Creativity and New Product Development: Working with Virtual Teams

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Abstract

For several years, a course on *Creativity and New Product Development* (C&NPD) has been offered at the University of Virginia. Two different delivery modes have been used: a traditional on-campus class and the distance-learning mode. The course has been taught twice in our academic outreach program. These two offerings were quite different from each other, and both differ from the experience of more traditional classes. In each class, student teams develop a new product concept, prototype it, create a business and marketing plan, and produce a patent application and a funding proposal.

Last semester, I taught C&NPD in distance learning mode with 12 on-grounds students, and 12 off-grounds. The off-grounds students were all engineers working full-time in industry. The on-grounds students included both undergraduates and grad students. We assembled teams so that most teams had at least one member at a remote site. One class each week was delivered in the asynchronous mode (as streaming video on the internet), while the other was conducted in real time (as a live television broadcast with two way video capability). Throughout the semester, we did extensive evaluation of team and individual performance, as well as assessing the class itself and student reactions to it. In this paper, we provide an overview of the course, present some of the assessment results, and review the lessons learned: what worked, what didn't?

Introduction

A course on *Creativity and New Product Development* has been taught at the University of Virginia since 1995. Henry Bolanos and Dave Lewis developed the original version of this course. Henry is an independent inventor and has founded several businesses; Dave worked for IBM before joining the faculty of the University of Virginia. He owns a small business and holds several patents. They proposed a course that would teach the new product development process by simulating it in class. Student teams would come up with ideas for new products, design and prototype a concept, develop a bill of materials and manufacturing plan, and prepare a financial analysis, a marketing strategy, and a business plan. Each teams' final presentation for the course would be a briefing to a group of venture capitalists - appealing for funding for their new company. Each team was also expected to submit a disclosure document or provisional patent to the U.S. Patent and Trademark Office. When I assumed responsibility for this course in 1998, I sought to maintain its original vision while introducing some new topics and approaches.

The course now covers topics in four categories: ***Technical skills*** focus on issues of product specification, concept selection, product architecture, modeling and documentation, bill of materials, prototyping (virtual and physical), manufacturing, and production planning. ***Thinking creatively*** explores how to generate ideas; how to elaborate concepts and alternatives; what psychologists, artists, engineers, and scientists know about creativity; and how to develop and foster, or stifle and kill, creativity. ***Business strategies*** include assessing customer needs; project scheduling; financial analysis; protecting your ideas; marketing, advertising, selling; and entrepreneurship. ***People skills*** involve team dynamics and roles; negotiating styles and strategies; appealing to the customer; understanding individual differences and preferences; and how to present your ideas effectively.

Some classes are devoted to lectures and discussion, and others to guest speakers on particular topics such as patents, intellectual property, and venture capital. But, most class periods are devoted to team interactions, with the professor observing, facilitating, and occasionally advising. We assign readings on new product development [1,2,7] and entrepreneurship [3], and suggest web resources on creativity, invention and design, modeling and prototyping, patents, and entrepreneurship.

Initial Distance Learning Experiment (1999)

Distance learning is now a critical component of the educational delivery system for many schools. At the University of Virginia, we have offered distance-learning programs since 1983 [4,5]. In 1999, we offered *Creativity and New Product Development* for the first time through Virginia's Commonwealth Graduate Engineering Program [6]. Our Distance Learning courses have traditionally involved televised lectures and videotapes, supplemented by the Internet and e-mail. For a hands-on, team-based, project-oriented course, the distance-learning environment presents some challenges.

In the first distance-learning version of this course, there were 33 students at 8 sites in Virginia and Pennsylvania. On-campus we had a mix of undergraduates and graduate students; the off-grounds students were all graduate students with full time jobs in industry. In this initial course, there were seven teams: three teams developed ideas that were patentable, designed and built a reasonable prototype, and had convincing business plans. Two teams had reasonable ideas, but failed to achieve convincing business plans. Two other teams developed analytical approaches they were not able to realize as working prototypes. The best teams had one or more champions for their project - members with a personal interest in the idea and enthusiasm for the product.

These students reported generally high levels of satisfaction with the course and its content. They felt they got what they wanted from the class, and that we covered the material well. The only consistent complaints were from a few graduate students and most of the undergraduate students who don't like the distance-learning format. Off-grounds students expressed some dissatisfaction with the on-grounds students; they felt that the undergraduates weren't serious enough about their duties and deadlines, and that the graduate students were too concerned with theory and analysis, and not focused on practical issues. Overall, the students were far more satisfied with the course than I was.

This initial experience with a project-based course taught in the distance-learning environment left me with many ideas for improving future offerings. The remainder of this paper discusses the 2002 Distance Learning version of *Creativity and New Product Development.*

This Year's Class (2002)

Creativity and New Product Development was offered in distance-learning mode for the second time in the spring of 2002. Lectures and demonstrations were available asynchronously via streaming video on the Internet. Class met formally only one day each week, but the students were expected to have viewed the on-line lecture prior to each meeting. Class time was reserved for team interaction and group activities. Additional facilities were made available for video-conferencing, so teams could arrange meetings outside the scheduled class period.

Twenty-four students were enrolled in this class: 12 on-grounds at the University of Virginia, and 12 located at other sites. Four were women and 20 men; 8 undergraduates, and 16 graduate students. Six teams were assigned by the instructor. Table 1 shows the composition of these teams.

Table 1: Team Composition

Team	Local	Remote	Women	Men	Graduate	Undergrad
Ergonomic hand basket	2	2	3	1	2	2
Water balloon launcher	0	4	0	4	4	0
Screw driver guide	3	1	0	4	4	0
E-zzz Wake Alarm	2	2	0	4	3	1
Walker/mobility aid	2	2	0	4	2	2
Collegiate back pillow	3	1	1	3	1	3

Assessments and Evaluations

Table 2 lists the many assessments we gathered during this class. This paper will focus on the first day survey, the midterm survey, and the end-of-course survey. These provide information on how the students reacted to the course and its structure, and some reactions to their team experience. Another paper will focus more on the team and project assessments. On these surveys, our primary interest was focused on the questions: what did you expect from this class, is the class meeting your expectations (giving you what you wanted), and did you get what you wanted from this class?

Table 2: Assessments used in MAE 692

First day survey	Overall course survey
Creativity survey	Project ratings by faculty and students
Learning Styles Index (LSI)	Official course evaluation
Midterm course evaluation	Post Class Activities
Team and project assessment	Later communications with students

The **First Day Survey** asked for basic background information from the students: who they were, how to contact them, what they wanted to get out of this class, and each student's self-assessment of their basic computing skills and knowledge. Most students were Mechanical Engineers. The other demographic information for these students was summarized in Table 1, which also shows the composition of the teams. Data from the first day survey and information gained from the first few classes were used to construct these teams. Team assignment was not random, but it was not based on systematic methods either. It depended on my impressions of who would work well together, and some geographic constraints.

Table 3 summarizes what students expected to get out of this class. Most of these corresponded very well with the instructor's objectives.

Table 3: What do you hope to get out of this class?

Learn about the product design and development process
To see the big picture of mechanical design
Learn to generate and develop my own ideas
How to decide whether an idea is good
How to create a marketable product
Become more creative; exercise my creative abilities
Understand patents and intellectual property
Marketing, market research, business plans
Working on a team, what makes teams successful?
Improve CAD/CAM knowledge

The **Midterm Survey** was the most important assessment, because we could still make changes as the semester progressed. This survey was a combination of 13 open ended and targeted questions. The first three asked about the best and worst features of the class and what could be improved. Table 4 summarizes the results for these three questions. The other items asked about workload, delivery mode, the class homepage, homework submission, assignments, the book, accessibility of the instructor, and whether the course was providing what the students expected.

Table 4: Summary of Midterm Course Evaluations

What do you like best about this class?
Being creative
Designing a new product and carrying it through to completion
Working on our own project
Open structure
Class discussion, interaction with other students and teams
Asynchronous classes, lectures
Team concept and challenges of dealing with teams, insights into team dynamics
" Encourages new ways of thinking compared to other classes where there is one way to look at issues."
"You are asking for input mid way through the course. Usually it is at the end of a class and by then it is too late."
What do you like least about this class?
Lack of clear boundaries
Expectations of class deliverables not clear enough
Let us know what things are worth gradewise
Distance from other students; working in groups over long distances; half my group is located elsewhere
Lack of time to meet with team members not from same area
Recorded online classes, difficult to pay attention, easily distracted, timing of lectures
Fuzziness of asynchronous lectures, problems using microphones
What can we do to improve MAE 692?
Better video quality; improve compression quality of the video classes
Hold team classes more often, regularly scheduled segments for team interaction
Post all assignments on a special Homework section on the web

The **overall course survey** first asked whether the students got what they wanted from the class. All responses to this item were positive, most extremely so. Here are few representative comments:

" I was able to exercise my creative side in an engineering setting more in this class than I ever was able to do in any other courses in the e-school."

" I was looking for ideas on how to explore the hidden talent inside me and to work as a group in achieving the final objective. It definitely served the purpose."

"Definitely, I thought that this class was very useful and I found a new interest in creativity and product development. Most importantly it was fun."

To the question 'what topics were most valuable?, the most frequently occurring responses are shown in Table 5.

Table 5: What topics did you find most valuable?

Topic	**Frequency of response**
Patents	13
Creativity	10
Business plans/Marketing	9
Team building	4
Design techniques	2
Manufacturing/prototyping	2

What topics were least valuable? Most students felt all the topics were valuable. The only topics mentioned here by more than one person were House of Quality (3), ergonomics (2), and manufacturing (2).

The item "How can we improve this course? What changes would you suggest?" elicited a number of good suggestions. They clustered around several themes:
1. Start the team activities faster. Next time I will assign teams after the first class.
2. Do more interactive activities (brainstorming, spontaneous class exercises) early in the semester. Get the students interacting with each other right away.
3. Deliver just-in-time lectures. Discuss a topic only when it is needed - not too far in advance, and never late.
4. Develop step-by-step guides on topics such as *how to obtain a patent* and *how to form your own company.*
5. Provide more explicit details and directions, especially at the start. Present an organized plan with clear milestones, and require frequent and regular reporting.

We asked for suggestions of better ways to assign teams and team size? Few students suggested alternatives; most indicated that they were happy with how it was done. There was unanimous agreement that four members on a team is the right size.

The class toolkit page (a web page) was rated useful by all students. All lecture notes were posted to the class web page. After each spontaneous class, a summary of the activities and results was also posted. In addition, all classes were available as streaming video over the Internet.

"I think the toolkit page is a serious step forward in educating engineers for the real world. I mentioned in class one day that we do business over the web, via email and teleconference/video conference all the time in Industry and engineers coming out of school should be aware of this fact." **Bill Flood**

The students felt that the on-line materials should be better organized. The video files and toolkit page were maintained separately and there were not adequate links between them.

Three items probed students' reactions to the delivery mode for this class. We had different audiences and they initially had different expectations of and reactions to the class structure. The on-grounds students favor a familiar classroom situation with regularly scheduled classes. They do not like the distance-learning environment.

On the midterm survey, several on-grounds student expressed their dislike of the asynchronous lectures. But by the end of the class, there was less dissatisfaction with asynchronous mode. Perhaps it had become familiar, and this led to greater acceptance. The off-grounds students were generally in favor of the asynchronous class. As one student noted

" My job often requires odd hours, trips, or last minute presentations. Only having one class that I had to make each week freed me up to do the other class at home when I had the time."

Some students felt that sitting in front of a computer watching a lecture for an hour was taxing. So, I decided to break my presentations into shorter units. These ½ to ¾ hour modules seemed to be better accepted, especially by the on-grounds students.

A few students wanted two regularly scheduled classes each week. In future classes, we will record lectures at regularly scheduled times and then put them onto the web. Those students who wish to attend the lecture can, but those who do not will have the option of asynchronous viewing. On the midterm survey, some on-grounds students reported that they had trouble motivating themselves to watch the asynchronous classes. To counter the tendency to skip the asynchronous class, I started to imbed assignments in them. The material from the lecture included hints on how to do the assignment.

Whereas some students maintained a preference for onsite groups only, others came to value the experience of working with people off-site. Most of the teams arranged face-to - face meetings, and a couple made extensive use of video-conferencing.

In response to the question "Would you would recommend this class to another student?" All students said they would; most with great enthusiasm. Five students reported that they already had recommended this course to others, one said he would like to take it again himself, and another wanted it to continue into a second semester.

Conclusions

There was an unusual dynamism to this class. We had an exceptional group of students with great enthusiasm for their projects. Since this class was not required, everyone in it wanted to be there, and as the first day survey indicates, they knew what they were getting into. As the semester progressed, a degree of competitiveness between the teams added to the excitement of the class, and elevated the quality of the projects and presentations. All six teams designed a novel product, constructed a working prototype, developed a reasonable business plan, and gave a convincing final presentation; and the students had fun. Some teams were better than others, but that seemed to be due to chance - the particular individuals who happened to be assigned to the team, rather than selection variables.

Virtual teams can be effective, but they require different strategies for success than collocated teams. Virtual teams need to plan better and coordinate their efforts. Collocated teams can put in intense last minute efforts (the weekend before each critical deadline). They can also work with evolving prototypes, which are physically available to

all team members. Virtual teams must pace themselves better and utilize electronic media effectively. To me, the message is that I must supply the tools to enable the teams to manage their activity and progress. In the future, I will provide up-front instruction in how to effectively use the electronic media, and I will tell the new students what previous student teams learned to do.

This semester clearly established for me that an on-line version of this course could be as effective as the traditional delivery mode. Virtual teams can be as effective as collocated ones. In addition, the on-line version of this course requires students to learn new, and increasingly valuable, skills. Bill Flood, an on-line student, expressed this well in his response to a survey question:

"The sooner folks get exposed to the way we do business in America today, the better off they'll be for at least two reasons. 1.) the more comfortable an engineer is with a long distance project and the quirkiness of working around time zones and possibly never meeting the people you work with the better the engineer will be at performing under these circumstances. 2.) If the engineers are better doing business long distance, the engineering projects will be higher quality/lower cost. If the projects are better, we all win, we get better products, and the engineer probably will get promoted before those who do not thrive in the long distance environment."

Should this class be offered again in this format? Yes, this is exactly the kind of course engineers practicing in industry want. They are seeking practical courses focused on business issues. Was the second on-line version better than the first? Yes! We have learned what works, and what doesn't. The next time will be even better.

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