TEACHING AND LEARNING: A SYSTEMS PERSPECTIVE

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ABSTRACT

University business instructors seek to teach transferable knowledge and skills providing the ability for their students to succeed in future business careers. The application of systems theory, along with a clear understanding of student cognitive processes provides a paradigm for understanding and structuring classroom interactions. However, naïve implementation of cognitive-reflective teacher-student classroom approaches can lead to suboptimal learning outcomes. The careful application of recent research regarding cognition and human intelligence promises improvement in desirable learning outcomes. An empirical analysis regarding situated learning is provided. Students of a lower-division social sciences calculus class were shown to have prior contextual knowledge regarding differential and integral calculus. Implicit knowledge not formally provided in the classroom was evidenced providing support for the situative perspective of human cognition.

INTRODUCTION

The typical educational enterprise can be viewed as a system including the teacher, learner, peer students, situation and environment interacting towards a purposeful end, student learning. The basic principles of system theory suggest that teachers take students and other inputs and through appropriate teaching methods produce educated students as outputs. Unfortunately, this simplistic view masks a great deal of insight that is provided by modern systems theory. Specifically, this discussion will highlight the following characteristics of the systems view of education:

1. All entities enter the system with prior personal and group experience, along with personal psychological, emotional, intellectual and physical characteristics. Teachers and students enter the classroom with a deep cache of evolving personal experience and characteristics uniquely impacting their development within the educational system. The system itself is created within a dynamic cultural context that governs much of the system characteristics that are also changing over time.
2. All entities change and interact dynamically. While the intent may be that students learn from and are changed by the teacher, it is also true that students learn from and are changed by other students, and that teachers learn from and are changed by their students. Additionally, all entities interact dynamically with the external environment through a porous system boundary.

Recent theories of human intelligence have moved from a psychometric perspective, defining intelligence as a single underlying ability, to more representative, contextual, and practical notions of intelligence including the concepts of multiple intelligences and contextual intelligences.

The literature providing possible paradigms, models and theories of learning is broad and diverse necessitating some effort to categorize learning theories by general characteristics. One categorization was proposed by Fenwick [1]. He suggested first that educators should give up the premise that "experiential learning" can be uniquely captured and defined, since by definition every moment is one of experience, consequently, all learning is experiential learning. Additionally, Fenwick indicated that human cognition cannot be contained by a particular theory, but that multiple perspectives add to the overall understanding of learning and thinking. One of Fenwick's perspectives, participation, suggested that the learner is an active participant and that learning is situative meaning that knowledge is contextual. Classroom success is dependent on the understanding that students bring contextual knowledge with them to the classroom setting and that learning in the classroom will be contextual.

The assertion that the participation perspective is crucial to understanding learning and cognition is supported by a number of studies seeking to document the situative aspects of human learning. Two of these empirical verifications of contextual learning include:

- Schliemann [3] described the mathematical capabilities of street vendors and cooks and the use of scalar arithmetic in their every day activities. Their mathematical capabilities were sophisticated within the context of their work, but not generalizable without additional training. Another contextual anecdote was provided regarding the voting behavior and perceptions of a Brazilian woman. In this situation the woman's interpretation of graphical information was influenced by her voting preference.
- Similarly, Lave [2] studied the mathematical sophistication of ordinary people living their ordinary lives in the adult math project (AMP) and found that in many situations mathematical capabilities were uniquely situated.

EXPERIMENTAL METHOD

To test the hypothesis that lower division students arrive at the university with implicit knowledge an experiment was conducted in an introductory social sciences calculus course at a regional state university. The assessment instrument, consisting of a set of four related problem versions, was taken from Sweeney and Sterman [4] who described a larger set of tools for assessing competency regarding individual understanding of dynamic systems. In each problem students were provided with the initial stock of a resource, along with a simple graph delineating the rate at which the resource flowed into and exited from a fixed system, and the students were asked to provide a corresponding graph of the accumulation of the resource over time. These four problems included elementary cash flow (CF) and bathtub (BT) problem descriptions. Each student received only a single version of the problem and the four problems were distributed randomly among the students. The four problems, CF1, BT1, CF2 and BT2 were assigned randomly across nine sections of the course. After discarding responses due to both scoring and response irregularities 165 remained in the study. Demographics including age, gender, class standing and major were collected from university records.

The null hypotheses assumed that the students brought no implicit or situated knowledge into the course; consequently, the expectation was that performance on the two algebraically equivalent problems would be equal. Performance was measured as the fraction, p, of students who answered the problem correctly. Unequal performance on the two equivalent problems indicated differential knowledge regarding bathtubs and cash flows lending support to the situative knowledge perspective.

Hypotheses: Student performance would be equal for the algebraically equivalent problems.

H_o: $p_{CF1} = p_{BT1}$

H_o: $p_{CF2} = p_{BT2}$

RESULTS AND DISCUSSION

The performance results are summarized in the table below accompanied by the test of hypotheses. Note that due to the small number of respondents answering correctly the t-test is not valid for the second hypothesis.

Summary of Performance Results

Question	Num	Correct	%
Bathtub 1	43	9	20.9%
Cash Flow 1	44	4	9.1%
Bathtub 2	39	0	0.0%
Cash Flow 2	39	1	2.6%
Total	165	14	8.5%

Hpotheses Tests:
H_o: CF1 = BT1, t = 10.07, p < .001
H_o: CF2 = BT2, *t not applicable for small p
**Note: the t statistic is not applicable for the second test with p_1 = 0.0 and p_2 = .026; the statistical test of the first hypothesis is also at the border of the utility of the t statistic. Ideally, np would equal 5 or greater.*

For the first set of problems, CF1 and BT1, we rejected the null hypothesis of equality of performance on the bathtub and the cash flow problems and accepted the alternative that performance was not equal. These results provide support for the situative/participation perspective. The results are also consistent with the results found by Sweeney and Sterman [4].

In light of the results of this study we concluded that these two groups of students did have differentiated situative knowledge regarding constant bathtub flows and cash flows that they brought to the classroom. Another interesting facet of the results was that student performance, and by inference implicit knowledge, was not significantly different regarding continuously changing rates of change for both the current study and for the Sweeney Sterman students. This result appeared to be consistent with common experience regarding bathtubs and cash flows. A number of implications for pedagogical improvements were suggested by the current study and by related discussion and analysis.

- First, instructors should carefully consider the cultural, economic, social, emotional, intellectual and physical homogeneity of their students.
- Next, pedagogy should be designed to take advantage of shared implicit knowledge.
- Finally, the classroom can be viewed as the one common component for learning.

REFERENCES

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[2] Lave, J., Cognition in Practice: Mind, Mathematics and Culture in Everyday Life, New York: Cambridge University Press, (1988)

[3] Schliemann, A.D., "Logic of Meanings and Situated Cognition," Learning and Instruction, 8 (No. 6, 1998), 549-560.

[4] Sweeney, L.B. and Sterman, J.D., "Bathtub Dynamics: Initial Results of a Systems Thinking Inventory," System Dynamics Review, 16 (No. 4, 2000), 249-286.

Note: A full version of the paper is available from the first author.