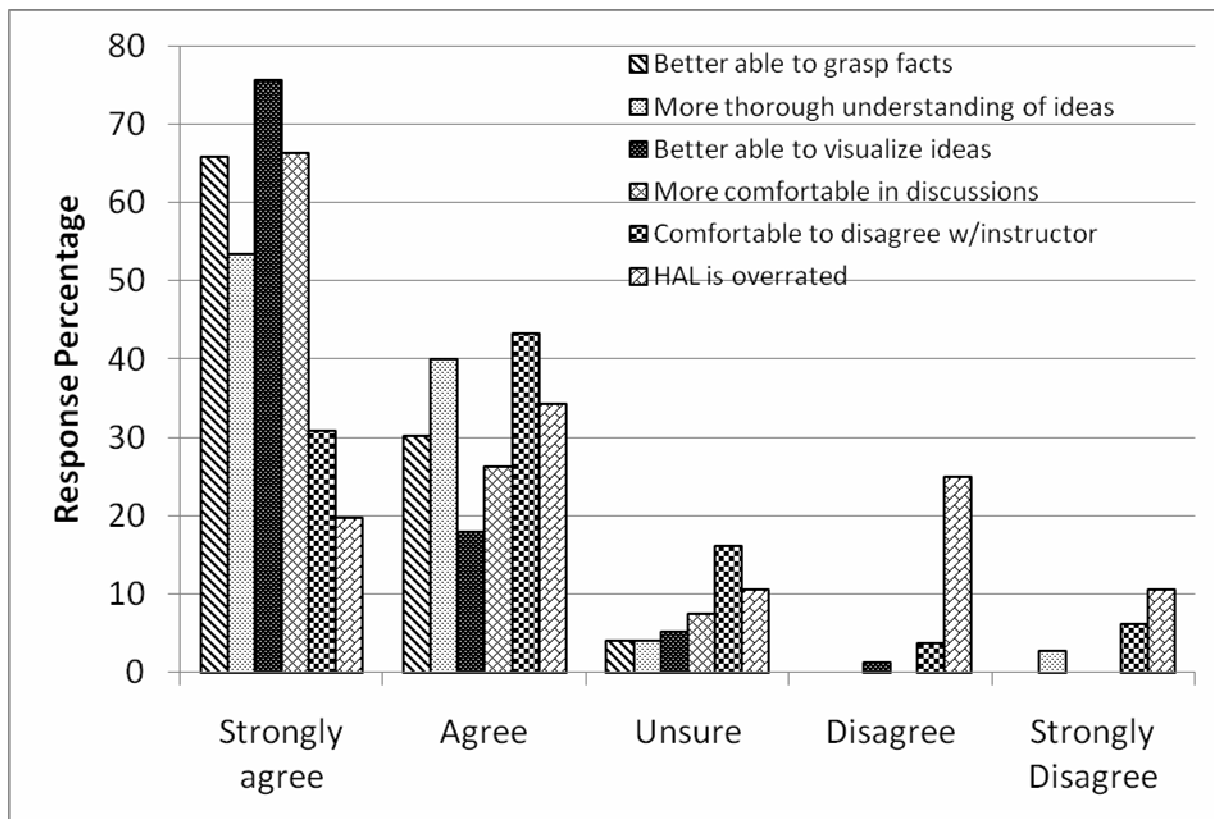


Figure 2: Students response to the question "to what extent do you agree..."

Impact on education in developing nations

The introduction of the DLM and its attendant pedagogy has in no small measure helped in ameliorating some of the challenges inherent in developing nations such as lack of exposure to industrial equipment. Due to the curiosity it generated when it was first introduced, students were observed to gather around the equipment in groups discussing concepts and manipulating the controls. The DLM promotes cooperation within a group. For example, because the DLM reaches steady state within tens of seconds, it will take one person to adjust a control knob, one to observe data displays and speak out values, one to hold a timer, one to record values, one to supervise the process, and yet another to reflect on what all of this means. We also note that because the DLM reaches steady state quickly it creates a particular advantage for the introduction of HAL when using a small number of units in a large African classroom as a large number of groups can be passed through the stations within the class period. At Washington State University (WSU) where the DLMs have previously been implemented (Golter *et al.*⁸), class sizes typically range from 10 to 30 in rooms with ample desk space and seating capacity, and infrastructure that provides ready access to power and hot and cold water supplies. In contrast ABU class sizes range between 100 to 200 students meeting with no access to utilities.

Conclusions:

From preliminary Concept Inventory outcome analysis and the flash light survey we conclude that the new pedagogy and the DLM have enhanced conceptual growth in fluid flow principles and were well received by the majority of students. Based on feedback from the recipients it is envisaged that further work on development of new DLMs and concept inventories will be carried out on other aspects of transport phenomena including mass transfer and combined heat and mass transfer.

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