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Facilitating Collaborative Learning in Online Engineering Student Teams

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Effective teamwork and collaboration is critical in systems engineering

- So,
  - Academic programs frequently use team projects.
  - Engineering Development programs are frequently team focused.
- But, students often resent working in teams[1].
  - Frustrated with little influence and no control over their team-mates;
  - Belief that their grade will not reflect their contribution or competence;
  - That the transaction cost of scheduling meetings, and working collaboratively are not worth the rewards, of which they see few.
- This raises several important questions:
  - Do students learn how to effectively function as a team simply by working on team projects?
  - Should students be given classes, training, or guidance on how to be a team player?
  - Does the act of working in a team benefit or hinder a student's learning of course content?

In short, do engineers working in teams become more proficient engineers AS WELL AS better team members?

There is little consensus on the efficacy of student teams

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- On the one hand:
  - Students benefit from working in teams through social construction[2, 3] .
  - Through peer interaction and collaboration student's are able to synthesize and evaluate their ideas collectively[4].
- But:
  - Bad team experiences can sour students on teamwork far beyond their education studies and in to the workplace[5].
  - The tendency for student teams to work cooperatively rather than collaboratively can severely impact learning[6].
  - Without intentional interventions, individual learning does not improve in effective teams[7].

Effective teams need guidance

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- Cooperative teamworking (where the total work is divided across the teams) is often the default strategy.
  - It assumes that the correctness of a subsystem is intrinsic – it isn't!
  - Role specialization means that each individual experiences only a portion of the development process or the developed system.
  - Might be the preferred approach of those drawn to the engineering disciplines[8].
- Collaborative teamworking (where the team works together on a single shared goal) requires more time and effort.
  - Team members experience all aspects of the development process and the system.
  - Coordination and governance are more demanding
  - Social construction aids student learning.

Collaborative learning needs guidance too!

- We realized that encouraging students to work together on the project did not translate into collaborative learning of course content. We hit the literature for ideas.
- Peer-tutoring met our needs - considered advantageous not only to the tutee, but also to the tutor, a form of learning through teaching[9].
- There are many variations of peer-tutoring, however[10]:

Peer tutoring Style	Description
Cross-year small-group tutoring	Upper year undergrads tutoring lower year undergrads.
The Personalized System of Instruction	Instructor creates learning material; student progresses at their own pace; tutor checks work, tests student, records progress.
Supplemental Instruction	One cross age 'leader' working with several tutees. Used for courses with difficult material and minimal student interaction.
Same-year dyadic fixed-role tutoring	Tutoring between pairs in the same point in the course. One person retains role of tutor throughout.
Same-year dyadic reciprocal peer tutoring	Tutoring between pairs in the same point in the course. Tutor role is reciprocated between pairs.
Dyadic cross-year fixed-role peer tutoring	Tutor has a higher academic status than tutee.
Same-year group tutoring	Rotating presentations by individual students to the peer group.
Peer assisted writing	Using paid, trained, student tutors in a writing center.
Peer assisted distance learning	Variations from one study: 1. students met in peer support groups, 2. Students had peer support groups and were provided distance learning on study skills, 3. Utilized the first two variants and also included a mentor (previous graduate).

Peer tutoring Design

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- We adopted a peer tutoring approach grounded in the "*same year group tutoring*" and "*peer assisted distance learning*" formats.
- Each week a different student took the role of *Keystone*.
- Keystones were provided instructions on their role, the benefits and activities, as well as technical notes to scaffold discussion.
- Extrinsic motivation was provided by making the tutoring a small portion of the grade (5%) assessed by the instructor based upon the quality and quantity of peer discussion and interaction.

Hypotheses

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- The goal of this research was to investigate the full extent of the efficacy of the collaboration model in improving the outcomes of teams and individuals.
- In previous publications we have shown support of the following 3 hypotheses:
  - *H1. Use of the model by team members will improve the project outcomes for that team[11].*
  - *H2. Use of the model will facilitate the forming of a team mental model[11].*
  - *H3. Use of the model will facilitate team learning[7].*
- But despite these improved team outcomes, previous experiments could not confirm:
  - *H4: An individual's learning is improved when working on an effective team[7].*
- In this study we refined and enhanced the collaboration model to include online mediated peer-tutoring to test the following hypothesis:
  - *H5: An individual on a team using the OMCM, including participating in online peer-tutoring, will experience improved academic achievement.*

Our experiment

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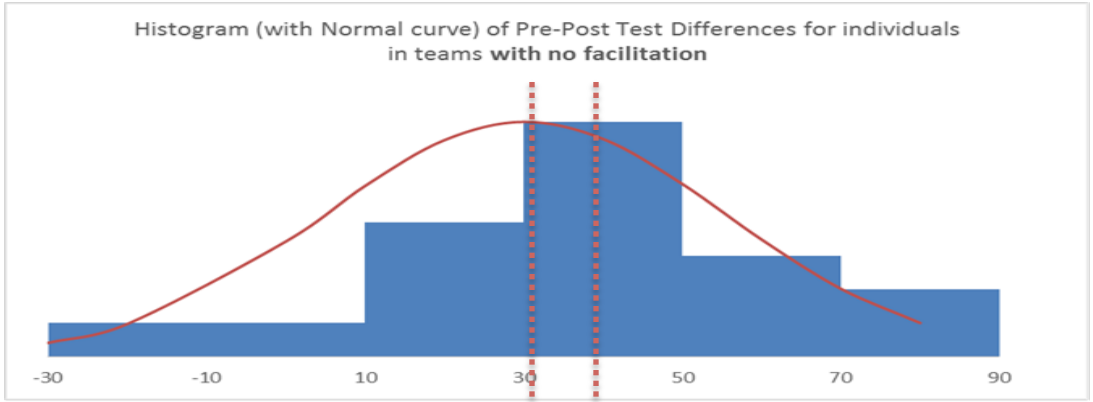
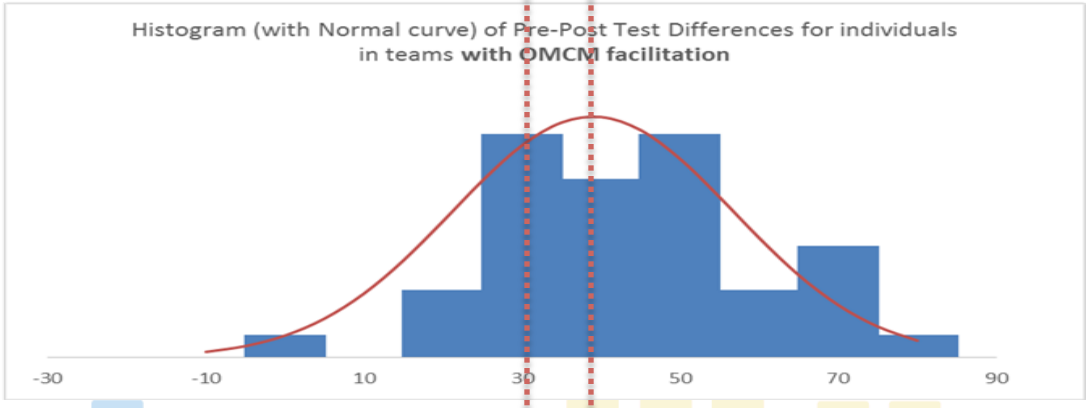
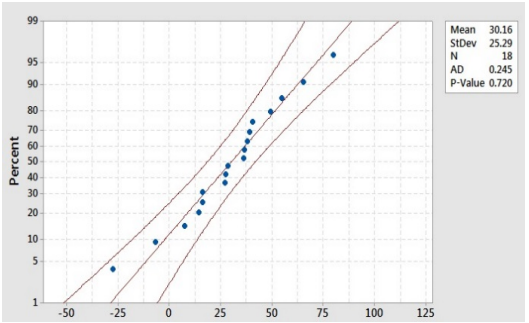
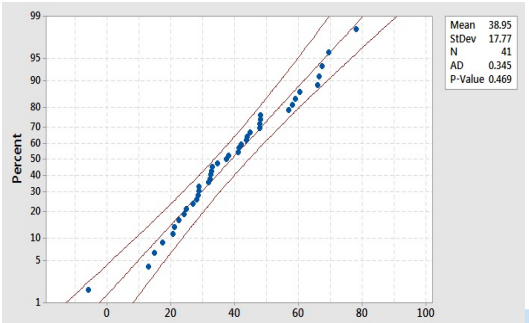
- Subjects were graduate engineering students working in teams of 4 and 5.
- This experiment was conducted using three sections of an online graduate course covering the principles of analysis, design, and architecture and their representation using standard modeling languages.
- One section was the control group (n=18) and the other two sections (n=41) were the treatment group following the guidance framework and engaged in peer-tutoring.
- Pre- and post-testing employed to determine the degree of individual learning using identical assessments.
  - Pre-test – benchmark test designed to assess prior knowledge of course content
  - Post-test – course exam designed to assess course learning objectives

Results


Histogram (with Normal curve) of Pre-Post Test Differences for individuals in teams with no facilitation
-30
-10
10
30
50
70
90


Histogram (with Normal curve) of Pre-Post Test Differences for individuals in teams with OMCM facilitation
-30
-10
10
30
50
70
90


Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
-50
-25
0
25
50
75
100
125
Mean 30.16
StDev 25.29
N 18
AD 0.245
P-Value 0.720


Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0
20
40
60
80
100
Mean 38.95
StDev 17.77
N 41
AD 0.345
P-Value 0.469

Significance testing

- We next performed an F-test of the two samples to determine if their variances were equal:

F-Test Two-Sample for Variances		
	Control	Experiment
Mean	30.16	38.95
Variance	639.52	315.64
Observations	18	41
df	17	40
F	2.026088	
P(F<=f) one-tail	**0.033537**	
F Critical one-tail	1.8851112	

- The test revealed that they are not equal so we employed a one-tail two-sample t-Test assuming unequal variances:
- The test reveals that there was a modest (p=0.97) significant improvement: 8.8 point increase on average.

t-Test: Two-Sample Assuming Unequal Variances		
	Control	Experiment
Hypothesized Mean Difference	0	
df	25	
t Stat	-1.336251	
P(T<=t) one-tail	**0.0967518**	
t Critical one-tail	1.7081408	

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Implications

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- Team projects and team assessment are frequently used in engineering programs, but do they:
  A. Facilitate learning at the individual level?
  B. Accurately discriminate the understanding and knowledge of the individual?
- Team-based approaches to personnel development programs also often confound team learning and team outcomes with individual improvement.
- But with simple interventions, including some that incent peer tutoring, both team and individual achievement can be improved.

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