Scavenger Hunt: Computer Science Retention Through Orientation

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ABSTRACT

This paper describes Scavenger Hunt, a team-based orientation activity for incoming freshmen in the Department of Computer Science at the University of Illinois at Urbana-Champaign. Like many large research universities, Illinois has struggled with the high attrition rate of first-year students in computing disciplines. Scavenger Hunt, which has been held each of the past three years, is intended to foster a sense of community within the department and acclimate new students to undergraduate life as computer science majors. A unique aspect of the activity is the use of handheld computers to manage most aspects of the competition, which enables physically handicapped students to participate on an equal footing with their able-bodied peers. Thus far, Scavenger Hunt has been directly responsible for the increased participation of new students in departmental activities and organizations. In addition, we have observed a significant correlation between student participation in Scavenger Hunt and retention rates in the department. Along with other retention-oriented activities, Scavenger Hunt is measurably improving the attitude of new students towards computer science.

Categories and Subject Descriptors: K.3.2 [Computer and Information Science Education]: Computer science education

General Terms: Human factors

Keywords: scavenger hunt, retention, orientation

1 MOTIVATION

Like many large research universities, the University of Illinois has struggled with the high attrition rate of first-year students in computing disciplines. In the five year period prior to 2003, roughly 25% of the total number of entering freshmen have dropped out of the program by the end of their first year (see Table 1). In particular, the attrition rate of women and minority students is quite high, averaging about 35% for the same period.

In exit interviews, many students transferring out of the department cite inadequate support networks with which to remedy academic deficiencies as a major contributing factor to their withdrawal.

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	1998	1999	2000	2001	2002
Incoming Freshmen	276	235	232	296	233
Left CS in 1st Year	68	50	56	71	74
Retention (%)	75.4	78.7	75.9	76.0	68.2

Table 1. One-year retention of freshman computer science majors at Illinois for the period 1998 - 2002.

Such networks are universally held to be one of the most effective means of helping undergraduates cope with the rigors of technical majors [2, 5] and are especially necessary to help dispel the widely held myth of computer science as an antisocial, solitary vocation [4].

A lack of connection between undergraduates and the rest of the department can have other negative consequences besides adversely affecting retention. Students who do not feel as if they are part of a larger academic community are less likely to participate in extracurricular activities and organizations [6]. In large computer science departments like Illinois, where the total number of enrolled undergraduates has varied between 900 and 1200 in recent years, feelings of isolation can also discourage students from attempting to establish meaningful relationships with professors, an activity essential for securing undergraduate research opportunities and strong letters of recommendation.

In an effort to combat these problems, the department has instituted several programs designed to foster a sense of community between freshmen, current undergraduates, graduate students, professors, and staff. In this paper we present Scavenger Hunt, which is in its third year of operation as the orientation activity for incoming undergraduates. Designed to introduce new students to the campus, each other, and key members of the department, Scavenger Hunt is a critical-thinking competition that requires students to travel across the campus in small groups, collaborating to solve puzzles in order to progress from destination to destination.

2 ACTIVITY OVERVIEW

Conducted the day before classes start each Fall, Scavenger Hunt is a ninety-minute-long competition that begins with students being randomly grouped into teams of five. Women are assigned to teams in pairs in an effort to ensure an atmosphere conducive to their active participation [3]. Each team is given a Hewlett Packard Jornada 680 Handheld PC running the Scavenger Hunt program and an annotated campus map identifying approximately fifty potential destinations, each with its own short ID code. The software then displays a clue, which may consist of text or images, corresponding to some location on the campus map. Teams work together to discover the solution to the clue, input the appropriate location

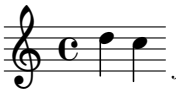
code into the Jornada for confirmation, and proceed to that location to have the next clue unlocked by a volunteer. Each team is sent to eight separate locations and the team that has the shortest combined solution time at the end of the competition is declared the winner.

2.1 Clues and Hints

The location clues are designed to jump-start students' critical thinking skills immediately prior to the start of the semester. Some clues involve simple wordplay[1]:

> *You stand before a headless onion, after removing Windows® from the state*.

Some are tailored more specifically to mathematical and scientific subjects:

$$2(2^9+1)+\sum_{n=7}^{10} n^2$$  $$\int_0^L (\sin^2 x+\cos^2 x)dx$$

Other, more whimsical clues, reference popular internet subculture themes:

90 70 7|-|3 b453|\/|3|\|7 0f 9|241|\|93|2.

Some clues defy categorization:

+5 N33J9 °3 L0h

This wide variation in the type and focus of clues is intended to allow students with different backgrounds and strengths to all materially contribute to their team's progress.

If an incorrect solution is entered for a particular clue, the Scavenger Hunt software provides a hint. On the third incorrect attempt, the software reveals the solution. Students may elect to receive a hint at any time without attempting to solve the clue by pressing the "Hint" button.

2.2 Scoring

In traditional scavenger hunt competitions the winning team is the first team to return to the starting position with all objectives completed. This system, however, places a heavy emphasis on a team's physical ability to travel quickly, and mobility-challenged students are typically unable to fully participate. To address this issue, our scoring system counts only the time actually spent solving clues. It should be noted that this decoupling of the scoring from travel time would not have been possible without the software system we implemented and the use of the Jornada Handheld PCs.

Table 2. The scoring algorithm

Number of Hints	Score
0	Time to solve the clue or 2.5 minutes, whichever is less.
1	2.5 minutes
2	3.5 minutes
3	4.5 minutes

The first year the activity was held, scoring was based directly on solution time and teams were penalized an additional 9, 12, or 15 minutes depending on whether one, two, or three hints were used for a given clue. This algorithm not only resulted in wide variation between teams' scores, but also had the effect of essentially disqualifying any team that used even a single hint. Each subsequent year, we have modified the scoring to reduce the penalty for using hints.

The specific scoring algorithm used in the most recent competition is given in Table 2. This algorithm, which is presented to students prior to the start of the activity, was designed to keep the competition both fun and challenging. In particular, teams are encouraged to solve clues fairly quickly, thus ensuring that each team visits all eight locations within the ninety-minute time period. Stumped teams may use one hint without incurring a substantial time penalty, and the flat scores for subsequent hints help to ensure that all teams will finish with roughly the same final score while simultaneously discouraging random guessing. This past year, the winning team used one hint and had an average solution time of 68 seconds. The average solution time for all teams was 180 seconds.

2.3 Routes

Although the campus map provided to students lists nearly fifty locations, only about twenty appear in routes and are staffed with volunteers. These locations consist of specific rooms in campus buildings where required courses are frequently taught, in addition to administrative offices and other areas of interest to incoming freshmen such as campus post offices and computer labs. While traditional campus tours are offered as part of the standard university freshman orientation procedures, Scavenger Hunt affords students an opportunity to visit individual classrooms and locations that will be directly relevant to their undergraduate careers in computer science.

Each team of students is sent on a different route through an eight location subset of the staffed locations to prevent congestion and ensure that teams cannot simply follow each other through the course. A simple Perl script was used to generate a list of several hundred potential routes sorted by approximate total path distance. Routes were then selected from this list to ensure that each team covers roughly the same amount of ground. Although travel time does not affect scoring, it does affect total time competing, so it seems only fair to attempt to equalize it.

2.4 Prizes and Wrap Up

At the end of the competition participating students and event volunteers gather for refreshments before the winners are announced and prizes are distributed. This lull in the schedule of events presents a prime opportunity for faculty, departmental staff, and student groups to mingle with freshmen in an informal setting. In particular, minority students and women can be approached personally by relevant student organizations and made aware of educational and social opportunities. As a result, incoming students start the school year having already met many of the department's key figures.

All participants are given gift certificates and coupons to local stores and restaurants. To foster a competitive atmosphere, each member of the winning team receives the use of a departmental laptop for the academic year. A door prize, usually solicited from the department's industrial contacts, is also awarded at the end of the competition to keep all students involved for the full duration of the activity.

3 SOFTWARE AND TECHNOLOGY

A key aspect of the Scavenger Hunt program is the custom Scavenger Hunt software we developed for the event. The software,

[1] Solutions and explanations can be found in Appendix A.

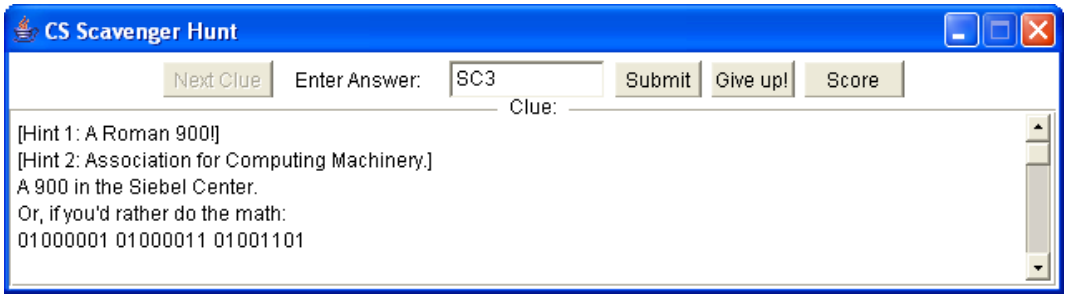


Figure 1. A screenshot of the Scavenger Hunt program, showing a clue and two hints

written in Java to ensure widespread portability, presents a simple and intuitive user interface to students while simultaneously providing event organizers with powerful, easy-to-use mechanisms for assigning routes and authoring clues. A screenshot of the interface is shown in Figure 1.

The software relies on two auxiliary files for operation: a route file, containing a list of location codes specific to a given handheld PC, and a clue file, containing the clue, hints, and associated passkey for each location. Clues are written in a subset of HTML. Both files are encrypted to prevent students from compromising the integrity of the competition.

As each team progresses through the competition, the Scavenger Hunt software keeps a complete history of the team's actions. This not only allows the software to recover seamlessly in the event of a power failure (or if a team intentionally turns off their Jornada), but it also provides organizers with precise data on each team's performance at the end of the competition.

4 EVALUATION OF IMPACT

We evaluated Scavenger Hunt in two ways: by surveying students on their attitudes toward the activity and by correlating participation to retention data.

4.1 Attitudinal study

A short, anonymous, written survey of participants was conducted roughly a month after the 2004 event took place. To ensure an adequate response rate and that respondents were not self-selected, the survey was conducted during a core introductory computer science class by a faculty member.

4.1.1 Methodology

Our evaluation sought to answer the following questions:

1. To what extent does Scavenger Hunt connect students with their peers?
2. To what extent does Scavenger Hunt make students feel like part of a larger community?

To this end, we presented students with six statements and asked them to gauge the degree to which they agreed or disagreed with each statement. The statements are presented below:

I. Scavenger Hunt helped me meet people in my classes.

II. Scavenger Hunt made me more familiar with campus.

III. Scavenger Hunt helped me make friends in the department.

IV. Scavenger Hunt made me feel like part of the department.

V. Scavenger Hunt was a valuable activity.

VI. Scavenger Hunt should be repeated for future students.

Stmt.	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
I.	2	5	3	15	1
II.	0	2	0	17	7
III.	1	3	8	13	1
IV.	2	3	7	12	2
V.	2	5	1	16	2
VI.	1	2	2	14	7

Table 3. Survey responses of 26 participants

In addition, each respondent was asked to list the first names of the other members of his or her team.

4.1.2 Results

In general, the response to Scavenger Hunt was quite positive. Of the 26 freshmen surveyed, 69% indicated that the activity was valuable and 81% indicated that the event should be repeated for future students. 92% indicated that the event made them more familiar with the campus, and 54% indicated that the activity had helped them make friends and feel like part of the department. Additionally, 17 students were able to name at least one of their teammates, and 6 were able to name all four. Complete statistics are presented in Table 3.

Another measurable result of Scavenger Hunt has been the increased participation of incoming students in departmental organizations. Women in Computer Science (WCS) and !Bang, a computer science outreach organization specific to Illinois, both had members present at Scavenger Hunt and made initial contacts with students who subsequently became active members of the organization. !Bang gained six new officers from the freshmen participating in Scavenger Hunt 2003: three times as many as had been recruited in the previous two years combined.

One unexpected benefit of Scavenger Hunt's development was the degree to which the development process contributed to the activity's stated goals. Over seventy volunteers have been involved with the project since it was first conceived in July of 2003, many of whom put in long hours together in the months directly before the event. Senior faculty, instructors, departmental staff, graduate students, and undergraduates all worked together to make Scavenger Hunt a reality, and the friendships that resulted have persisted far beyond the duration of the program.

	Retained	Left Program	Total
Did Participate	112	29	141
Did Not Participate	52	28	80
Total	164	57	221

Table 4. One-year retention categorized by Scavenger Hunt participation for 2003.

4.2 Retention study

In order to assess the effect of Scavenger Hunt on retention, we examined freshmen who entered the department in Fall 2003 and 2004, the two years immediately following Scavenger Hunt's inception.

Retention data categorized by Scavenger Hunt participation for freshmen entering the department in 2003 is presented in Table 4. Of the 141 incoming students who took part in the activity, 79.4% remained in the major for at least a full year. This is 4.6% higher than the five-year historical average, and 11.2% higher than the total percentage retained in 2002 (see Table 1). In stark contrast, of the 80 students who did not participate, only 65% were still in the major as of Fall 2004. A Pearson's Chi-Square test performed on Table 4 yields $\chi^2 = 5.55$ with df = 1, indicating that the correlation between participation and retention is statistically significant with $p = 0.0184$.

It is also instructive to examine the relationship between academic preparedness and retention. One-year retention data categorized by students' high school percentile ranking is presented in Table 5. For freshmen entering in 2003, the median percentile was 94. Of the 87 students who ranked 95th percentile or better in their high school class, 74.7% stayed in the computer science program through the first year. 71.3% of the remaining 115 ranked students remained in the major. Of the 19 students who were not ranked, only 2 left the department. Chi-Square test results for Table 5 yield $\chi^2 = 2.83$, df = 2, and $p = 0.24$, indicating that the slight predisposition of highly ranked students to remain in the program for at least the first year is not statistically significant. Instead, this analysis appears to indicate that high school preparation and retention are independent.

Also worth noting is the fact that Scavenger Hunt is presented to incoming students as a mandatory activity. In addition, students are not told of the nature of the event prior to their arrival. While schedule conflicts and communication problems inevitably prevent some students from participating, because the activity is billed as mandatory it is not likely that self-selection plays a significant role in participation rates.

Although data correlating scavenger hunt participation with retention information for freshmen entering the department in 2004 is not available, the overall retention rate remained strong in the second year after Scavenger Hunt's introduction. Of the 213 freshmen who entered the department in 2004 only 44 had left the major by Fall of 2005, yielding a retention rate of 79.3%: the highest in the department since at least 1998.

While it would be patently unrealistic for us to conclude that a single ninety-minute activity could be the sole causal factor of increased departmental retention, we do believe that the observed correlation is somewhat causative. Students who feel as if they are a part of the department are more likely to remain in it, and the relevance of engaging community-building activities like Scavenger Hunt should not be underestimated.

	Retained	Left Program	Total
Above Median	65	22	87
Below Median	82	33	115
Not Ranked	17	2	19
Total	164	57	221

Table 5. One-year retention categorized by high school class percentile rank for 2003. Of the 202 students for whom data was available, the median percentile was 94.

5 CONCLUSIONS AND FUTURE WORK

In this paper we have described Scavenger Hunt, an orientation activity for new computer science students at the University of Illinois. While it would be difficult to ascertain the precise effect that Scavenger Hunt has had on retention within the department, we believe that the correlation between participation and retention is worthy of further study. Regardless, the activity has measurably succeeded in familiarizing new students with the campus, introducing them to their peers, and making them feel like an integral part of the department. We believe that Scavenger Hunt and other socially-focused events can have a significant impact on undergraduate education, and we encourage other schools to experiment with similar activities.

Central to any successful Scavenger Hunt implementation is the judicious use of technology. Using handheld computers yields several important benefits:

- Solution times may be recorded precisely. Manual timing mechanisms would be unlikely to provide sufficient accuracy to ensure a fair competition.
- Travel time may be trivially omitted from scoring. This omission is essential to allow equal participation by physically handicapped students and keep the competition a test of brains rather than brawn.
- Team scores are immediately available and do not need to be tabulated by hand. The winning team is known within minutes of the end of the competition.
- There is a significant "coolness" factor involved: it seems only fitting that students' first activity in the computer science department be high tech.

However, such widespread integration of handheld technology has one very pronounced disadvantage: it requires a great number of handheld computers which may not be readily available or cost-effective to acquire (our Jornadas were obtained from Hewlett Packard some years ago on a grant unrelated to orientation and retention activities). A less fundamental disadvantage is that the competition requires several weeks of preparation, particularly as we have no way to centrally administer the thirty or so Jornadas we use. On the other hand, our software is portable, well documented, and freely available (see Section 6), which could mitigate the time investment necessary to develop a Scavenger Hunt activity at other schools.

In departments without access to handheld computers, a traditional, paper-based system could be substituted. When a team arrives at a location, a volunteer would supply the team with their next clue and record the time, supply hints as requested while the team determines their next destination, record the team's solution time after the clue has been solved, calculate their score, and record it in the team's journal. Such a strategy would obviously require a

great deal of careful planning and volunteer training. Another alternative requiring significantly less manpower would be to run a purely virtual Scavenger Hunt using an existing computer lab. It is doubtful, however, that either of these strategies would be as effective and engaging as the competition in its current form.

The most interesting alternative to relying on handheld computers would be to use students' cell phones to deliver clues and submit solutions [1]. There would be no shortage of available devices, and a server-based Scavenger Hunt implementation would be substantially simpler than the current system predicated on non-networked handhelds. With the Jornadas aging, we are hoping to implement this approach in the coming year.

In addition to this technical work, there are several other areas in which we plan to apply more effort. Because Scavenger Hunt traditionally takes place immediately before the start of the school year and therefore before many students have activated their university email accounts, attendance has thus far been less than optimal: in 2004, only 115 of the 176 incoming freshmen were present. In the future, more diligent efforts should be made to ensure 100% attendance. Also, although routes are chosen to normalize each team's total travelling distance, no effort has yet been made to normalize clue difficulty. By using average solution time from past competitions as a rough metric, this could easily be accomplished.

One final planned extension of Scavenger Hunt is to involve participating freshmen in the development of the next year's event. Organizing interested students to collaborate on the development of new clues and hints would be an excellent way for them to become more involved in the department and to interact with key faculty members and staff. Additionally, several other departments, including Electrical and Computer Engineering as well as Mechanical Engineering, have expressed interest in replicating the program. Expanding the activity within the College of Engineering would undoubtedly be beneficial in many ways.

6 WEB RESOURCES

More information about Scavenger Hunt can be found on the activity's website:

`http://scavengerhunt.cs.uiuc.edu/`

Source code for the Scavenger Hunt software, including route generation scripts, sample clue files, and detailed instructions are all available.

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APPENDIX

A SOLUTIONS TO PROVIDED CLUES

The first clue is in a style frequently found in cryptic crossword puzzles. "You stand before a headless onion" indicates the reader should add the letter "U" onto the front of the word "onion" with its head (first letter) removed. "Removing Windows® from the state" instructs the reader to remove "OS" (for Operating System) from "Illinois" giving "Illini." Connecting the two in the indicated order gives the answer: "Illini Union."

The second clue requires a few quick calculations. The summation on the left comes to 1320, and the definite integral on the right evaluates to L (relying on students' knowledge of the trigonometric identity $\sin^2 x + \cos^2 x = 1$). The music notes in the center are "D" and "C", so the clue reads "1320 DCL," which refers to the large lecture hall in the Digital Computer Laboratory.

The third clue is written in "leet," a novel form of the English alphabet characterized by the substitution of typographically similar non-alphabet characters for letters. The slang is popular in internet games and online communities. Once this realization is made, it's fairly easy to see that the clue "spells" out "Go to the basement of Grainger," the campus' Engineering Library.

The last clue seems very difficult until one turns it upside-down. It then becomes quite obvious that the solution is "407 E. Green St." (the address of the local Walgreens).