Report on the LIKES Workshop at Santa Clara University

Executive Summary

The "Living In the KnowlEdge Society (LIKES) Community Building Project" is funded by the National Science Foundation under the initiative of CISE Pathways to Revitalized Undergraduate Computing Education (CPATH, through awards CCF-0722259, 0722276, 0722289, and 0752865). The vision of LIKES is to build a community that will define the way to make systemic changes in how computing concepts are taught in both computing-related disciplines and the disciplines of the broader workforce and society. The first of four workshops, titled "Defining Problems and Applications of the Knowledge Society," was held in Santa Clara University (SCU) on November 30 and December 1, 2007, with a goal of defining key terms related to the knowledge society, identifying key computing concepts, and mapping the needs of different disciplines with the computing concepts. Thirty-four scholars and educators participated in the workshop. Deliverables of the workshop include descriptions of computing concepts, the importance of learning of computing concepts, and mappings of computing concepts. Participants provided in a post-workshop satisfaction survey their feedback and ratings, which show a general satisfaction on the various aspects of the workshop. Their written comments indicated that they benefited from the group discussions and keynote speeches. Yet they would like to see improvements regarding group facilitation and clarification of tasks. Lessons learned and recommendations for future workshops are discussed.

1. Background

The vision for the LIKES project is to build a community that will lead the way to make systemic changes in how computing concepts are taught in both computing-related disciplines and the disciplines of the broader workforce and society. Revitalizing education in computing-related disciplines is necessary to reach a broader audience of potential students and produce a larger number of professionals with the computing competencies and skills that are imperative to designing and building the innovations of the future. More people are needed in all computing-related disciplines, e.g., computer science, information systems, and information technology, to maintain our competitiveness and ensure the health, security, and prosperity of the nation in the face of outsourcing and globalization.

However, it is not sufficient to increase the numbers of computing professionals. The needs of the Knowledge Society also require improvements in the computing competencies and skills of people in all disciplines. This is due to the pervasive and growing needs for computing in society. Many jobs require workers to have knowledge and ability to apply computing concepts to accomplish individual, group, organizational, and societal goals. Yet, most students from non-computing related disciplines have limited opportunities to learn computing concepts. If anything, they only learn rudimentary uses of searching for information, creating reports/presentations, and communicating through email – i.e., "computing as simple tool". Providing curious undergraduate students with a broad knowledge of computing concepts can empower them as individuals, and transform their thinking about society.

The LIKES project includes a series of four workshops. Each workshop includes a virtual community that is involved prior to the workshop to evaluate the planned activities and enhance the effectiveness of the workshop, then to collaborate on developing reports of the results of the workshops.

The objectives for the first goal of identifying the problems existing in other disciplines include: 1) Identifying different approaches to delivering university core courses across the nation; 2) Identifying disciplines from the university core classes; 3) Recruiting interested faculty from the core disciplines; 4) Working with faculty from the core disciplines to identify the problems they face in teaching key ideas in their domain that they believe could be enhanced by using computer-based tools. The result of this workshop will be an initial list of problems to be addressed and a virtual community of faculty from computing and other disciplines collaborating to identify problems that can benefit from the application of computing concepts.

The objectives for the second goal of identifying computing concepts and then mapping the concepts to the problems identified include: 1) Bringing together a group with expertise in computing concepts; 2) Reviewing model curricula for computer science, information systems, and information technology to ensure that the entire range of computing concepts are included; 3) Filling in the cells of the matrix to show the types of tools and modules to be created. This is one of the most important activities of the proposed community building project.

2. The SCU LIKES Workshop Details

The first LIKES workshop, titled "Defining Problems and Applications of the Knowledge Society," was held in Santa Clara University (SCU) on November 30 and December 1, 2007, from 8am - 5pm both days. Located in the Silicon Valley of the San Francisco Bay area, SCU is renowned for its strong commitment to service learning and its excellent connection with hi-tech companies. The topics of the workshop include:

1) Definition of key terminologies such as "knowledge society", "knowledge worker", and "global society"
2) Identifying non-computing disciplines that would benefit from the teaching of computing skills and concepts
3) Identifying the skills and concepts that those disciplines require
4) Developing connections between non-computing disciplines and computing and IT disciplines
5) Identifying businesses and professions that employ graduates, from non-computing disciplines, who possess relevant computing skills and knowledge
6) Mapping the needs of non-computing disciplines with the concepts and skills taught by computing and IT disciplines

2.1 Schedule

The main venue for the workshop was Kennedy Commons in Santa Clara University. With a capacity of over 100, the room provided flexible seating, configurable tables, audio-visual support, a projector that can connect to laptops, and Internet connectivity (both wired and wireless). In addition to the room, we also held breakout sessions in several nearby rooms in the Benson Center and Kennedy Building, all located within walking distance.

Nov. 29, 2007 (Thursday)

5:30-7:00 pm	Reception

Nov. 30, 2007 (Friday)

7:30-8:30 am	Breakfast and registration
8:30-9:30 am	Welcome: Ed Fox; Keynote Speech 1: Larry Rowe, FXPAL
9:30-10:30 am	Breakout session 1: Defining key terms and identifying non-computing disciplines that would benefit from the teaching of computing skills and concepts (I)
10:30-11:00 am	Tea break
11:00-12:00 noon	Breakout session 2: Defining key terms and identifying non-computing disciplines that would benefit from the teaching of computing skills and concepts (II)
12:00-1:00 pm	Lunch
1:30-3:30 pm	Breakout session 3: Identifying skills for a knowledge society
3:30-4:00 pm	Tea break
4:00-5:15 pm	Breakout session 4: Developing connections between non-computing disciplines and computing disciplines
5:45-8:00 pm	Dinner

Dec. 1, 2007 (Saturday)

7:30-8:30 am	Breakfast and registration
8:30-9:30 am	Keynote Speech 2: James Frew, UC Santa Barbara
9:30-10:30 am	Breakout session 5a: Mapping the needs of non-computing disciplines with the skills and computing concepts taught by computing disciplines
	Breakout session 5b: Evaluating the list of computing concepts (in computing lab)
10:30-11:00 am	Tea break
11:00-12:00 noon	Breakout session 6a: Mapping the needs of non-computing disciplines with the skills and computing concepts taught by computing disciplines
	Breakout session 6b: Evaluating the list of computing concepts (in computing lab)
12:00-1:00 pm	Lunch
1:30-3:30 pm	Breakout session 7: Mapping the needs of non-computing disciplines with the concepts and skills taught by computing and IT disciplines (II)
3:30-4:00 pm	Tea break
4:00-5:15 pm	Concluding session: Reporting of outcomes achieved
5:45-8:00 pm	Dinner

2.2 Logistical Issues

Most participants stayed in a nearby hotel, named Candlewood Suite, which provided each participant with a full-scale suite with both basic lodging needs and extra services, such as an oversized executive desk and a full kitchen. The hotel is within walking distance from the workshop location.

The SCU Angel online community support system was used during the workshop to support instant communication among participants. Participants posted their ideas, comments, and deliverables in the system. It also supported the post-workshop online satisfaction survey.

3. Participant Profiles

No.	Name	Affiliation	In CS discipline
1	Richard Plant	UC-Davis	

2	Nancy Yen-Wen Cheng	Architecture, U. of Oregon	
3	Tim Hesterberg	Insightful Corporation	
4	Jerry P. Suits	U. of Northern Colorado	
5	Ken Williams	NC A & T University	Yes
6	Richard Selfe	Ohio State University	
7	Jarom McDonald	Brigham Young U.	
8	Judith Kirkpatrick	Kapi'olani Community College, Univ. of Hawai'i	
9	Ellen Spertus	Google	Yes
10	Ge Wang	Stanford University	
11	Norm Chonacky	Yale University	Yes
12	Mialisa Moline	University of Wisconsin - River Falls	
13	James Frew	UC-Santa Barbara	
14	Ghaleb Abdulla	Lawrence Livermore National Lab	Yes
15	David L Tauck	SCU Biology	
16	Narendra Agrawal	SCU OMIS	
17	Ed Fox	Virginia Tech	Yes
18	Ryan Richardson	Virginia Tech	Yes
19	Ed Carr	North Carolina A&T University	Yes
20	Robert Beck	Villanova University	Yes
21	Steven Sheetz	Virginia Tech	Yes
22	Patrick Fan	Virginia Tech	Yes
23	Carlos Evia	Virginia Tech	Yes
24	Chris Zobel	Virginia Tech	Yes
25	Sneha Veeragoudar	UC Berkeley, Graduate School of Education	
26	Colleen Lewis	UC Berkeley, Graduate School of Education	
27	Mark Howison	UC Berkeley, Graduate School of Education	
28	Wingyan Chung	SCU OMIS, Local host	Yes
29	Shelby McIntyre	SCU Marketing	
30	Craig Stephens	SCU Biology Department	
31	Chaiho Kim	SCU OMIS Dept Head	
32	Suzanne K. Schaefer	UC Irvine ICS	Yes
33	Mehran Sahami	Stanford University CS	Yes
34	Larry Rowe	FX Palo Alto Laboratory	Yes

4. Workshop Deliverables

4.1 Definitions of Computing Concepts

Computer Concepts	**Definition**	**Architecture**	**Geography/GIS**	**Business**
Logic	Logic is the study of the principles and criteria of valid inference and demonstration.	Boolean Conditions in Modeling	Boolean Conditions	
Data Structure (graph,trees)	A data structure is any data representation and its associated operations. Common examples include stacks, queues, binary search trees, B-trees, hash tables, etc. Data structures can be the implementation of mathematical constructs with well-defined properties, such as graphs and trees.		Network Analysis	

Programming	A programming language is a programmer's principal interface with the computer. Programmers need to understand the different styles of programming promoted by different languages.	Parametric Design, Scripts (Macros)	Scripting	
Algorithms/Problem Solving	An algorithm is a method or process used to solve a problem. Algorithms are fundamental to computer science and software engineering. The real-world performance of any software system depends on only two things: (1) the algorithms chosen and (2) the suitability and efficiency of the various layers of implementation.	Generative systems/Simulation	Simulation	Excel Scenario Analysis, @Risk analysis
Communications+Networking	Net-centric computing covers a range of sub-specialties including: computer communication network concepts and protocols, multimedia systems, Web standards and technologies, network security, wireless and mobile computing, and distributed systems.	Virtual Teams	Web-based GIS	Tele-commuting, Collaboration, Wide Area Network, Webx
HCI	Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. It is often regarded as the intersection of computer science, behavioral sciences, design, and possibly other fields of study.	User Needs	Google Earth, customization	
Graphics/Visualization	Computer graphics is the art and science of communicating information using images that are generated and presented through computation. Visualization. The field of visualization seeks to determine and present underlying correlated structures and relationships in both scientific (computational and medical sciences) and more abstract datasets. The prime objective of the presentation should be to communicate the information in a dataset so as to enhance understanding.	3D Modeling, Animation, Presentation	Cartography, Scene visualization	Charts, Supply Chain, Business Intelligence
Knowledge Representation, Retrieval, Storage	This area includes the capture, digitization, representation, organization, transformation, and presentation of information; algorithms for efficient and effective access and updating of stored information, data modeling and abstraction, and physical file storage techniques.	Building Info Models, Energy, Lighting, Cost, Symbol Libraries	Meta Data	Knowledge Management
Database and Data Modeling	This topic includes history and motivation for database systems; components of database systems; DBMS functions; database architecture and data independence, data modeling; conceptual models and object-oriented models.		Geospatial data models,Vector, Raster, Networks	Business Data, SAP
Social Context	Students need to develop the ability to ask serious questions about the social impact of computing and to evaluate proposed answers to those questions. This includes being able to anticipate the impact of introducing a given product into a given environment	Digital workflow		Digital divide, access by under-priviliged

IP+Privacy+Civil Liberties	Students need to be aware of the basic legal rights of software and hardware vendors and users, and they also need to appreciate the ethical values that are the basis for those rights. This includes ethical and legal basis for privacy protection; privacy implications of massive database systems and technological strategies for privacy protection.	Web reports copyrights	Data ownership	E-Commerce
Computer Literacy	User familiarity with basic knowledge of MS Office (or open source equivalent), email, the Internet, and computer usage	Yes	Yes	Yes
Software Engineering	Software engineering is the discipline concerned with the application of theory, knowledge, and practice for effectively and efficiently building software systems that satisfy the requirements of users and customers.	Project/Team Management		

4.2 Computer Lab sessions: Rating the importance and ease of learning of computing concepts

Two computer lab sessions were conducted to rate the importance of the concepts identified and to determine which concepts participants believed would be easiest to learn for students taking core courses. This process provides a basis for determining which concepts should be included within the LIKES core framework.

First each participant was asked to rate how important it is for students in non-computing disciplines to learn each computing concept. A five option scale was used from 5 – Not at all important, 4 – Slightly important, 3 – Important, 2 – Highly important, to 1 – Extremely important. The average importance ratings for the group were displayed and the group discussed the mean ratings and the relative importance of the concepts. The group then rated the importance of the computing concepts a second time. This process was conducted with two groups. The following table shows how computing concepts ranked on importance with their mean importance ratings.

Computing Concepts	Mean Rating	Calc Rank
Social Context	1.88	4.33
IP+Privacy+Civil Liberties	1.94	4.56
Algorithms/Problem Solving	2.06	4.64
Logic	2.29	5.47
Knowledge Representa-tion, Retrieval, Storage	2.47	5.81
Computer Literacy	2.65	6.33
Communications+Network-ing	2.53	6.42
Database and Data Modeling	2.65	6.72
Programming	2.76	7.14
HCI	3.12	8.44
Modeling and Simulation	3.24	8.67
Graphs and Trees	3.59	9.47

The concepts of Social Context, Intellectual Property/Privacy, and Algorithms/Problem Solving an were deemed most important, while the Programming, Foundations of HCI, Modeling/Simulation, and Using Graphs/Trees concepts were deemed least important. The level of agreement on the overall ranking of the concepts was calculated using Kendall's coefficient of concordance (W). The calculated value of W= .22, p=.001, indicates that there was very low agreement among the participants on the ranking of the concepts by importance.

The next activity in the computer lab session was for each participant to respond to the statement: This ______________ (computing concept) will be easy for students in non-computing disciplines to learn. A five option scale was used from 5 – Strongly agree, 4 – Agree, 3 – Undecided, 2 – Disagree, to 1 – Strongly Disagree. The average importance ratings for the group were displayed and the group discussed the mean agreement ratings of the concepts. The group then responded to the statement a second time. This process was conducted with two groups. The following table shows how computing concepts were ranked in terms of being easy to learn with their mean agreement ratings.

Computing Concepts	Mean Rating	Calc Rank
IP+Privacy+Civil Liberties	1.41	3.00
Social Context	1.41	3.17
Computer Literacy	1.66	4.06
HCI	2.12	5.58
Logic	2.29	6.22
Communications+Network-ing	2.35	6.25
Database and Data Modeling	2.53	6.92
Algorithms/Problem Solving	2.71	7.50
Knowledge Representa-tion, Retrieval, Storage	2.88	8.22
Graphs and Trees	3.12	8.61
Programming	3.18	8.81
Modeling and Simulation	3.35	9.67

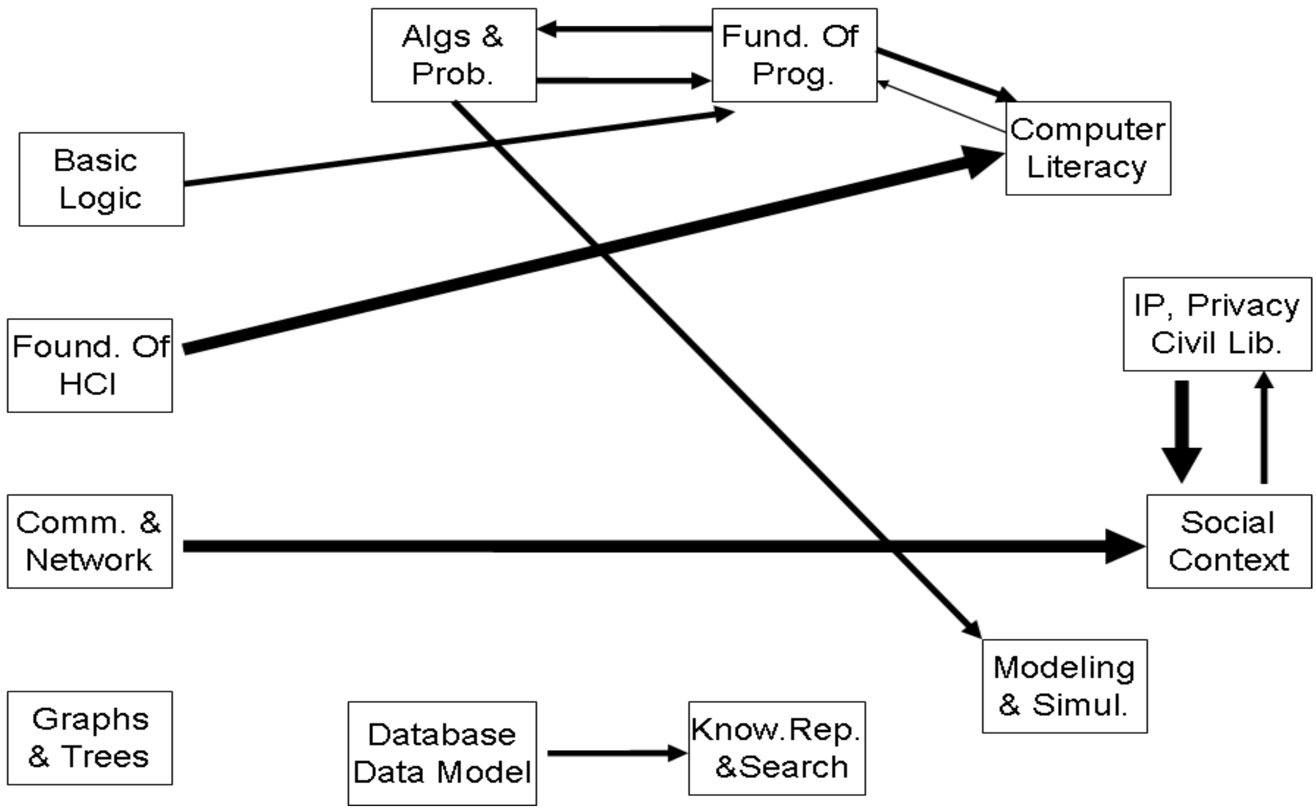
The concepts of Social Context and Intellectual Property/Privacy were viewed as the easiest for students to learn, while participants disagree that Using Graphs/Trees, Programming, and Modeling/Simulation concepts will be easy for students to learn. The level of agreement on the overall ranking of the concepts was calculated using Kendall's coefficient of concordance (W). The calculated value of W= .44, p=.001, indicates that there was low to moderate agreement among the participants on the relative ease of learning of the concepts.

4.3 Cognitive maps of learning computing concepts

In the third session in the computer labs, participants were asked to identify relationships among the computing concepts. They responded to the statement: Learning computing concept _________ (A) has a (slight, moderate, or strong) (positive or negative) influence on learning computing concept _________ (B). During this session each participant used a Group Cognitive Mapping System (GCMS) to create their individual cognitive map showing the relationships they believe exists among the computing concepts. All twenty-five participants identified 283 relationships, about 11 per participant, among the computing concepts. Participants participated in two groups, the first group included 11 participants the second group included 14 participants.

The GCMS then computed the group maps from the individual maps developed by the participants for each group. The maps for each group are presented below.

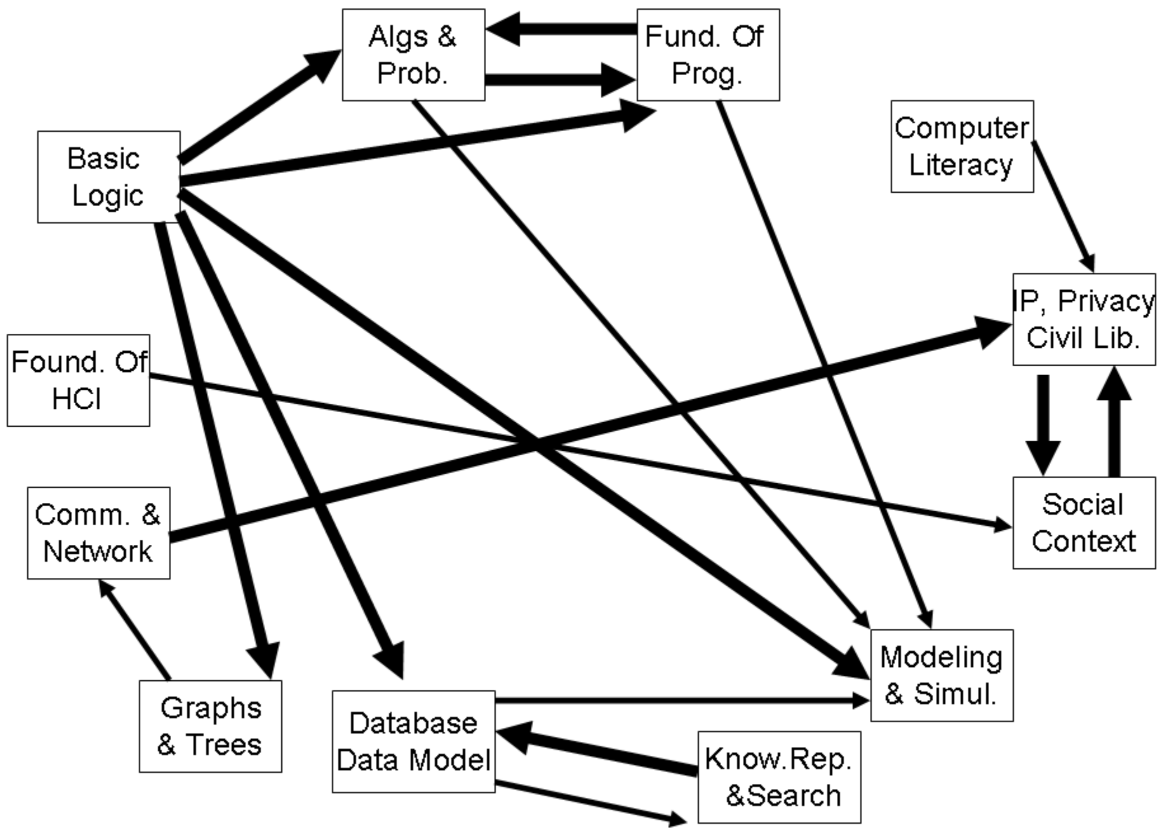
Group 1 Cognitive Map (relationships identified by at least 3 of 11 participants)



The map for group one emphasizes the relationships of algorithms and problem solving with the fundamentals of programming, then connecting to the computer literacy concept. In this map, fundamentals of programming is the most cognitively central concept, participating in five relationships. The next most cognitive central concepts are algorithms, computer literacy, and social context, each with three relationships. Higher cognitive centrality for programming and the related concepts of algorithms and computer literacy seems to represent the long held idea that computer literacy is strongly associated with programming skills. This group also recognizes the importance of the social aspects of computing and sees learning these ideas as separate from programming concepts.

The map for group two emphasizes that basic logic is needed before learning other computing concepts. With five strong relationships it is the most cognitively central concept for the group and has strong influences over the next most cognitively central concepts of algorithms/problem solving, fundamentals of programming, database, and modeling/simulation. Show that participants also see programming as important. However, the perspective of this group is broader than that of the first group, extending beyond programming to include the database and simulation concepts. The do not see computer literacy as involved with programming or other technical concepts, but do relate it to the softer issues of social aspects of computing represented by the intellectual property, privacy, and civil liberties concept. This group also recognizes the importance of the social aspects of computing and sees learning these ideas as separate from programming and other more technical computing concepts.

Group 2 Cognitive Map (relationships identified by at least 3 of 14 participants)



5. Results of the Satisfaction Survey

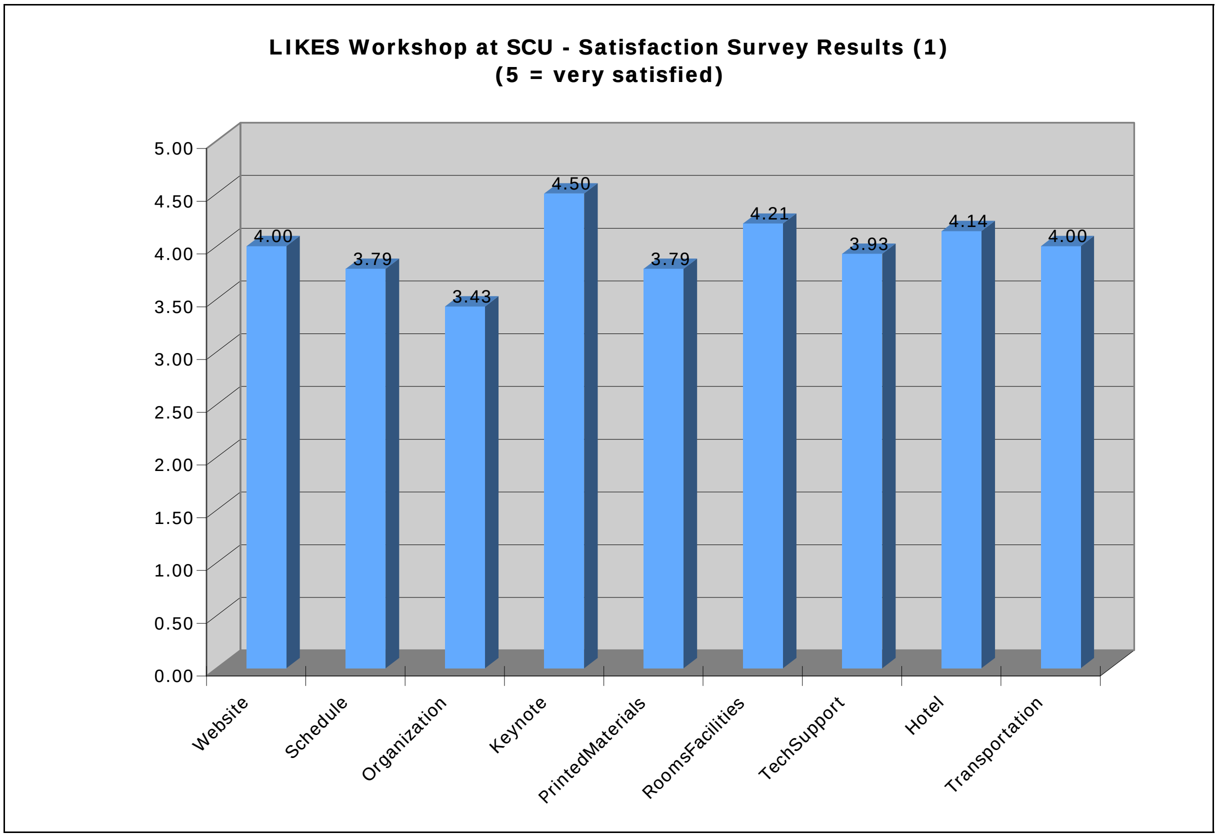
A set of 36 questions were asked in a post-workshop satisfaction survey targeting the participants. These questions are listed in the following table. In questions 1-20 and 23, a five-option scale (Very satisfied = 5, Satisfied = 4, Neutral = 3, Dissatisfied = 2, and Very Dissatisfied = 1) was used. Question 22 uses a slightly different 5-point scale (see the table). All the others questions are open-ended questions or questions asking for demographic information.

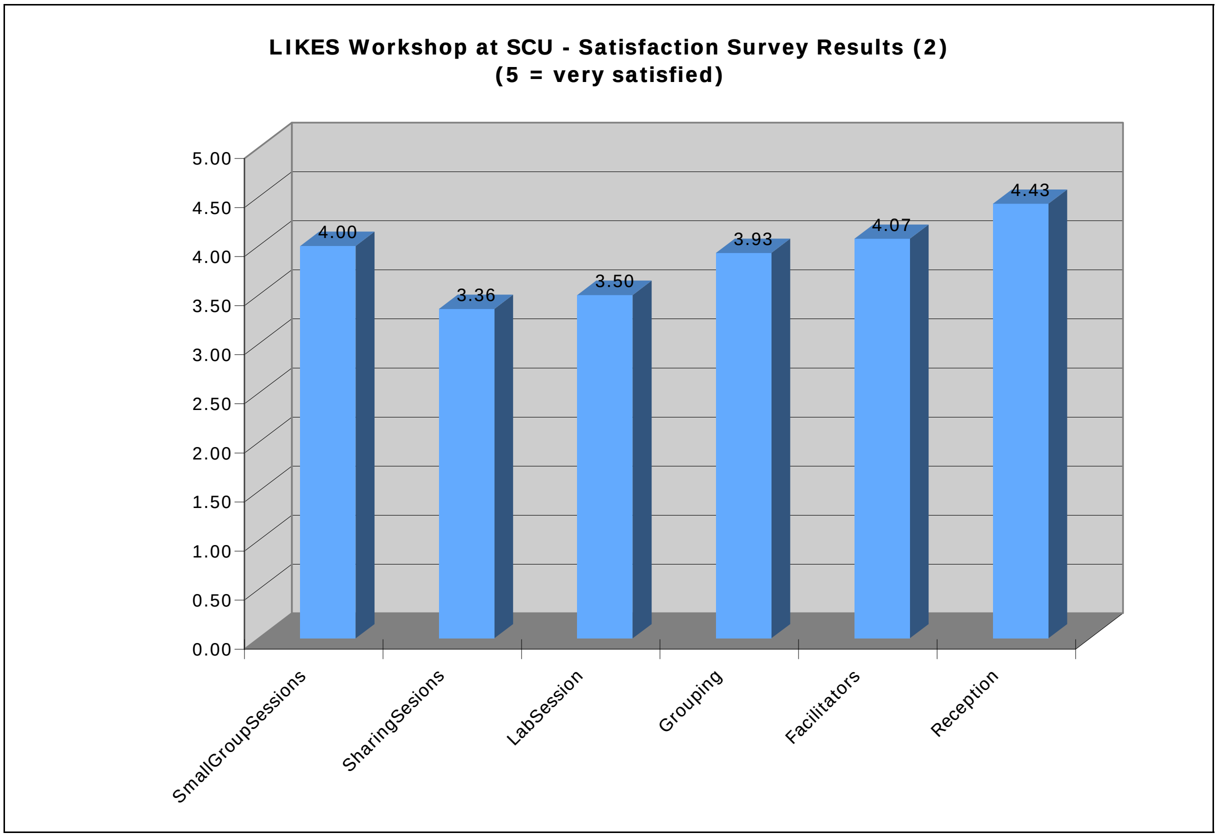
1. How satisfied were you with the workshop Web site?
2. How satisfied were you with the workshop schedule?
3. How satisfied were you with the organization of activities?
4. How satisfied were you with the keynote speeches?
5. How satisfied were you with the workshop's printed materials?
6. How satisfied were you with the workshop's rooms and facilities?
7. How satisfied were you with the technology and multimedia support?
8. How satisfied were you with the workshop hotel?
9. How satisfied were you with the transportation arrangements?
10. How satisfied were you with the sessions for small-group discussion?
11. How satisfied were you with the sessions for all groups to share discussion results?

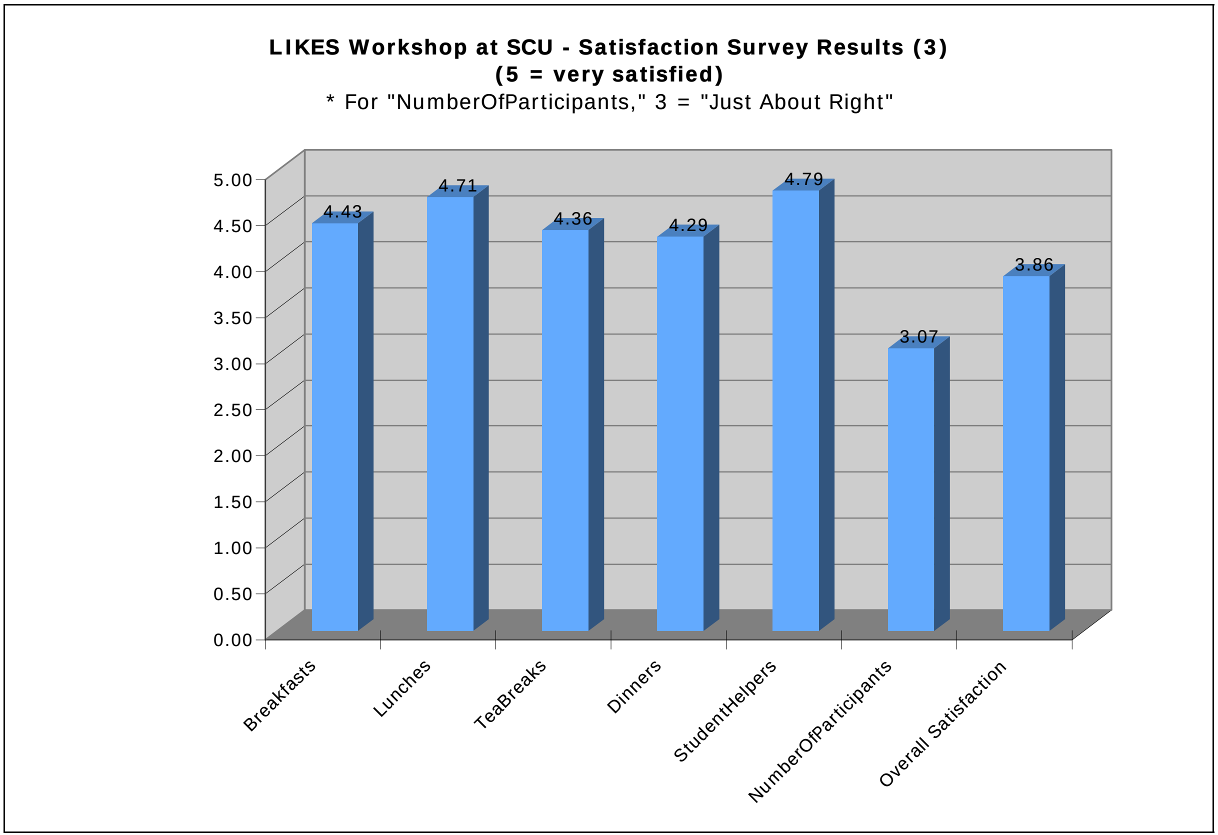
12. How satisfied were you with the session in computer lab?
13. How satisfied were you with the grouping of participants?
14. How satisfied were you with the group facilitators?
15. How satisfied were you with the reception held on Thursday?
16. How satisfied were you with the breakfasts?
17. How satisfied were you with the lunches?
18. How satisfied were you with the tea breaks?
19. How satisfied were you with the dinners?
20. How satisfied were you with the services of the student helpers?
21. If your answers were "Dissatisfied" or "Very dissatisfied" in any of the above questions, could you please specify the reasons?
22. Would you say the number of participants in this workshop was: Way too many, Too many, Just about right, Too few, Way too few
23. Overall speaking, how satisfied were you with this workshop?
24. What did you like most about the workshop? Why?
25. What, if anything, could be done to improve your experience as a participant in this workshop?
26. To what extent do you think this workshop fulfilled the objectives of the LIKES initiative? Please comment.
27. Overall, how do you feel about this workshop? What suggestions can you provide on future LIKES workshops?
28. Will you consider attending future LIKES workshops?
29. Will you consider participating in LIKES online communities?
30. Your name:
31. Your affiliation:
32. Your title:
33. Your email address:
34. Your phone number:
35. Your mailing address:
36. Your Web site:

5.1 Results on Objective Questions

Fifteen participants filled in the survey. The following three charts show the results on objective questions. In general, the participants provided a rating of 4 or above (where “5” means “very satisfied”) in many of the aspects. They were most satisfied on the keynote speeches (4.5), student helpers (4.79), and lunches (4.71). They were not quite as satisfied regarding group arrangement, where the ratings ranged from 3.36 to 4.07 (see the second chart). They felt that the number of participants was about right (Question 22, see the third chart). The overall satisfaction was 3.86 (Question 23, see the third chart).


LIKES Workshop at SCU - Satisfaction Survey Results (1)
(5 = very satisfied)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
4.00
3.79
3.43
4.50
3.79
4.21
3.93
4.14
4.00
Website
Schedule
Organization
Keynote
PrintedMaterials
RoomsFacilities
TechSupport
Hotel
Transportation


LIKES Workshop at SCU - Satisfaction Survey Results (2)
(5 = very satisfied)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
4.00
3.36
3.50
3.93
4.07
4.43
SmallGroupSessions
SharingSesions
LabSession
Grouping
Facilitators
Reception



5.2 Results on Open-ended Questions

The participants provided many written comments regarding Questions 21 and 24-27. On the positive side, the participants liked the atmosphere and cooperation created in the workshop. Many of them highly appreciated the opportunity to work with a diverse and thoughtful group of scholars and educators. They enjoyed the in-depth discussion and the exchange of ideas among the group members. For example, a participant said: "The organizers had brought together a thoughtful group of participants and created a useful framework. They fostered a strong atmosphere of cooperation that was generally adopted. I appreciate that they picked up on participant suggestions for the format and content of some of the sessions." Another participant said: "The participants were great resources - it would have been interesting to have more time for them to share ideas and examples of things they have done or know about that have worked well." Another said: "I liked the depth of thought we achieved. We were working well together to produce some rather significant and profound ideas." The discussion elicits further thinking as well, as seen in a participant's comment: "I was motivated to ponder, consider, and do keep thinking about the various small groups discussions! That's a positive."

In addition, the discussions among the participants were considered to be generally productive. For example, some comments from the participants are: "Overall, I felt that everyone at the workshop put in a sincere effort to grapple with the challenging issues and the two days were fairly productive." "(I) really enjoyed it. (This is) one of the few workshops I've been to that actually felt productive!" New ideas were identified as a result of these discussions, as seen in their comments: "The conversations we had in small groups were, to me, the most productive.

Our generated ideas were extremely useful and have sparked further conversations via email, etc. I also think just the very focus of the workshop has provided some extremely useful ideas that I've taken back to my own institution to see if we can actually start effecting some change." "I liked the depth of thought we achieved. We were working well together to produce some rather significant and profound ideas."

On the other hand, the participants also provided constructive comments on how to improve the workshop. These comments are related to the project goals and objectives, group sessions, and arrangement and logistics issues.

Some participants said they had an unclear picture about the goals of the LIKES project. One participant said: "It sometimes wasn't clear what we were supposed to do. We ignored the directions to break into two's - there wasn't time for that." Another said: "I felt that the participants' time was not used very effectively. I would have rather done some work beforehand to make the actual workshop tighter." They would like to see a more articulated description of workshop goals.

Regarding the group sessions, the participants suggested improvements on time control, group facilitation, and clarification of tasks. A participant suggested that having a protocol or rubric to guide group discussion would improve the presentation of the deliverables. Several participants pointed out that the all-group sharing sessions were not organized well, in that too much time was spent and presenters were not given enough time on preparation. Sample comments are: "The small group discussions might be improved if the facilitators were better prepared. A simpler protocol/rubric might have made this possible." "The presentations at the all-group sessions were very uneven." "I thought the 'presentation of small group discussions' sessions tended to slow down the process and disrupt the depth of thought we achieved."

The participants provided further comments on arrangement of activities and some logistical issues. They would like to see more non-CS (Computer Science) people to participate in the workshop. Some of them felt constrained by the CS terminologies listed in the curriculum materials presented to them. Some suggested that providing huge post-it-notes and a space for posting these notes would facilitate visual representation of work done in different groups., They suggested that a self-selected group might be a better arrangement than the grouping enforced by the organizers.

6. Summary and Lessons Learned

From the participants' comments and our observations, we believe that there are a number of lessons learned from this workshop.

First, we were limited by the time and resources available to invite participants. The workshop dates were finalized only at the end of September, giving potential participants less than two months' time to decide on whether to participate in the workshop. By the time they received an invitation, most of them already had prior commitment scheduled during the workshop dates, which unfortunately fell on the typically busiest final week of the Fall semester or quarter in most schools. Therefore, out of the 300+ invitees, only about two dozens of them were able to attend the workshop. Nevertheless, the number of attendees was perceived to be about right by the participants (see ratings on Question 22 in the satisfaction survey).

Second, due to the limitation of inviting participants, we were not able to have a large-enough number of non-CS scholars and educators. Out of the 34 participants, 18 were not in the

CS discipline. This situation created difficulty for some participants to understand the terms in the CS curriculum, which is a major part of what we discussed in the workshop.

Third, because the participants did not have a common vocabulary in the discussion, some time was spent on understanding terms, clarification, and discussion of concepts. Such time would be saved if prior consensus was established.

Fourth, the arrangement of workshop activities was not clearly communicated to and agreed on by participants. Although a detailed script of the workshop activities was given to each participant, not all participants were in complete agreement on such an arrangement. Many of them also did not fully understand the rationale behind the arrangement.

Fifth, while each group was charged to discuss certain topics, no concrete template for documenting the deliverables was given. As a result, each group used its own way of documenting and presenting the results, included hand-written notes, digitized presentation slides, spreadsheets, discussion forum messages, and so on. This created some difficulty in summarizing and aggregating the results of the group discussions.

7. Recommendations for Future Workshops

Based on the aforementioned issues and input from participants, we recommend the following measures for upcoming LIKES workshop organizers.

First, invitation of workshop participants should begin at least three months before the workshop. This would provide a sufficient time frame for invitees to consider attending the workshop. Different strategies should be used in the invitation: personal contacts, face-to-face meetings, telephone conversations, emails, etc.

Second, we should choose for each workshop about six specific disciplines from which we would invite participants. This would narrow our scope to a more specific level and would allow participants to have a larger common vocabulary to aid their discussion. For each discipline we choose, we should have about 5 to 6 participants. Then we would group these participants into a group. For example, we can have in one workshop the following disciplines: music, geography, physics, biology, history, and statistics. Six groups will then be formed in the workshop, each representing one discipline.

Third, we should communicate clearly with invitees about the goals and objectives of the project and the workshop. Outputs from the prior workshop can be used to motivate invitees to consider participating. Incentives like professional networking, publication opportunities, contribution to advancing education of their disciplines, and reimbursement of travel expenses, should be clearly communicated.

Fourth, once the invitees have agreed to participate, we should keep a close communication with them before the workshop dates. We suggest sending weekly emails to participants one month before the workshop dates. In those emails, we should explain the goals of the project, the people involved, the location, the participant profiles, etc. The purpose of this close communication is to establish a cooperative atmosphere and to begin the thinking process before the workshop, so as to minimize any misunderstanding and to avoid false expectations.

Fifth, in all the group assignments, we should provide a clear template to document the deliverables. For example, we should provide a template for creating slides. Each group facilitator, who will be one of the PIs, co-PIs, or key personnel, should serve as a controller in documenting the deliverables. The facilitator should ensure that time is used and controlled properly in all group sessions. During all-group reporting sessions, another person (who will be one of the PIs, co-PIs, or key personnel) should keep track of the presentation arrangement, time control, and logistical items.

8. Appendix

LIKES Workshop Brochure and Participant Profiles.