Broadening Studio-Based Learning in Computing Education
Final Report to NSF 2015

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Information & Computer Science, University of Hawaii

Technical Report CSSE18-01
Department of Computer Science & Software Engineering
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**Accomplishments**

* What are the major goals of the project?

The vision of this project was to systematically investigate an innovative pedagogical approach to computing education called Studio Based Learning (SBL). Adapted from architectural education, the studio-based instructional approach develops students' skills of computational thinking, critical analysis, collaboration and communication by having them solve complex design problems and present their solutions to their peers and instructor for review. This vision was realized by achieving the goal of implementing and evaluating the SBL approach on a national scale during the proposed project.

The following three objectives were met.

1. We supported a national community of 17 computing educators (out of which 10 belonged to underrepresented communities in computing: eight women and two African-Americans) who adopted and implemented the SBL approach in their classrooms through four annual faculty development workshops during 2010-2013.

2. The SBL approach was evaluated by assessing the motivational and learning outcomes that resulted from having a broad spectrum of undergraduates—from different states, in a variety of computing courses and at different types of institutions ranging from community colleges to research universities—participate in SBL, and comparing student learning and attitudes between SBL and traditional implementations of the same courses in a quasi-experimental approach.

3. Disseminated information on SBL in computing education, including its pedagogical foundations, practical advice, curricular resources and case studies, through publications, presentations and a web portal during the course of the
Major Activities: Major activities of the reporting period for this final report, 01/01/2014 - 09/30/2014, were organizing qualitative data and analyzing it to complement the quantitative data organization and analyses carried out during previous reporting periods.

Specific Objectives: The specific objectives of the aforementioned activities were to uncover student attitudes towards the SBL instructional model, and to see if students who took SBL implementations of computing courses reported more positive attitudes than those who took traditional implementations of the same courses, and whether these attitudes corresponded with student performance comparisons across these courses.

Significant Results: The table attached as a supporting file (NSF0939055_Qualitative_Data_Analysis_Summary.pdf) summarizes statistically significant results of analyzing qualitative responses extracted from surveys submitted by students taking SBL and traditional versions of all computing courses from 15 institutions in seven states. Here are the highlights:

- 87% of SBL students reported motivation to take more computing courses versus 57% of traditional students.
- 32% of SBL students said that the SBL courses improved their attitude towards majoring in a computing related discipline, whereas only 26% of traditional students felt their courses improved their attitude towards majoring in computing.
- 84% of SBL students felt that their learning benefited from SBL activities that they engaged in, whereas only 37% of students taking traditionally taught courses reported learning benefits from SBL-type activities (which are not mandated in traditional instruction).
- 67% of SBL students reported improving their problem solving skills, compared to 52% of students taking traditionally taught courses.
- 92% of SBL students said the SBL courses improved their comfort level in working with others, whereas only 48% of traditional students felt their courses improved their comfort level in working with others.
- 95% of SBL students felt that the course lectures benefited their learning compared to 53% of traditional students, even though the SBL model does not alter the lecture format!
- 98% of SBL students felt that lab activities (which are different in the SBL approach) benefited their learning compared to 83% of traditional course students reporting that lab activities were beneficial.
- By design, SBL exposes students to a multitude of problem solutions, and 65% of SBL students reported that it was easy for them to learn about the solutions of other students compared to 49% of students taking traditionally taught courses.

Key outcomes or Other achievements: The key outcomes of this project are:

1. It demonstrated the feasibility of modifying traditionally taught computing courses - a variety of courses at different undergraduate levels and offered by different types of institutions across the country - and modifying them to fit the SBL model of instruction.
2. Quantitative data analyses showed that, despite different instructors implementing the core features of SBL in their own ways and despite differences in course contents and levels, student characteristics, institutions, and geographic locations, in most cases students performed in SBL courses as well or better than traditional courses.
3. Furthermore, SBL succeeded in improving students’ critical thinking, peer
learning and sense of community-connectedness compared to traditional teaching.

4. SBL also succeeded in stemming a decline in students' task value, self-efficacy, and intrinsic goal orientation at significantly higher levels than traditional teaching.

5. These results are supported by results from qualitative data analyses. Students felt that their learning benefited from both lectures and SBL-specific activities such as being exposed to peer solutions in SBL courses, resulting in improved problem solving skills.

6. SBL also improved students' comfort level in working with others, and their motivation to take more computing courses and major in a computing-related discipline.

* What opportunities for training and professional development has the project provided?

This project helped train, and develop the data analytic skills of, one female student of education and two male graduate students of computing at Auburn University. This is in addition to the training and professional development opportunities reported by the collaborating institutions (University of Hawaii and Washington State University) in their final reports. It contributed to computing faculty development through training and engaging fifteen computing educators across the country in the SBL approach to computing education. Furthermore, approximately 750 undergraduate students majoring in a variety of computing related disciplines in seven states were exposed to the SBL instructional method.

* How have the results been disseminated to communities of interest?

Through a web portal, publishing scientific papers and making conference presentations as described in prior reports. Additional publications may be forthcoming in future.

Supporting Files

<table>
<thead>
<tr>
<th>Filename</th>
<th>Description</th>
<th>Uploaded By</th>
<th>Uploaded On</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF0939055_Qualitative_Data_Analysis_Summary.pdf</td>
<td>Table summarizes statistically significant results of analyzing qualitative data collected during this project.</td>
<td>N Narayanan</td>
<td>01/28/2015</td>
</tr>
</tbody>
</table>

Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers

Licenses

Other Conference Presentations / Papers


Other Products
Participants/Organizations

What individuals have worked on the project?

<table>
<thead>
<tr>
<th>Name</th>
<th>Most Senior Project Role</th>
<th>Nearest Person Month Worked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narayanan, N</td>
<td>PD/PI</td>
<td>2</td>
</tr>
<tr>
<td>Hendrix, Theron</td>
<td>Co PD/PI</td>
<td>1</td>
</tr>
<tr>
<td>Ross, Margaret</td>
<td>Co PD/PI</td>
<td>1</td>
</tr>
<tr>
<td>Fathema, Nafsaniath</td>
<td>Graduate Student (research assistant)</td>
<td>6</td>
</tr>
</tbody>
</table>

Full details of individuals who have worked on the project:

**N H Narayanan**
- **Email:** naraynh@auburn.edu
- **Most Senior Project Role:** PD/PI
- **Nearest Person Month Worked:** 2

**Contribution to the Project:** Lead PI responsible for project activities and coordination/communication with NSF. Assisted in project data analysis, writing reports and scientific publications.

**Funding Support:** No other funding support.

**International Collaboration:** No

**International Travel:** No

**Theron D Hendrix**
- **Email:** hendrtd@auburn.edu
- **Most Senior Project Role:** Co PD/PI
- **Nearest Person Month Worked:** 1

**Contribution to the Project:** Project Director responsible for oversight of project logistics and management. Provided technical support to faculty from participating institutions. Assisted in project data analysis. Helped write reports and scientific publications. Implemented SBL in a computing course. Organized and managed the logistics for annual faculty development workshops.

**Funding Support:** No other funding support.

**International Collaboration:** No

**International Travel:** No
Margaret E Ross
Email: rossma1@auburn.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Director of Evaluation for the overall project responsible for leading project data collection and analysis, and coordination/communication with NSF and SRI. Provided support to faculty from participating institutions on issues related to human subjects (IRB), data collection and analysis. Helped write reports and scientific publications. Presented data analysis results and helped participating faculty understand and interpret results during annual faculty development workshops.

Funding Support: No other funding support.

International Collaboration: No
International Travel: No

Nafsaniath Fathema
Email: nzf0003@auburn.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Research Assistant for project data analyses. Primary author on a research publication.

Funding Support: No other funding support.

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

<table>
<thead>
<tr>
<th>Name</th>
<th>Type of Partner Organization</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>California State University, San Bernardino</td>
<td>Academic Institution</td>
<td>San Bernardino, CA</td>
</tr>
<tr>
<td>Centre College</td>
<td>Academic Institution</td>
<td>Danville, KY</td>
</tr>
<tr>
<td>University of North Carolina at Asheville</td>
<td>Academic Institution</td>
<td>Asheveille, NC</td>
</tr>
<tr>
<td>University of South Alabama</td>
<td>Academic Institution</td>
<td>Mobile, AL</td>
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<tr>
<td>Washington State University</td>
<td>Academic Institution</td>
<td>Pullman, Washington</td>
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<tr>
<td>Florida Agricultural and Mechanical University</td>
<td>Academic Institution</td>
<td>Tallahassee, FL</td>
</tr>
<tr>
<td>Leeward Community College</td>
<td>Academic Institution</td>
<td>Pearl City, HI</td>
</tr>
<tr>
<td>Samford University</td>
<td>Academic Institution</td>
<td>Birmingham, AL</td>
</tr>
<tr>
<td>University of California, Santa Barbara</td>
<td>Academic Institution</td>
<td>Santa Barbara, CA</td>
</tr>
<tr>
<td>University of Hawaii at Hilo</td>
<td>Academic Institution</td>
<td>Hilo, HI</td>
</tr>
</tbody>
</table>
**Name** | **Type of Partner Organization** | **Location**
---|---|---
University of Hawaii at Manoa | Academic Institution | Honolulu, HI
University of Kentucky | Academic Institution | Lexington, KY
University of Mobile | Academic Institution | Mobile, AL

**Full details of organizations that have been involved as partners:**

**California State University, San Bernardino**

**Organization Type:** Academic Institution  
**Organization Location:** San Bernardino, CA

**Partner's Contribution to the Project:**  
Collaborative Research

**More Detail on Partner and Contribution:** Josephine Mendoza, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

**Centre College**

**Organization Type:** Academic Institution  
**Organization Location:** Danville, KY

**Partner's Contribution to the Project:**  
Collaborative Research

**More Detail on Partner and Contribution:** Joseph Oldham, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

**Florida Agricultural and Mechanical University**

**Organization Type:** Academic Institution  
**Organization Location:** Tallahassee, FL

**Partner's Contribution to the Project:**  
Collaborative Research

**More Detail on Partner and Contribution:** Christy Chatmon and Bobby Granville, two faculty members at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course. This partner institution is designated as a Minority-Serving Institution (HBCU).

**Leeward Community College**

**Organization Type:** Academic Institution  
**Organization Location:** Pearl City, HI

**Partner's Contribution to the Project:**
Collaborative Research

**More Detail on Partner and Contribution:** Blanca Polo, a faculty member at this partner institution, implemented the SBL approach in one or more on-line computing courses, and helped collect and report data from studio and traditional implementations of the same course. This partner institution is designated as a Minority-Serving Institution (API).

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**Samford University**

**Organization Type:** Academic Institution  
**Organization Location:** Birmingham, AL

**Partner's Contribution to the Project:** Collaborative Research

**More Detail on Partner and Contribution:** Gregory Kawell, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

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**University of California, Santa Barbara**

**Organization Type:** Academic Institution  
**Organization Location:** Santa Barbara, CA

**Partner's Contribution to the Project:** Collaborative Research

**More Detail on Partner and Contribution:** Phillip Conrad, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

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**University of Hawaii at Hilo**

**Organization Type:** Academic Institution  
**Organization Location:** Hilo, HI

**Partner's Contribution to the Project:** Collaborative Research

**More Detail on Partner and Contribution:** Keith Edwards and Barbara Meguro, two faculty members at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course. This partner institution is designated as a Minority-Serving Institution (API).

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**University of Hawaii at Manoa**

**Organization Type:** Academic Institution  
**Organization Location:** Honolulu, HI

**Partner's Contribution to the Project:** Collaborative Research

**More Detail on Partner and Contribution:** This was a collaborative research project in which similar research and
evaluation activities were carried out at this collaborating university (Martha Crosby, PI). Reports submitted by this institution contain details of its project activities. Here we mention only those activities that contributed to SBL implementations and data collection. Michael-Brian Ogawa, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course. Barbara Endicott–Popovsky, another faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course. This partner institution is designated as a Minority-Serving Institution (API).

University of Kentucky
Organization Type: Academic Institution
Organization Location: Lexington, KY
Partner's Contribution to the Project: Collaborative Research
More Detail on Partner and Contribution: Joseph Oldham, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

University of Mobile
Organization Type: Academic Institution
Organization Location: Mobile, AL
Partner's Contribution to the Project: Collaborative Research
More Detail on Partner and Contribution: Sharon Vest and Leo Denton, two faculty members at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

University of North Carolina at Asheville
Organization Type: Academic Institution
Organization Location: Asheville, NC
Partner's Contribution to the Project: Collaborative Research
More Detail on Partner and Contribution: Susan Reiser, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

University of South Alabama
Organization Type: Academic Institution
Organization Location: Mobile, AL
Partner's Contribution to the Project: Collaborative Research
More Detail on Partner and Contribution: Debra Chapman, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

Washington State University

Organization Type: Academic Institution
Organization Location: Pullman, Washington

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: This was a collaborative research project in which similar research and evaluation activities were carried out at this collaborating university (Christopher Hundhausen, PI). Reports submitted by this institution contain details of its project activities. Here we mention only those activities that contributed to SBL implementations and data collection. Christopher Hundhausen, a faculty member at this partner institution, implemented the SBL approach in one or more computing courses, and helped collect and report data from studio and traditional implementations of the same course.

What other collaborators or contacts have been involved?
NO

Impacts

What is the impact on the development of the principal discipline(s) of the project?
The principal discipline of the project is undergraduate computing education. We developed a model of instruction for making computing courses collaborative and engaging, implemented it at a national scale, and collected and analyzed a significant amount of quantitative and qualitative data. This project has thus contributed to expanding the base of knowledge on computing education through a systematic demonstration of the impact of a novel pedagogical method on student learning and attitudes.

What is the impact on other disciplines?
Nothing to report.

What is the impact on the development of human resources?
This project helped train, and develop the data analytic skills of, one female student of education and two male graduate students of computing at Auburn University. This is in addition to the training and professional development opportunities reported by the collaborating institutions (University of Hawaii and Washington State University) in their final reports. It contributed to computing faculty development through training and engaging fifteen computing educators across the country in the SBL approach to computing education. Furthermore, approximately 750 undergraduate students majoring in a variety of computing related disciplines in seven states were exposed to the SBL instructional method.

What is the impact on physical resources that form infrastructure?
Nothing to report.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?
Nothing to report.
What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?
Nothing to report.

**Changes/Problems**

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.
Table 1. Chi-Square and Percent Values of students responses

<table>
<thead>
<tr>
<th>Items</th>
<th>Traditional Learning</th>
<th>Studio Based Learning (SBL)</th>
<th>N</th>
<th>Chi Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning benefits of lectures</td>
<td>53.40%</td>
<td>46.60%</td>
<td>95.20%</td>
<td>4.80%</td>
</tr>
<tr>
<td>Learning benefits of SBL or any ground activities</td>
<td>36.60%</td>
<td>63.40%</td>
<td>83.90%</td>
<td>16.10%</td>
</tr>
<tr>
<td>Learning benefits of lab activity</td>
<td>83.10%</td>
<td>16.90%</td>
<td>98.40%</td>
<td>1.60%</td>
</tr>
<tr>
<td>Motivation to take more computing courses</td>
<td>57%</td>
<td>43%</td>
<td>87.20%</td>
<td>12.80%</td>
</tr>
<tr>
<td>Computing problem solving skill</td>
<td>52.30%</td>
<td>47.70%</td>
<td>67%</td>
<td>33.00%</td>
</tr>
<tr>
<td>Access to helpful peer feedback</td>
<td>74.70%</td>
<td>25.30%</td>
<td>82.60%</td>
<td>17.40%</td>
</tr>
<tr>
<td>Ease of learning about other students’ solutions</td>
<td>48.60%</td>
<td>51.40%</td>
<td>65.00%</td>
<td>35.00%</td>
</tr>
<tr>
<td>Reviewing other students’ work and providing feedback</td>
<td>22.70%</td>
<td>77.30%</td>
<td>74.50%</td>
<td>25.50%</td>
</tr>
<tr>
<td>Learning from reviewing others work and providing others feedback</td>
<td>63.60%</td>
<td>36.40%</td>
<td>76.80%</td>
<td>23.20%</td>
</tr>
<tr>
<td>Comfort level of working with others</td>
<td>48.40%</td>
<td>51.60%</td>
<td>92.10%</td>
<td>7.90%</td>
</tr>
<tr>
<td>Attitude toward majoring in computing</td>
<td>25.30%</td>
<td>74.70%</td>
<td>31.60%</td>
<td>68.40%</td>
</tr>
</tbody>
</table>