The Introduction of Informal Cooperative Learning into our Programming Laboratories

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INTRO

Our Mission

Redesign foundational courses by using research findings to create student-centered teaching and learning environments.

Our Goals

These faculty-led redesigns will foster student learning gains, student success, development of positive skills and attitudes, student well-being and institutional cultural change.

http://www.purdue.edu/impact/
Self-Determination Theory (SDT; Deci & Ryan, 1985; 2000)

- According to self-determination theory, self-determined motivation is motivation guiding behaviors that are valued and chosen volitionally (identification)
- Student-centered learning environments satisfy the needs for competence, autonomy (choice), and relatedness.
- Autonomy-supportive environments student motivation becomes more self-determined leading to improved learning outcomes.

FIND OUT MORE: http://www.purdue.edu/impact
Learning to Program can be Difficult

World-wide, only 2 in 3 students enrolled in CS1 are successful

- Bennedsen and Casper (2007)
- Watson and Li (2014)
Structured, informal cooperation during computer labs

“Informal cooperative learning consists of having students work together to achieve joint learning goals in temporary, ad-hoc groups that last from a few minutes to one class period.”

- Johnson et al. (2002, 2006)
The Experiment Was Done in CNIT155

- The change was incorporated in the laboratory portion of CNIT155 “Introduction to Software Development Concepts”.
- CNIT155 is the first programming course required for students pursuing a degree in CIT (Computer Information Technology) at Purdue Polytechnic.
- The course is structured as two 50 minutes lecture and one 110 minutes lab per week.
- Students normally take this course during their Freshman Year.
- There is no prerequisite for this class.
- Most of the students are first time programmers.
Learning Environment

- Most students (~70%) have little or no programming experience
- Avg. class (laboratory) size is 22 students
- Students work individually throughout the lab session.
- When in doubt, they raise their hand and ask the TA for assistance.
- The wait time to get help can be long.
The Collaborative Process

Students briefly work in pairs (i.e., collaborate) at strategic points during their lab session.
Hands On Activity

Let’s try this together …

› Sit in a group with few other participants.
› Work on the given problem individually (5 min.)
› Collaborate with the adjacent person to review, evaluate, discuss each other’s solutions (5 min.)
› Finally, share your solution with other people at the table.
Assume there are 9 identical balls.

One of the balls is heavier than the others.

There is a scale to weigh the balls.

What is the minimum number of times you have to use the scale to identify the heavier ball?
Discussion

› What do you think?
  • Did working together enhance your solution?
  • Did you enjoy working with others?
  • Did you feel more motivated?
Results

Learning Outcomes

Comparison Fall 2015 vs. Fall 2016
Comparison Spring 2016 vs. Spring 2017

Grades

Students self-perceptions

Comparison Pre vs. Post Fall 2016
Comparison Pre vs. Post Spring 2017
Results

Learning Outcomes

Grades

Comparison Fall 2015 vs. Fall 2016
Comparison Spring 2016 vs. Spring 2017

Students self-perceptions

Comparison Pre vs. Post Fall 2016
Comparison Pre vs. Post Spring 2017
## PROCEDURE – IDENTIFYING LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Description</th>
<th>Bloom’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO1</td>
<td>Be able to employ critical thinking and problem solving – Basics of OOP – GUI Objects</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>LO2</td>
<td>Be able to manipulate numeric and textual data (Variable &amp; Data Types, Input / output, arithmetic)</td>
<td>2 &amp; 3</td>
</tr>
<tr>
<td>LO3</td>
<td>Be able to interpret and employ different coding structures: Sequential, Selection, Repetition</td>
<td>3 &amp; 4</td>
</tr>
<tr>
<td>LO4</td>
<td>Be able to modularize the program to make it more manageable (Writing helper methods to do a task).</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>LO5</td>
<td>Be able to manipulate large amount of data in the program (1-D Arrays &amp; Files)</td>
<td>2, 3, 4, 5</td>
</tr>
</tbody>
</table>

### Bloom’s Taxonomy

1. Remembering – Ex: Naming standards
2. Understanding – Ex: What is a Textbox
3. Applying - Ex: Calculate something
4. Analyzing – Ex: What coding structure should be used to ....
5. Evaluating – Ex: Measure the efficiency of an algorithm
6. Creating – Ex: Develop an original software

Note: Despite mapping the LOs into Bloom’s levels we did not analyze gains in Bloom’s because of the overlapping between levels.
## PROCEDURE – MAPPING EXAM QUESTIONS INTO LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>No</th>
<th>Questions</th>
<th>L. Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The extension of the source file is --------.</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>If a program runs without generating any errors, but produces wrong results, it probably contains -----</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1. int.parse( ) is used to:</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1. Which data type provides the most decimal place precision?</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Which is the best data type to store the number of books</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>1. Which one is a comment in C#?</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Which of the following statements will clear the listBox?</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>In a C# Windows application, what happens if you delete</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>What value is stored in variable answer after executing the</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>What will be displayed if the user clicks on the button 5 times</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Which of the following IS a valid name for a variable?</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>What is the 3 letter prefix for naming a ComboBox?</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>What value will be stored in ans by the following statements?</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>What is stored in num by executing the following code?</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>Which statement will perform a real division? Assume:</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>Which property of the Radio Button indicates if it has been selected?</td>
<td>3</td>
</tr>
</tbody>
</table>

...
**FINAL EXAM – Fall 2015 vs. Fall 2016**

**Final Exam LOs**  
**Fall 2015 vs. Fall 2016**

- **LO1**: Be able to employ critical thinking and problem solving – Basics of OOP – GUI Objects
- **LO2**: Be able to manipulate numeric and textual data (Variable & Data Types, Input/Output, arithmetic)
- **LO3**: Be able to interpret and employ different coding structures (Sequential, Selection, Repetition) - Data Validation
- **LO4**: Be able to modularize the program to make it more manageable (Writing helper methods to do a task).
- **LO5**: Be able to manipulate large amount of data in the program (1-D Arrays & Files)

- **No significant gains between Fall 2015 and Fall 2016**
- **Numerical gains in all outcomes (except LO 3)**
Significant gains in the lab exam between Fall 2015 and Fall 2016

\[ t(93) = 2.703, p = 0.008, d = 0.56 \]
FINAL EXAM – Spring 2016 vs. Spring 2017

Learning Outcome | Description
--- | ---
LO1 | Be able to employ critical thinking and problem solving – Basics of OOP – GUI Objects
LO2 | Be able to manipulate numeric and textual data (Variable & Data Types, Input / Output, arithmetic)
LO3 | Be able to interpret and employ different coding structures (Sequential, Selection, Repetition) - Data Validation
LO4 | Be able to modularize the program to make it more manageable (Writing helper methods to do a task).
LO5 | Be able to manipulate large amount of data in the program (1-D Arrays & Files)

Numerical gains in all outcomes (except LO 4 and 5)

Significant gains in LO 1 between Spring 2017 and Spring 2017

LO 1: \( t(250) = 3.335, p = 0.001, d = 0.42 \)
LAB EXAM – Spring 2016 vs. Spring 2017

No gains in the lab exam between Spring 2016 and Spring 2017.
GRADE DISTRIBUTION – Fall 2015 vs. Fall 2016

FALL 2015

- A: 33%
- B: 40%
- C: 14%
- D: 7%
- F: 4.70%
- W: 8.70%

FALL 2016

- A: 44%
- B: 37%
- C: 17%
- D: 0%
- F: 2%
- W: 5%
GRADE DISTRIBUTION – Spring 2016 vs. Spring 2017

**SPRING 2016**

- 34% A
- 39% B
- 20% C
- 18.00% D
- 6% F
- 2% W

**SPRING 2017**

- 51% A
- 25% B
- 20% C
- 2% D
- 0.80% F
- 1.70% W

**GRADE DISTRIBUTION – Spring 2016 vs. Spring 2017**
SURVEYS – STUDENT PROGRAMMING SELF-EFFICACY & SELF-BELIEFS

Scott & Ghinea (2014) instrument adapted for use in the specific context of this course.

Responses were given in 5 point scales and higher values mean more desirable beliefs (some items were reversed to reflect this).
Survey Results
Pre vs. Post Fall 2016

- PSC: $t(49) = 3.074, p = 0.003, d = 0.44$
- Overall: $t(49) = 2.096, p = 0.041, d = 0.30$

Average Score

<table>
<thead>
<tr>
<th>Category</th>
<th>Pre</th>
<th>Post</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debugging Self-Efficacy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming Self-Concept</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming Interest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming Anxiety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming Aptitude Mindset</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Significant difference at $p < 0.01$.
I am confident that I can understand Visual C#.
I am confident I can solve simple problems with my...
I am confident I can write the code from a...
I am confident I can debug a program that calculates...
I am just not good at programming
I learn programming quickly
I have always believed that programming is one of...
In my programming labs, I can solve even the most...
I enjoy reading about programming
I do programming because I enjoy it
I am interested in the things I learn in programming...
I think programming is interesting
I often worry that it will be difficult for me to write...
I often get tense when I have to debug a program
I get nervous when trying to solve programming bugs
I feel helpless when trying to solve programming bugs
I have a fixed level of programming aptitude, and...
I can learn new things about software development,...
To be honest, I do not think I can really change my...
DSE: $t(99) = 6.604$, $p = 0.001$, $d = 0.66$

PSC: $t(99) = 5.262$, $p = 0.001$, $d = 0.53$

PANX: $t(99) = 4.195$, $p = 0.001$, $d = 0.42$

Overall: $t(99) = 5.726$, $p = 0.001$, $d = 0.57$
I am confident I can understand Visual C#.
I am confident I can solve simple problems with my...
I am confident I can write the code from a description...
I am confident I can debug a program that calculates...
I am just not good at programming
I learn programming quickly
I have always believed that programming is one of my...
In my programming labs, I can solve even the most...
I enjoy reading about programming
I do programming because I enjoy it
I am interested in the things I learn in programming...
I think programming is interesting
I often worry that it will be difficult for me to write the...
I often get tense when I have to debug a program
I get nervous when trying to solve programming bugs
I feel helpless when trying to solve programming bugs
I have a fixed level of programming aptitude, and not...
I can learn new things about software development,...
To be honest, I do not think I can really change my...
Focus Groups

everyone

assistance

confidence

lab
Focus Groups

Themes

▫ Forcing students to cooperate helped them meet their peers. It “gave them permission” to interact with their peers, something traditionally prohibited in their experience.

▫ Student confidence increased when they were able to help someone else

▫ Student confidence increased when they realized others were experiencing the same difficulties they were

▫ Seeking peer assistance was faster/easier than seeking instructor assistance

▫ By the end of the semester, students no longer followed the prescribed schedule. They sought assistance from their peers whenever they needed it.

▫ Students reported that it became natural to assist each other in their other classes. That is, the cooperative relationships they formed in this class transcended this class.
Results - Summary

- Students performance significantly improved in some LOs, although findings were inconsistent. Numerical gains were replicated though.
- Letter grades D, F, W decreased and As increased
- Importantly, students self-beliefs about programming improved
- Programming interest does not seem to have improved
- However, students report increased confidence after engaging in collaboration with their peers and overall enjoyed the lab format.
Based on our study, we observed that students benefit from informal collaboration. Some of the benefits are:

- Reduced anxiety
- Sense of community
- Higher self belief
- Sense of enjoyment while programming
- Less dependence on the teacher
Per NSF report, the number of women graduating from CS discipline decreased from 28% to 18% between 2002 and 2011.

- Would methods like ours improve women’s retention and success in Computing fields?

- What else can be done to increase women’s success in CS?
Researchers

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References


References


Gallery: Students working Individually
Gallery: Informal Cooperation
Gallery: Lab Instructor Assistance
I thought the labs were effective because we could collaborate with our peers but still had to individually submit the program. This means that we still had to learn and understand what we were doing and not just let our peers code for us.
I’ve had a very good experience in this class. Seeing this is my first programming class, I can say I’ve learned a lot and it is a great first step in my programming career.
FIRST TIME CODER

CHALLENGING COURSE.

DOABLE WITH LOTS OF EFFORT

WITHOUT FRIENDS WOULD HAVE BEEN

MUCH WORSE

LOST FOCUS TOWARD THE END
The course was good. The in-class labs were very helpful in understanding the material better and helped in completing the assignments.