AC 2009-2045: EXPERIMENTAL CROSS-HYBRID COURSE FORMATS

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Experimental Cross-Hybrid Course Formats

Abstract

In a previous paper we described a hybrid course format in which the "lecture content" for core sophomore- and junior-level ECE courses was delivered via on-line streaming video and the regularly-scheduled class meeting times were used for instructor-directed, collaborative problem solving sessions, referred to as "directed problem solving" (DPS). Traditional lecture (TL) divisions of each course were offered simultaneously, to provide students an opportunity to select the course format they felt best matched their individual learning style. In this study, we consider two "cross-hybrid" variants of these: traditional lecture with integrated problem solving (TL-IPS), and directed problem solving with lecture summary (DPS-LS). Initial trials comparing outcome assessment and exit survey results for these formats are presented. The preliminary results demonstrate the viability of the various course delivery options, and provide a general indication of student preferences.

Introduction

The goal of our previously reported work[1] was to compare the relative effectiveness of the "traditional lecture" format with non-traditional "hybrid" course formats, specifically in which the roles of in-class and outside-of-class activities were largely "reversed". So-called "inverted" course formats were originally created for two core computer engineering classes at Purdue: a sophomore-level *Introduction to Digital Systems Design* course, and a junior-level *Microprocessor System Design and Interfacing* course. Both of these are 4-credit hour courses that include an integrated laboratory.

In the non-traditional formats, the basic lecture content was delivered asynchronously via streaming video, while collaborative solving of homework problems accompanied by a detailed walkthrough of their solutions was done synchronously (i.e., during scheduled class periods) – which we refer to as *directed problem solving* (DPS). Traditional assigned (outside-of-class) written homework was replaced by collaborative problem solving by students working in small teams (typically of two students each). Solutions devised by the various teams were evaluated "on the spot" through "self-grading" (based on an instructor-directed solution walk-through), thus providing immediate feedback and eliminating the time, overhead, and expense associated with homework paper collection and grading. Students' scores for the "homework" part of the course grade were determined solely based on attendance at their assigned DPS section. Because of the "virtual lecture" requirement, the DPS sections typically met twice each week (in contrast to the three weekly class meetings associated with the traditional lecture).

To help students decide which course format (TL or DPS) might best match their individual learning style, students were instructed to use the Index of Learning Styles (ILS) on-line survey[2] (developed by Felder and Soloman). Specifically, students with some combination of active, visual, and/or global preferences[3,4,5,6,7] were encouraged to consider choosing the DPS option. While allowing students a choice of course format may have introduced a non-quantifiable bias in the exam performance results obtained, an important finding of this study was the fraction of each cohort that elected the non-traditional option (and the rationale for doing so, based on exit survey results).

Initial success with the DPS format prompted us to consider various cross-hybrid possibilities, which we have begun to explore in the context of the sophmore-level digital systems course originally targeted in this study. The variant of DPS we have tried includes a lecture summary that prefaces the problem solving portion of the class meeting, which we call DPS-LS (the original hybrid employing “virtual (on-line) lecture” we now call DPS-VL). We also wanted to verify that, by comparison, we were casting the traditional lecture in the best possible light. To this end, we added an active learning component (in-class problem solving) to the traditional lecture trials, which we call TL-IPS. For the sake of completeness, a version of traditional lecture employing more conventional (“take-home”) homework, which we call TL-THW, is currently underway. Active learning opportunities are being incorporated into this trial via extensive use of CPS student response units (“clickers”).

A key, underlying goal of this project was to gain an understanding of how efficiently and effectively students learn in hybrid course environments relative to those that are more traditional. This outcome was evaluated by comparing scores on common exams. Another goal was to accommodate a wider diversity of learning styles by offering students a choice between alternate course formats – based on the premise that being required to make a choice forces students to think about how they learn and the environment in which they learn best. This outcome was evaluated based on exit survey data.

Standardized Outcome Assessment Results

There are six learning outcomes in the targeted sophomore-level course[8], each of which is assessed using a standardized in-class “hourly” exam:

1. an ability to analyze static and dynamic behavior of digital circuits;
2. an ability to represent Boolean functions in standard forms, to map and minimize them, and to implement them as combinational logic circuits;
3. an ability to use a hardware description language to specify combinational logic circuits, including various “building blocks” such as decoders, multiplexers, encoders, and tri-state buffers;
4. an ability to design and implement arithmetic logic circuits;
5. an ability to analyze, design, and implement sequential circuits and use a hardware description language to specify them, including various “building blocks” such as counters and shift registers; and
6. an ability to design and implement a simple computer.

Performance comparison for the various cohorts is provided in Figure 1. One qualification that should be noted is that, for the S08 trials, the in-class hourly exams were at 4:30 PM on Fridays; for the F08 trials, the exams were at 7:30 AM on Fridays (regrettably, course staff have no say on when class meetings are scheduled!). The effect of this basic difference among the various trials/cohorts is inconclusive. Another qualification is that cause of the precipitous dip in performance for Outcome 2 has been repeatedly observed, but the cause is presently unknown. The material covered is relatively straight-forward (switching algebra, combinational circuit analysis/synthesis, fundamentals of mapping and minimization), but the exam date (week) typically coincides with major exams in other sophomore-level ECE courses, which we believe is the primary contributing factor.

Given those qualifications, the DPS-LS (directed problem solving with lecture summary) cross-hybrid appears to have produced the highest/most-consistent exam performance across all six course outcomes. However, incorporating active learning into the traditional lecture (TL-IPS) has narrowed the TL-DPS performance gap somewhat (especially in the F08 trial, despite the early-morning exams). A final observation is that "standard" DPS-VL hybrid tends to track very closely with the performance obtained in TL-IPS. The trial currently underway will give us some additional insight on the comparison between in-class homework vs. "take home" homework in the traditional lecture format.

Exit Survey Results

Exit survey results for the traditional lecture (TL) and directed problem solving (DPS) trials are provided in Figures 2 and 3, respectively. Responses were based on a 5-point Likert scale, with 5=strongly agree, 4=agree, 3=neutral/no opinion, 2=disagree, and 1=strongly disagree. Average scores for each question are depicted in the graphs.

Traditional lecture students appeared to be "neutral" concerning whether or not they learned the material better than they might have in the alternate format offered (TL survey, Q8), while DPS students enthusiastically endorsed the virtues of the hybrid format (DPS survey, Q9 and Q12). The "likeability factor" associated with the DPS format is also readily apparent (DPS survey, Q10 and Q11); among the DPS variants, the cross-hybrid integrating a lecture summary (DPS-LS) appears to have a slight edge on most of the "positive attribute" questions (DPS survey, Q2, Q3, Q4, Q5, Q7, Q9, Q10, Q11, Q12, Q13, Q19) as well as a corresponding dip on the "negative attribute" questions (DPS survey, Q6 and Q18). A smaller percentage of the TL students indicated that they used the ILS survey to guide their choice than did their DPS counterparts (TL survey, Q2; DPS survey, Q1). Convincing students to make an *active choice* of course format (given this relatively unique opportunity offered to them in the computer engineering curriculum at Purdue), instead of merely a "default" choice, continues to be an area of concern. We may, in fact, not be realizing the full potential of the multi-format experimental offerings simply because students are not effectively choosing the instructional environment best suited for them. Independent of course format chosen, however, the *availability of a choice* was deemed important by all cohort groups (TL survey, Q3 and Q18; DPS survey, Q8 and Q20). DPS students, in particular, were strongly opposed to the course being offered in solely the traditional lecture format (DPS survey, Q18).

Summary and Future Work

The comparative exam performance results and exit survey data reported here confirm the effectiveness of hybrid course formats. This study also suggests that certain cross-hybrid variants (e.g., DPS-LS) can potentially be even more effective than the original "inverted" course format investigated (DPS-VL). An interesting, open question is: If one were forced to offer a given course in a *single* format only (based on economic and/or staff constraints), which of the various options available should be chosen? The DPS hybrids, which have been elected by 60-70% of each cohort in all trials completed to-date, appear to be "best liked" by students and produce comparable exam performance results with less recurring overhead (two face-to-face meetings per week instead of three, no homework to grade and return…but have the initial, rather substantial overhead of creating the series of virtual lectures along with the accompanying in-class exercises/quizzes).

The traditional lecture hybrid (TL-IPS), on the other hand, has slightly higher recurring overhead (one extra class meeting per week, but no homework to grade and return) with a much smaller "up front" investment (no "virtual lectures" required). The "conventional TL approach" (which we call TL-THW, one of the trials underway as of this writing), has the highest recurring overhead of all ("tweaking" each homework assignment, as well as grading and returning it). Does all this "extra work" manifest itself in better student performance and/or students liking the course/material better? If it can be demonstrated that such effort does *not* (or only does so marginally), would faculty and students alike be better served through widespread adoption of hybrid course formats?

Another open question concerns the type of "alternate-style" learners we are attempting to target in this study. As currently implemented, the "lecture" in both formats (traditional and "virtual") is targeted for auditory-sequential learners (the same *Lecture Workbook* format is utilized for both the live in-class presentations and the streaming video modules). An interesting alternative would be to specifically target visual-spatial learners in the on-line (virtual) lecture format, to better complement what we are trying to achieve in the directed problem solving sessions (i.e., providing more of a "big picture" approach to problem solving, instead of simply lecturing on the sequence of steps involved). Perhaps this would provide a "higher contrast" learning environment than the traditional lecture/virtual lecture option currently offered.

Bibliography

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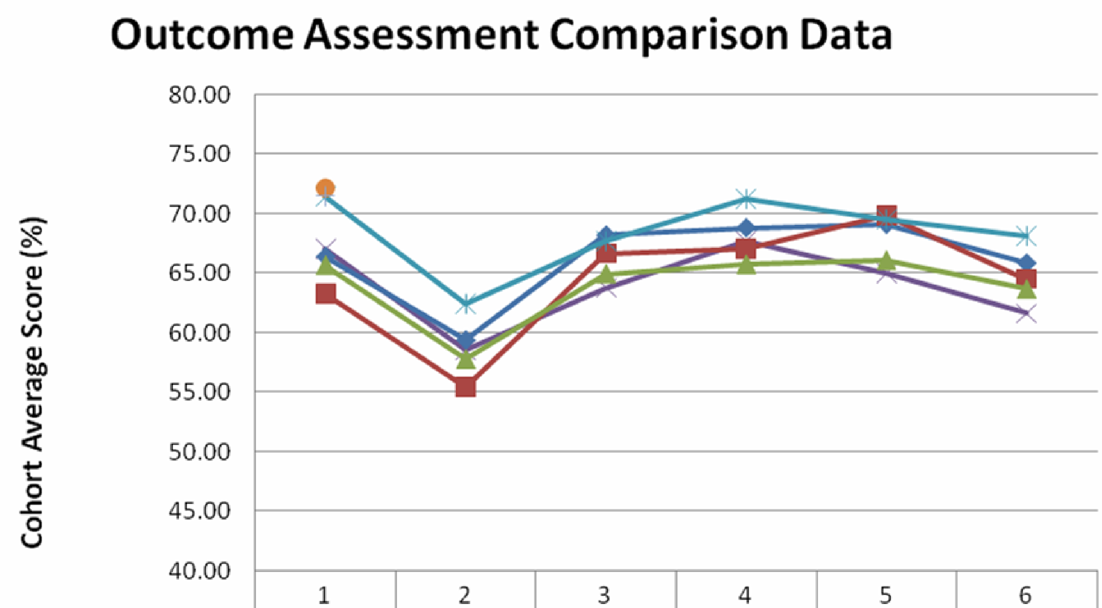
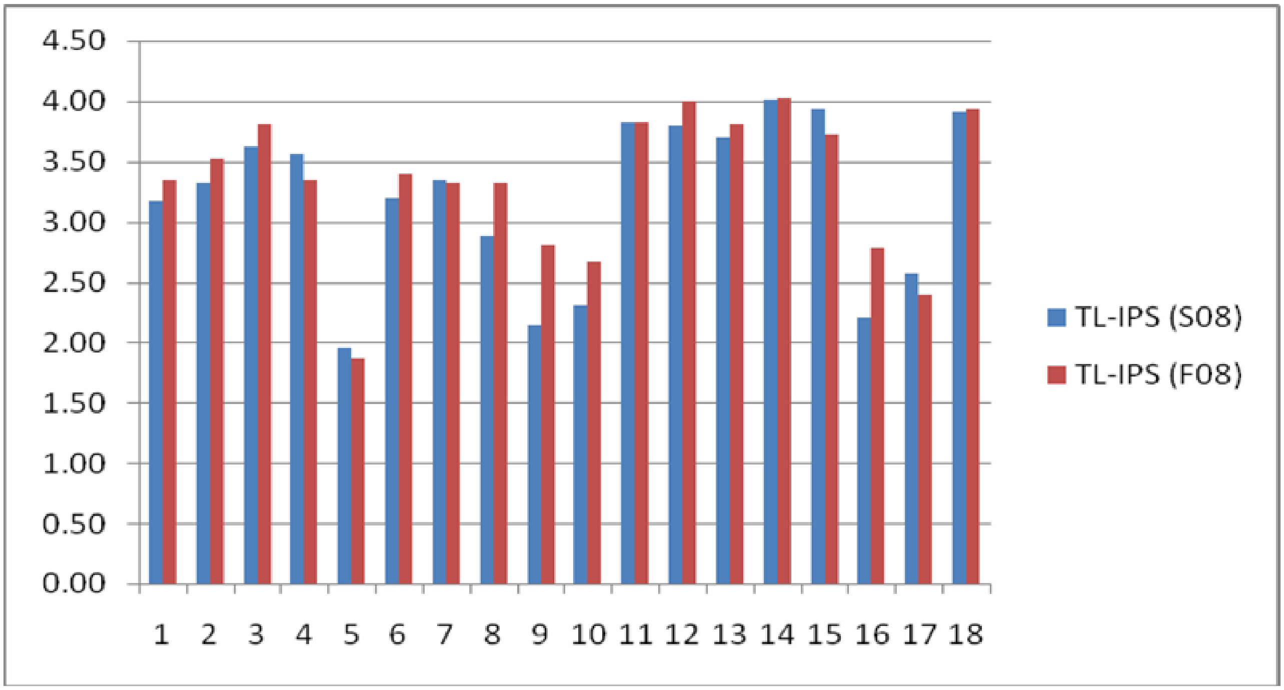


	1	2	3	4	5	6
DPS-VL (S08) - Instr "B"	67.06	58.56	63.75	67.69	65.00	61.63
TL-IPS (F08) - Instr "A"	66.43	59.43	68.22	68.85	69.13	65.88
DPS-VL (F08) - Instr "B"	63.27	55.41	66.68	67.06	69.87	64.50
TL-IPS (S08) - Instr "C"	65.69	57.83	64.97	65.76	66.10	63.69
DPS-LS (S08) - Instr "A"	71.50	62.44	67.69	71.29	69.53	68.12
TL-THW (S09) - Instr "A"	72.19					
DPS-VL (S09) - Instr "B"	71.47					

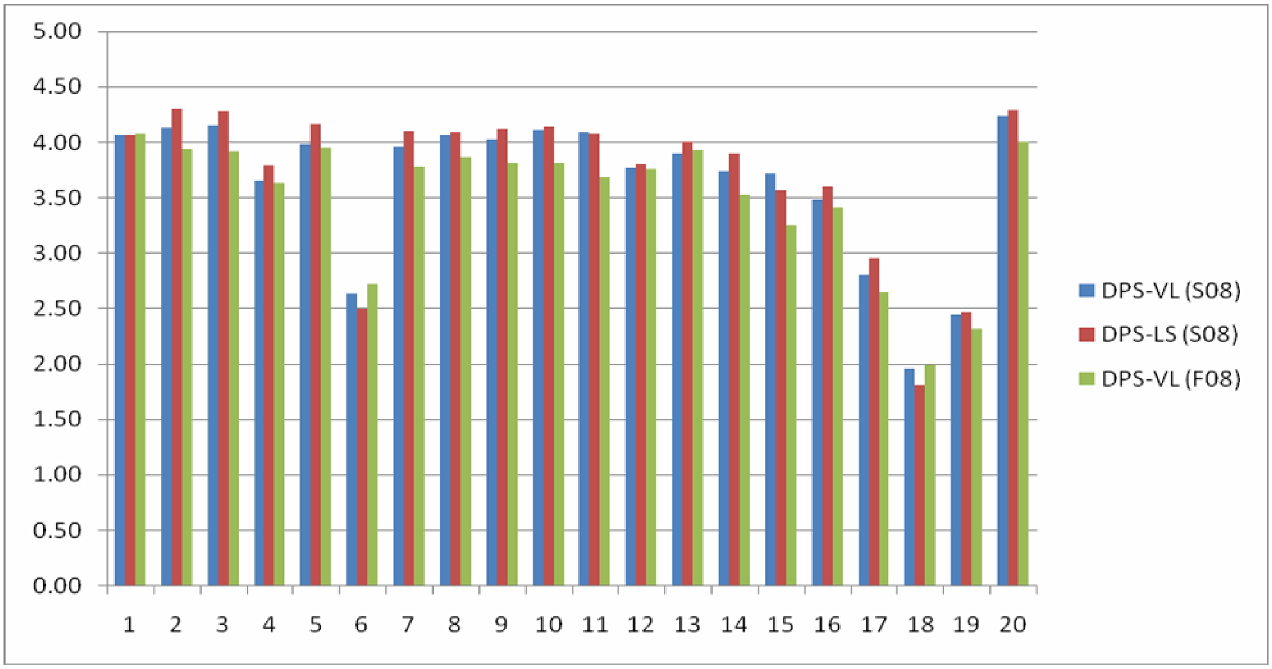
Figure 1. Performance comparison on standardized assessments of the six course outcomes tested in a sophomore-level digital systems course. DPS-VL is the "standard" directed problem solving format employing virtual lecture, DPS-LS is the "cross-hybrid" directed problem solving format employing live lecture summaries (to supplement the virtual lecture), TL-IPS is the traditional lecture format with integrated problem solving ("in-class homework"), and TL-THW is the traditional lecture format employing traditional homework (of the "take home" variety). Three instructors ("A", "B", and "C") were involved in these trials.



Question List:

1. I chose the traditional lecture option by default (i.e., arbitrarily).
2. I chose the traditional lecture option based on my *Index of Learning Styles* survey results.
3. I was glad that I had a choice between two different course delivery options.
4. I used the on-line lectures *in addition to* attending the "live" class lectures.
5. I used the on-line lectures *instead of* attending the "live" class lectures
6. The *Lecture Workbook* class note format helped me learn the course material.
7. I made effective use of <u>both</u> formats of the *Lecture Workbook* (skeleton and annotated).
8. I feel that I learn course material better in a traditional live lecture format than in a "virtual" (on-line) lecture format.
9. I would *not* consider taking *any* ECE course in a directed problem solving format.
10. Use of the "clickers" enhanced my in-class learning experience.
11. I took advantage of most of the on-line learning resources available for this course.
12. The in-class homework and attendance quizzes helped me learn the course material.
13. The practice homework sets and solutions helped me learn the course material.
14. The practice exams and solutions helped me learn the course material.
15. The modular, on-line ("virtual") lectures helped me learn the course material.
16. This course should *only* be offered in a traditional lecture format.
17. This course should only be offered in a directed problem solving format.
18. This course should continue to be offered in both a traditional lecture and a directed problem solving format.

Figure 2. Traditional lecture survey results (TL-IPS (S08): N=63, Instructor "C"; TL-IPS (F08): N=46, Instructor "A").



Question List:

1. I chose the directed problem solving option based on my *Index of Learning Styles* survey results.
2. The on-line lecture and directed problem solving session combination helped me learn the material better.
3. The on-line lecture and directed problem solving session combination helped me prepare for exams.
4. The on-line lecture and directed problem solving session combination helped me prepare for the laboratory experiments.
5. I would choose the on-line lecture and directed problem solving session combination in another ECE course (if available).
6. I would prefer *only a live (traditional) lecture* over the on-line lecture and directed problem solving session combination for this course.
7. I enjoyed learning course material in the directed problem solving format.
8. Having a choice of course delivery options enhanced my ability to learn.
9. The directed problem solving sessions enhanced my learning experience.
10. I enjoyed interacting with my peers during the directed problem solving sessions.
11. I feel that most of the other students enjoyed learning in the directed problem solving format.
12. The on-line lecture enhanced my learning experience.
13. The on-line lecture prepared me for the directed problem solving sessions.
14. I viewed the on-line lecture before participating in the directed problem solving sessions.
15. The *Lecture Workbook* class note format helped me learn the course material.
16. I made effective use of both formats of the *Lecture Workbook* (skeleton and annotated).
17. Use of the “clickers” enhanced my in-class learning experience.
18. This course should *only* be offered in a traditional lecture format.
19. This course should only be offered in a directed problem solving format.
20. This course should continue to be offered in both a traditional lecture and a directed problem solving format.

Figure 3. DPS survey results (DPS-VL (S08): N=47, Instructor “B”; DPS-LS (S08): N=46, Instructor “A”; DPS-VL (F08): N=68, Instructor “B”).