SYSTEMS THINKING: AN EXPERIMENTAL COURSE FOR COLLEGE FRESHMEN[*]

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Abstract

An experimental interdisciplinary freshman course called "The Systems Approach to the Universe" was taught at North Carolina State University in the spring of 1986. The goals of the course were to introduce principles of general systems theory; to provide examples through lectures and readings of applications of these principles in a wide variety of fields and disciplines; and to introduce and provide practice in critical questioning and evaluation. This paper outlines what was done, how it worked, and how the instructors and the students assessed the experience afterwards.

Introduction

> *The system of education in America's school program is misguided. Students are not rewarded for their reasoning ability. They are rewarded for their ability to follow rules and recite memorized information on command. Examinations do not test comprehension, but rather ask the student to spill out stored facts. Because of the condition of the educational system, students can complete the overwhelming majority of their studies without using formal reasoning. When students finally reach a situation or problem where formal thought is required, they fail to overcome it and do not understand why.*

That paragraph was written by a college freshman, Steve, in the preface to his term project report in a course called "The Systems Approach to the Universe." The course was taught to a class of about 20 freshmen, who had in common their participation in the N.C. State University Undesignated Program and little else. Our motivation for giving the course was expressed by Steve as well as we could do it. The course objectives were as follows:

1. To introduce concepts of general systems theory, particularly the following notions: (a) a system cannot be understood without considering the subsystems that comprise it and its environment; (b) a system cannot be understood merely by studying its components—the whole is always more than the sum of its parts; (c) everything affects everything—the trick is knowing where to draw the line.
2. To provide examples through lectures and readings of applications of these principles in a wide variety of fields and disciplines.
3. To introduce and provide practice in critical questioning and evaluation.

The course was an intriguing educational experiment. The students learned something about systems thinking, more about critical thinking, and a great deal about themselves; and the instructors were provided with valuable lessons on the need for flexibility, humility, realistic expectations, dogged persistence, and a good sense of humor when you attempt to get freshmen to do anything they are not accustomed to doing.

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Origin of the Course

Since 1984 about 150 entering freshmen have been admitted each year to a program at North Carolina State University called the University Undesignated (UU) Program. Students in this program are not required to declare a major field of study before entering the university. The goals of the program are to help the students make well-informed decisions about their majors and to encourage them to explore the diverse opportunities for personal growth available at the university.

All UU students take an orientation course and are provided with intensive personal advising and individualized learning experiences with faculty volunteers. In the fall of 1985 a group of the top 20 UU students (ranking based on SAT scores and high school averages) were invited to be part of an enrichment experience that included special seminars and workshops, field trips, and a multidisciplinary enrichment course in each semester of the freshman year. The enrichment courses were intended to demonstrate that all knowledge does not come neatly packaged within traditional academic disciplines; to help the students develop critical and creative thinking skills; and to stimulate intellectual excitement. The subject of this paper is the Spring 1986 enrichment course offering.

Course Activities and Procedures

Readings

Each week students were assigned material to read, including most of *The Turning Point* by Fritjof Capra (the course text). The subjects touched on in this reference include the history of science, modern physics, economics, psychology, medicine, technology, and geopolitics. Other readings included chapters or excerpts from several references on general systems theory; a newspaper article or editorial of the students choosing; and material designated as background for the talks presented by guest lecturers, including articles about psychological types and learning styles, the second law of thermodynamics, the holographic model of the brain, and management information science.

Guest Lecturers

Eight guest lecturers addressed the class during the semester, including two psychologists, an educational administrator, and professors of chemistry, science history, economics, computer science, and civil engineering. These were their topics:

- Psychological types and the Myers-Briggs Type Indicator
- Hemispheric models of the brain and learning styles
- Wholeness, health, and biofeedback
- The second law of thermodynamics
- Historical origins of systems theory
- Economics and systems
- Management information systems
- Planning a community water system

Students were assigned background readings before each lecture and were asked to prepare critical questions that could serve as bases for discussion following lectures.

Notebooks

The notebooks provided the framework and continuity for the course. Each week's entry in the notebook consisted of three parts: (1) an objective summary of the assigned reading; (2) a set of at least seven critical questions related to the reading; (3) a journal with personal comments and reactions to the reading, the course, or anything else the student felt like writing about. The students were allowed to work in pairs to formulate their critical questions, although most chose to work individually. The notebooks were collected each Tuesday, evaluated by both course instructors, and returned each Thursday.

Summaries varied in length from one paragraph to four pages. The skills we were attempting to develop through the summaries included abstraction of essential ideas from written material; concise and coherent expression of those ideas; and separation of objective evaluation from subjective reaction. Some of the readings were long and full of technical jargon; the students reacted negatively to them and initially almost rebelled against reading them, but over the course of the semester they discovered that they could get the main ideas being presented despite the difficulty of the material. Other readings were controversial, offering opinions that most of the students regarded as unjustified or heretical. Few students were initially capable of summarizing these readings without lapsing into personal and frequently emotional reactions, but by the end of the course most were able to write good objective summaries and to confine their personal reactions to their journals.

We defined critical questions as questions dealing with stated and unstated assumptions and implications, and we told the students we particularly wanted questions based on a systems approach to the subject of the reading. Examples:

- What systems (physical, social, individual, political, economic, etc.) are involved in the subject of this reading?
- What considerations related to each of these systems has the author failed to take into account?
- What assumptions has the author made and which of them are questionable?
- If the author's proposals were adopted, what would be the implications for [the economy, the environment, the neighborhood, various individuals, society as a whole, etc.]?

Initially we accepted almost any questions that were submitted; as the course progressed we discouraged questions that could not really be classified as critical, especially those that could be answered by looking something up in a dictionary or text.

Projects

Each student did a term project entitled "A Systems Approach to [a topic of the student's choosing]." The assignment was to summarize the different factors (subject areas, disciplines, etc.) involved in the chosen subject, to identify sources of information regarding each of the identified factors, and to discuss in detail selected aspects of the subject. Each student gave an in-class oral presentation on his or her topic and submitted a written project report. The topics chosen are given below in no particular order:

A systems approach to

- effective leadership
- starfish regeneration
- formation of human values
- formation of my personal values
- automobile manufacturing
- the senses
- the Black identity crisis
- musical tastes
- body building
- managing an intramural softball team
- transportation of material
- Booker T. Washington
- toxic waste disposal
- my attitudes as a Christian
- winning the ACC tournament
- thinking
- teenage pregnancy
- teaching formal thought in physics

Class Discussions and Brainstorming Sessions

Discussions were held on lectures, readings, and miscellaneous topics that arose as the course progressed. The most successful format for these discussions involved breaking the students up into small groups (three-four per group), posing a question, having the groups brainstorm answers with one group member serving as secretary, and then reconvening as a class to share and evaluate the ideas generated. The questions that served as the basis of these sessions could be specific or general. Examples:

- What are the main points in this reading? Given that these are the main points, how do you think the author would rank them in importance? How could the author have made his/her points more effectively?
- What subject areas are involved in this topic? What are the critical questions relating to each of the listed subject areas? What are possible answers?
- What were the strong points of last period's lecture? The weak points? What do you think the speaker's objectives were? How could they have been accomplished better? What did you learn from the lecture?

The group sessions involved a great deal of interaction, bantering, and debate: the students enjoyed themselves, the instructors enjoyed watching the students enjoying themselves, and everyone participated. This technique was the only way we found to get the strong introverts in the class (who constituted well over one-half of the population) involved in discussions in a meaningful way.

Individual Conferences

Every student in the class had at least one scheduled 30-minute conference with one of the course instructors at which the student's progress in the course was discussed. In addition, most of the students came in on one or more occasions for informal conferences.

Examinations

There were none.

Grading

There were initially 21 students in the course. Two dropped out during the first week. Of the remaining 19, one stopped handing in his notebook roughly halfway through the course and did not do a project, although he continued to attend class.

The students were told at the beginning of the course that grades would not be assigned on a competitive basis—that the potential existed for everyone in the class to receive A's. They were also encouraged to help one another with every aspect of the course. Although at first most were skeptical, they eventually came to believe that we meant it and a number of them commented positively in their course evaluations about the cooperative atmosphere in the class that stemmed from this policy.

In determining course grades, the notebook was given a weighting of about 60%, the project about 30%, and the balance was based on participation in class. The final distribution of grades was 14 A's, four B's, and one F.

Student Evaluations

On the last day of class we handed out evaluation forms. The forms were filled out, collected by a student, and put in a sealed envelope, where they remained until the course grades were assigned. Of the 18 students who completed the course, 14 returned the forms. A summary of the results is given in Table 1.

In their comments on the evaluation forms, many students observed that the course had taught them to think about things more deeply or critically. They also offered favorable comments about the open discussions, the project presentations, the instructors, some of the guest speakers, the things they learned about themselves, and the cooperative, noncompetitive class atmosphere. Things not liked included the course text, the classroom (a small windowless room with auditorium-style chairs), and the amount of reading assigned at the beginning of the semester. One student expressed a dislike of "everything," although he or she gave the course an overall neutral rating and the instructors a positive rating.

The student journals provide an interesting glimpse into the progression of the students' attitudes toward the course and to themselves. They came into the course curious.

> *Systems seems like it's going to be very challenging.* (Alexandra)
>
> *I think this class is going to be very interesting and informative, and if we're not careful we might even figure out what a system is.* (Jon)

As the readings multiplied and the students found that they were not getting the idea of summarizing, critically questioning, and all the other unfamiliar things we were asking for, they became increasingly unhappy and let us know about it in no uncertain terms.

> *I don't like this class anymore. I don't like the subject matter. It's too vague. There is nothing to grasp at but shadows of ideas. And everything says the same thing. If this class is an experiment—well, it's not working with this particular subject.* (Ben)

Table 1
Summary of Student Evaluations (N = 14)

Statement	***Agree***	***Neutral***	***Disagree***
The course			
was about what I expected beforehand ……..	29%	21%	50%
was easy …….	7%	36%	57%
was well organized ……	50%	14%	36%
was instructive ……...	79%	7%	14%
was interesting ……	79%	14%	7%
made me think ……	100%	0%	0%
was at the right level of difficulty ……..	79%	14%	7%
moved at a good pace …….	79%	14%	7%
I gained a lot from			
the course text (Capra) ……...	36%	14%	50%
the guest lecturers ……...	64%	14%	21%
the class discussions ……...	71%	29%	0%
keeping a notebook …….	71%	21%	14%
doing the project …….	64%	21%	14%
The course workload was reasonable ……..	36%	36%	29%
I would recommend the course to others …….	71%	7%	21%
Overall Ratings	***Positive***	***Neutral***	***Negative***
Course ……..	86%	14%	0%
Instructors ……	100%	0%	0%

They were particularly vocal on the subject of the course text.

> *Capra seems to dislike anything that deals with technology. He seems like the kind of person who would try and look for a bad point in a drug that cured all illnesses.* (Neil)
>
> *I get the feeling that Capra thinks he could "fix" the world if given six days to do as he pleased.* (Lisa)

As the weeks progressed, attitudes changed, although no one ever came to find the course easy.

> *The class seems to be becoming more clear with every meeting. I think I am getting the hang of this systems approach.* (Joseph)
>
> *To tell the truth, I thought seriously about dropping this course at the beginning of the semester. I'm glad I didn't because I would've missed a lot.* (Bill)

Readings and presentations in class triggered a variety of responses, and the students' spontaneous musings carried them in many directions.

If everything tends to go to disorder, then why do our cells and other organic things want to organize? If energy is always conserved, then why do we always hear about trying to save energy? How does Creation follow the theory of thermodynamics, especially entropy? (Joyce)

The left side of the brain is logical and linear. The right side is creative. I must be in the middle because I'm not logical or creative. (Bill)

"Nothing is understood until you can explain it to somebody else." *Ha—I don't understand how to tie my shoe!* (Alan)

What is the most horrible thing you can imagine? To know everything there is to know for an instant and then forget it. Or, be forced to be an accountant. (Ben)

I hope Georgia Tech kills Carolina tonight! (Bill)

Finally, if we ever have any doubts about whether there is any real value in programs like University Undesignated or courses like this one, we will reread the final journal entries. We could make our point with almost all of them, but two will suffice.

Now when I read articles, I automatically begin to ask myself questions. (Alexandra)

If we look at this class as our "world," with everything up to now "old" and from here on "new," we'll see what's going on. The old corresponds with old views—classical physics, mechanistic views, reductionism…the new corresponds with our paradigm shift, our shift to something that is new, unfamiliar, scary, and that might work. I think I understand now. (Ben)

Instructors' Evaluation

We are satisfied with the course format that eventually evolved, although there are things we will do differently next time. The primary emphasis in the course shifted from general systems theory to critical questioning and evaluation, which is where we think it should be. The use of the notebooks as the main focal point of the course and the projects as the secondary focal point worked out very well. The guest lectures were valuable, but we would not have as many of them next time. The small-group brainstorming sessions worked exceptionally well; in our opinion this approach could be used to good effect in any class on any subject where discussion and problem solving are considered necessary or desirable activities.

The oral presentations of the projects in our opinion constituted the most successful part of the course. The first few presentations were well-delivered, straightforward talks on the project topics, with little or no attention being directed to systems considerations. Following each of the first few talks we had the class brainstorm factors and subjects that should be considered in order to gain a full understanding of the topic. Subsequent talks began to include such considerations and the last few made them the focal point, as we had hoped they would be. The written project reports were much more uneven in quality; we believe the problem was that the reports were due on the last day of the semester, so that the students had no opportunity to get feedback and make corrections.

One of our major lessons in teaching the course was to make our expectations of the students realistic. We started out with grandiose ideas of presenting a high-level course on

general systems theory. We learned quickly that it would not work: the transition from the type of thinking required in high school courses (and sadly, in most college courses) to the type of formal, abstract reasoning we had in mind is just too great for most freshmen to be able to achieve in a single three-credit course. After we modified our expectations we still demanded a great deal of the students (as their evaluations indicate), but our demands were then within their capabilities, and most of them met or exceeded our expectations.

In a number of instances we were asking the students to do something different from anything most of them had ever been asked to do—notably, to formulate critical questions and present personal reactions to readings and lectures and to write project reports that focused more on questions than on answers. Based on our experience, we would advise anyone intending to ask freshmen to do something new and different to plan on making the request at least three times. The students will completely ignore the first request, as though not believing anyone could possibly want them to do anything that bizarre. They will grudgingly respond when asked for a second time but they will do it incorrectly. By the third time they will take the assignment seriously and start to get it right. There are few, if any, exceptions to this rule.

In summary, we are pleased with the way the course turned out, especially considering that it was a first offering and totally different from anything either of us had done before. We strongly recommend courses like this one and list below several suggestions for teaching them:

1. Keep the enrollment down to 20 or fewer and require a minimum first-semester (or predicted) GPA of 2.5 or more.
2. Provide and discuss illustrative examples when outlining the course requirements (notebooks, critical questions, written project reports, oral project presentations, etc.).
3. Emphasize the notebooks. Collecting notebooks regularly and making detailed comments on entries are absolutely essential to the success of the course.
4. As bases for notebook entries (summaries, critical questions, personal reflections), assign several newspaper articles, editorials, and advertisements in addition to journal articles and book chapters.
5. Have no more than four or five guest lecturers.
6. Use small-group brainstorming activities extensively. They are a rich source of ideas for discussion and problem-solving sessions and are extraordinarily effective at involving all members of the class, including the introverts.
7. Require first drafts of project reports three weeks before the end of the semester, so that comments can be made and incorporated into final drafts.
8. Emphasize cooperation and minimize competition in every aspect of the course.

Epilogue

The Systems course was given again in the Spring 1987 semester. Fewer outside speakers were invited, lighter reading loads were assigned in the first few weeks, and drafts of the term papers were due three weeks before the end of the semester. The student performance levels again exceeded our expectations and the evaluations were even better than those shown in Table 1. We plan to offer the course again in the spring of 1988 with no substantive changes.

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