A Study of Learning Effectiveness on the Dijkstra's Algorithm and 0/1 Knapsack Problem Modeled in an Interactive KLA Approach

Extended Material

APPENDIX A

IRB APPROVAL

State of California

Memorandum

California State Polytechnic University, Pomona

Office of Research Compliance

Date: 07-Feb-2016

To: Danny Luong , MS
, Computer Science Graduate Program

From: Dr. Jeffery S. Mio

Chair, IRB (Human Subjects Protection Committee)

cc: IRB file
Gilbert Young, PhD, Peter Chen, BS, Matthew Lai, BS

Subject: Protocol number 15-0075

Your request to amend protocol entitled "A Study of the Effectiveness of Alternative Teaching Methods for Computer Science, 14-0004 renewal 2015" has been reviewed by the Cal Poly Pomona Institutional Review Board (IRB) by the **Expedited** process. It was found to be in compliance with applicable federal and state regulations and Cal Poly Pomona policies regarding the protection of human subjects used in research. Thus, the Cal Poly Pomona IRB grants you approval to conduct the research. On its behalf, I thank you for your adherence to established policies meant to ensure the safety and privacy of your study participants. You may wish to keep a copy of this memo with you while conducting your research project.

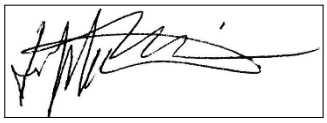
You may initiate the project as of 07-Feb-2016 and it must be completed by 06-Feb-2017. Federal regulations limit the IRB approval of studies for up to one year. If you find the need to renew your protocol, please remember to submit a request to the IRB at least a couple of weeks before this end date to ensure continuous human subjects' protection and IRB approval. It would be appreciated that you advise the IRB upon the completion of your project involving the interaction with human subjects.

Applicable notes: renewal done 1/14/15

Approval is conditional upon your willingness to carry out your responsibilities as the principal investigator under University policy. Your research project must be conducted according to the methods described in the final approved protocol. Should there be any changes to your research plan as described, please advise the IRB, because you may be required to submit an amendment. Additionally, should you as the investigator or any of your subjects experience any "problems which involve an undescribed element of risk" (adverse events in regulatory terms), please immediately inform the IRB of the circumstances.

If you need further assistance, you are encouraged to contact the IRB administrator, Bruce W. Kennedy MS RLATG CMAR CPIA at 909-869-4215.

The committee wishes you success in your research endeavors.



Jeffery S. Mio PhD

Professor, Psychology

College of Letters, Arts, and Social Sciences

APPENDIX B

CONSENT FORM

California State Polytechnic University, Pomona

Informed Consent Form for Research Involving Human Subjects

You are being invited to participate in a research study, which the Cal Poly Pomona Institutional Review Board (IRB) has reviewed and approved for conduct by the investigators named here. This form is designed to provide you - as a human subject - with information about this study. The Investigator or his/her representative will describe this study to you and answer any of your questions. You are entitled to an Experimental Research Subject's Bill of Rights and a copy of this form. If you have any questions about your rights as a subject, complaints about the informed consent process of this research study, or experience an adverse event (something goes wrong), please contact the Compliance Office within Cal Poly Pomona's Office of Research at (909) 869-4215. More information is available at the IRB website, www.cpp.edu/research/irb.

Consent to Participate in an Educational Research Subject Project

Introduction

This research study, "A study of the Effectiveness of Alternative Teaching Methods for Computer Science" (IRB protocol# 15-0075), is being conducted by Danny Luong, Peter Chen, and Dr. Gilbert Young at California State Polytechnic University, Pomona. The purpose of this research is to study the effectiveness of alternative teaching methods such as kinesthetic learning activities (KLAs) in comparison to the traditional lecture methodology in teaching computer science courses at college level.

Procedures

This quarter, Winter **2016**, you will participate in kinesthetic activities regarding computer science concepts and/or algorithms that are part of the course curriculum. If you are enrolled in CS331 Design and Analysis of Algorithms, you will take part in the "Dijkstra's Algorithm" and "Knapsack" activities and will be asked to stand beside your classmates and find the shortest paths from one node to all other nodes and to discover the maximum profit that a bucket can hold. A pretest will be given prior to the day the topics will be covered for Dr. Young's CS331 class. Furthermore, a post-test will be given after the kinesthetic activities have been conducted to study the effectiveness of the alternative teaching methodology. The tests will be anonymous. Students from these classes will then be asked to complete a short survey that will take 10-15 minutes. Surveys will be available

at the end of the last kinesthetic activities for the quarter. Some questions will ask about your personal views and feelings about learning by different teaching methods compared to the traditional lecture methodology. The survey will be handed out in class and will be anonymous. All data will be destroyed once research is completed.

Benefits

The benefit of this study may result in improved teaching methods being used by faculty; hopefully not just in the computer science department This study seeks to understand whether and how the use of kinesthetic activities increase learning and understanding.

Risks/Discomforts

There are minimal risks for participation in this study. This project will be studying the effectiveness of alternative teaching methods such as kinesthetic learning. You will be asked to provide some information about how effective the activities were in helping with your learning. As a result, the self-reflection might cause slight discomfort.

Confidentiality

All information you provide will remain anonymous and will only be reported as group data with no identifying information. All data, including questionnaires will be kept in a secure location and only those directly involved with the research will have access to them. After the research is completed, the tests and surveys will be destroyed.

Compensation

There is no compensation for those who volunteer. Furthermore, no penalty will be given to those who do not wish to participate in the research.

Participation

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely without jeopardy to your class status, grade or standing with the professor, department, or college.

Questions about the Research

If you have questions regarding this study, you may contact

Danny Luong, dannyluong@cpp.edu,

Peter Chen, peterpchen@cpp.edu, or

Dr. Young, gsyoung@cpp.edu,

I have read, understood, and received a copy of the above consent and desire of my own free will and volition to participate in this study.

Signature: _____ Date: _____

Participant Name: _____

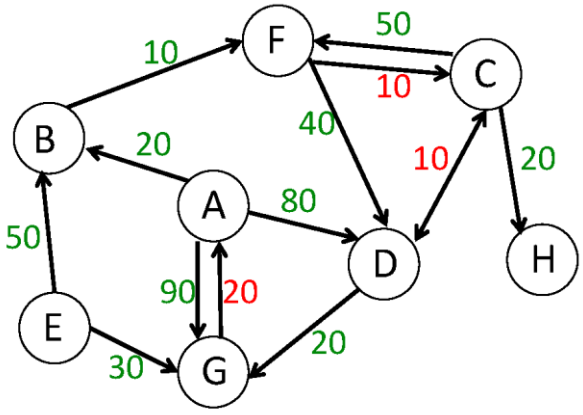
APPENDIX C

PRE/POST-TEST FOR DIJKSTRA'S ALGORITHM

Pre/Post-test for the project of
"A Study of the Effectiveness of Alternative Teaching Methods for Computer Science"
Co-PI: Peter Chen (peterpchen@cpp.edu)
Dr. G. Young (gsyoung@cpp.edu)

Date: _____

1.



a. Using Dijkstra's Algorithm, fill in the table below

Iteration	Distance of found shortest path	Found shortest path
1	0	A → A
2		
3		
4		

b. Which nodes are candidates for being the ending node of the shortest path to be explored for the 4th iteration?

2. Describe in your own words what occurs during each iteration of Dijkstra's Algorithm

APPENDIX D

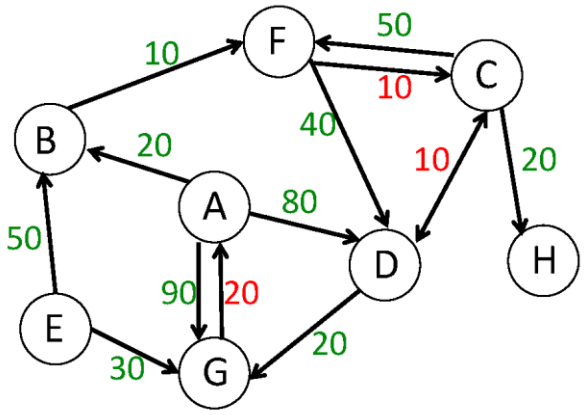
SOLUTIONS TO PRE/POST-TEST for DIJKSTRA'S ALGORITHM

Pre/Post-test for the project of
"A Study of the Effectiveness of Alternative Teaching Methods for Computer Science"

Co-PI: Peter Chen (peterpchen@cpp.edu)
Dr. G. Young (gsyoung@cpp.edu)

Date: _____

1.



a. Using Dijkstra's Algorithm, fill in the table below

Iteration	Distance of found shortest path	Found shortest path
1	0	A → A
2	**20**	**A → B**
3	**30**	**A → B → F**
4	**40**	**A → B → F → C**

b. Which nodes are candidates for being the ending node of the shortest path to be explored for the 4th iteration?

C,D,G

2. Describe in your own words what occurs during each iteration of Dijkstra's Algorithm

At each iteration, a set of nodes are considered for exploring. The node that gets selected is the one which has the shortest path from the initial node to that node. Once a node is explored, it does not get consideration for exploration again.

APPENDIX E

PRE/POST-TEST FOR KNAPSACK

Pre-Test for the project of
"A Study of the Effectiveness of Alternative Teaching Methods for Computer Science"
Co-PI: Peter Chen (peterpchen@cpp.edu)
Dr. G. Young (Computer Science, ext. 4413)

The problem:

Given *n* objects $O_1, O_2, \ldots, O_n$, with $p_1, p_2, \ldots, p_n$ profit,

knapsack of capacity *M*, $w_1, w_2, \ldots, w_n$, weight

Goal: find $x_1, x_2, \ldots, x_n$

s.t. $\sum_{i=1}^{n} p_i x_i$ is maximized subject to $\sum_{i=1}^{n} w_i x_i \leq M$, where $x_i = 0$ or 1.

(1) Number of objects = 3

M (maximum capacity of Knapsack) = 5

Object	Profit	Weight
1	10	4
2	5	3
3	7	2

Fill out the table below.

	capacity j					
i	0	1	2	3	4	5
0						

1

2

3

What is the maximum profit that the Knapsack can hold?

Which objects were selected?

(2) How to compute $f_i(j)$?

$f_i(j)$ = max {

(3) What is the order of complexity of this algorithm?

APPENDIX F

SOLUTIONS TO PRE/POST-TEST FOR KNAPSACK

Solution of

Pre-Test for the project of
"A Study of the Effectiveness of Alternative Teaching Methods for Computer Science"

Co-PI: Peter Chen (peterpchen@cpp.edu)
Dr. G. Young (Computer Science, ext. 4413)

The problem:

Given n objects $O_1, O_2, \ldots, O_n$, with $p_1, p_2, \ldots, p_n$ profit,

knapsack of capacity M, $w_1, w_2, \ldots, w_n$, weight

Goal: find $x_1, x_2, \ldots, x_n$

s.t. $\sum_{i=1}^{n} p_i x_i$ is maximized subject to $\sum_{i=1}^{n} w_i x_i \leq M$, where $x_i = 0$ or 1.

(1) Number of objects = 3

M (maximum capacity of Knapsack) = 5

Object	Profit	Weight
1	10	4
2	5	3
3	7	2

Fill out the table below.

	capacity j					
i	0	1	2	3	4	5
0	0	0	0	0	0	0

1	0	0	0	0	10	10
2	0	0	0	5	10	10
3	0	0	7	7	10	12

What is the maximum profit that the Knapsack can hold? 12

Which objects were selected? Objects 2, 3

(2) How to compute $f_i(j)$?

$f_i(j)$ = max { $f_i(j)$, $p_i + f_{i-1}(j-w_i)$

(3) What is the order of complexity of this algorithm?

O (nM)

APPENDIX G

STUDENT SURVEY

Survey for the thesis project of
"A Study of the Effectiveness of Alternative Teaching Methods for Computer Science"
PI: Danny Luong (dannyluong@cpp.edu)
Co-PI: Peter Chen (peterpchen@cpp.edu)
Co-PI: Matthew Lai (mlai@cpp.edu)
Dr. G. Young (Computer Science, ext. 4413)

Date: _____

(1) I learn best through (circle one or more which applies):

Visual Auditory Tactile/Kinesthetic I don't know

Briefly explain: _____
_____

(2) My overall evaluation of the kinesthetic learning activity (KLA) is: (circle one)

Excellent Good Fair Poor

Briefly explain: _____
_____

(3) Circle one for the following items:

		Strongly Agree				Strongly Disagree
(a)	I enjoyed the KLA experience.	1	2	3	4	5
(b)	The kinesthetic activities were easy to understand.	1	2	3	4	5
(c)	The kinesthetic activities were easy to follow.	1	2	3	4	5
(d)	KLA is effective in helping me learn concepts.	1	2	3	4	5
(e)	KLA helped me to be more engaged in the learning process.	1	2	3	4	5
(f)	I would recommend KLA as an alternative way of teaching.	1	2	3	4	5

(4) How would you rate the effectiveness of learning via KLA vs. lecture? _____
_____
_____
_____

(5) What did you like **<u>best/least</u>** about the kinesthetic learning approach?

_____

_____

_____

(6) Did class pass by quicker during a KLA class vs a traditional lecture?

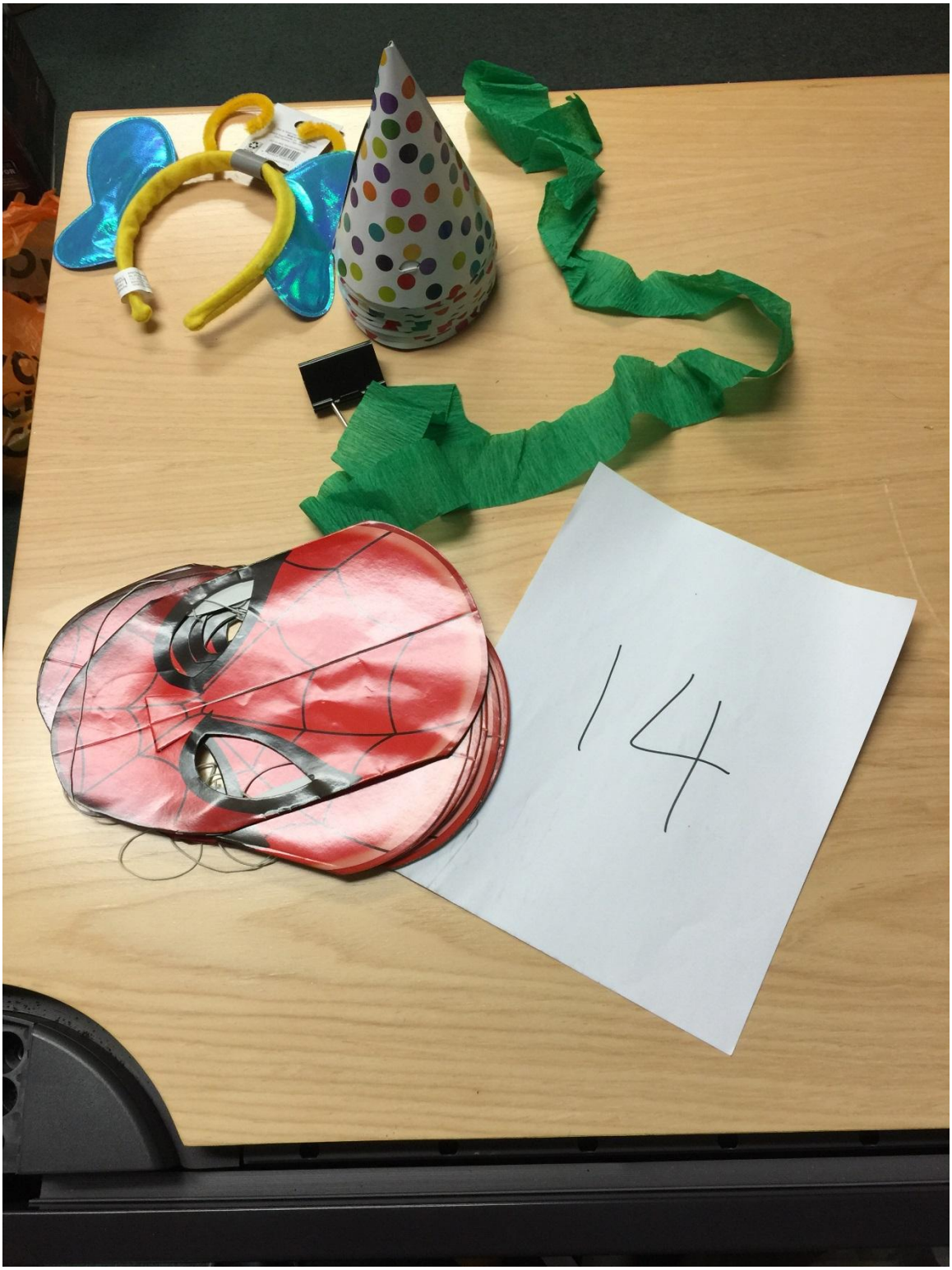
_____

_____

_____

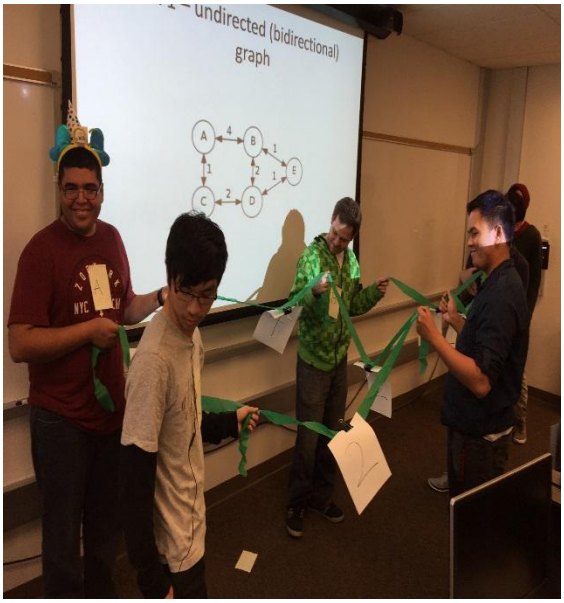
APPENDIX H

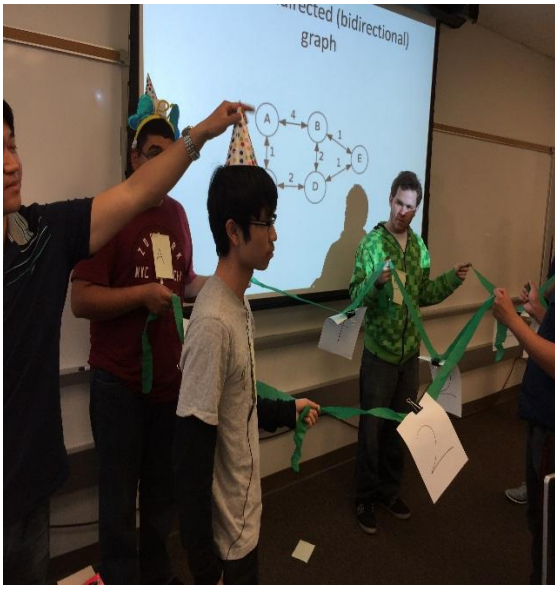
DIJKSTRA'S KLA PROPS

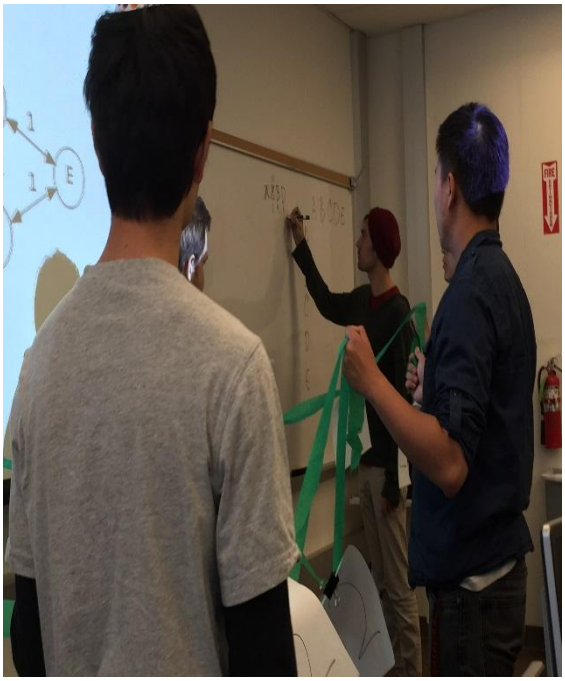


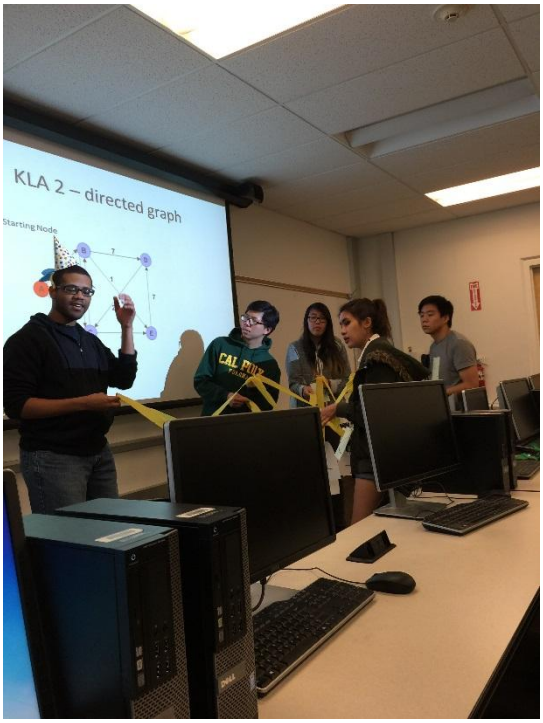
APPENDIX I

DIJKSTRA'S KLA IN ACTION



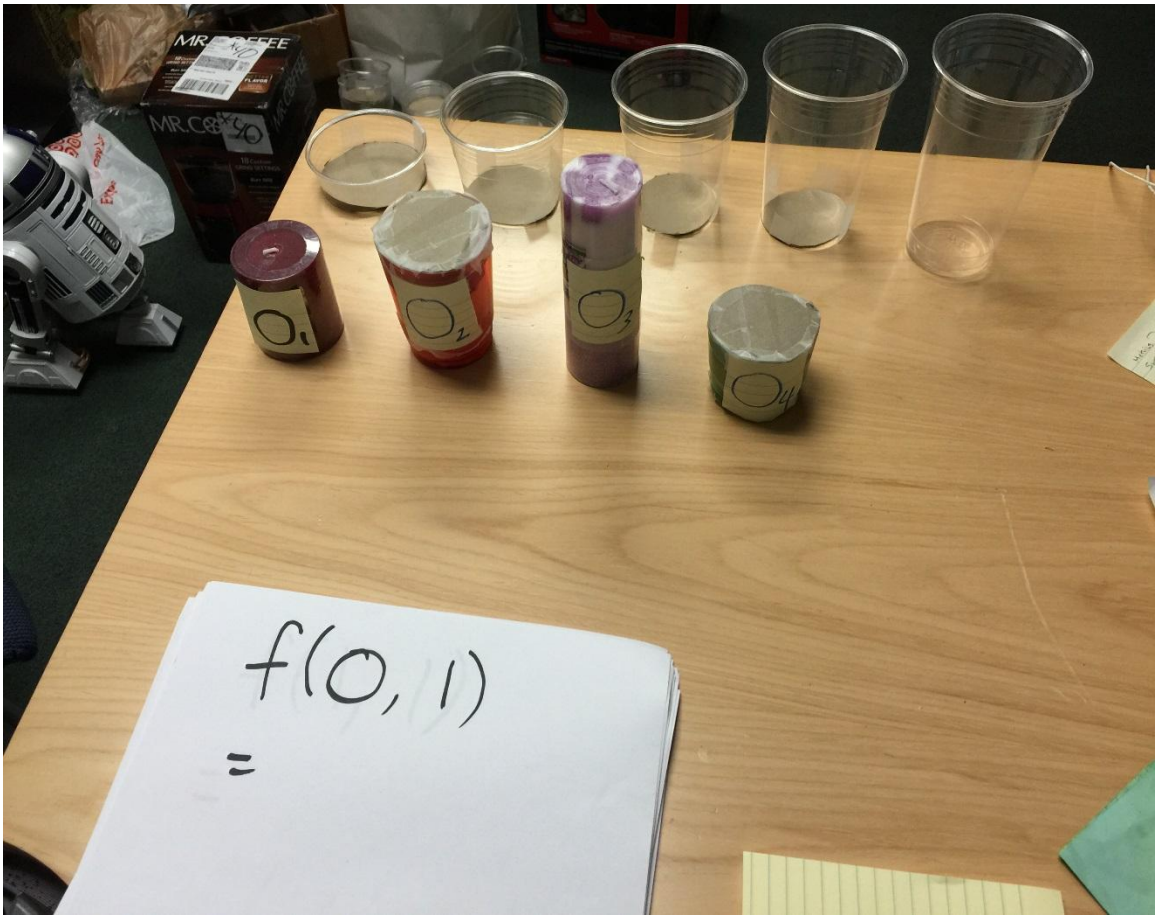






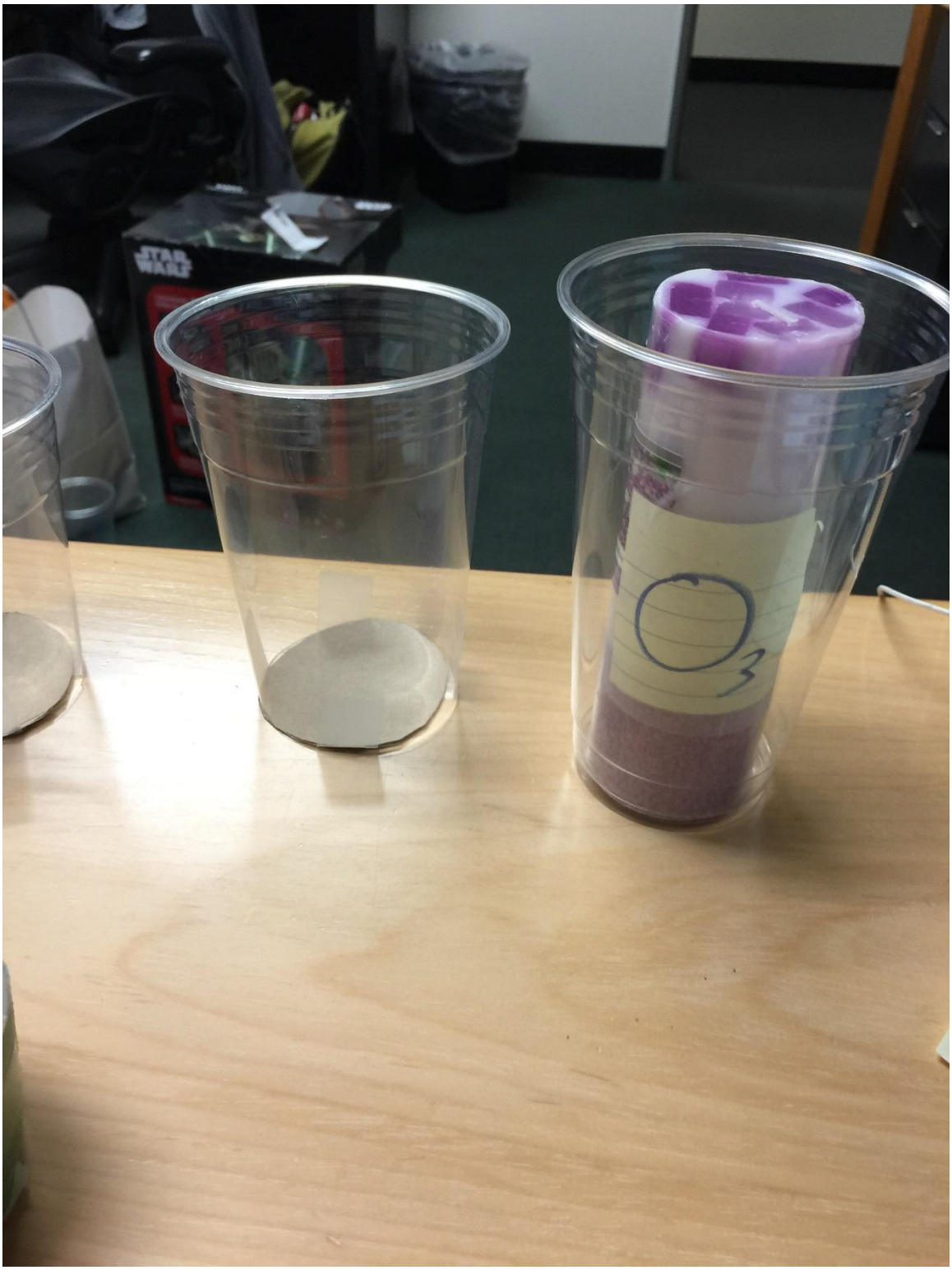
APPENDIX J

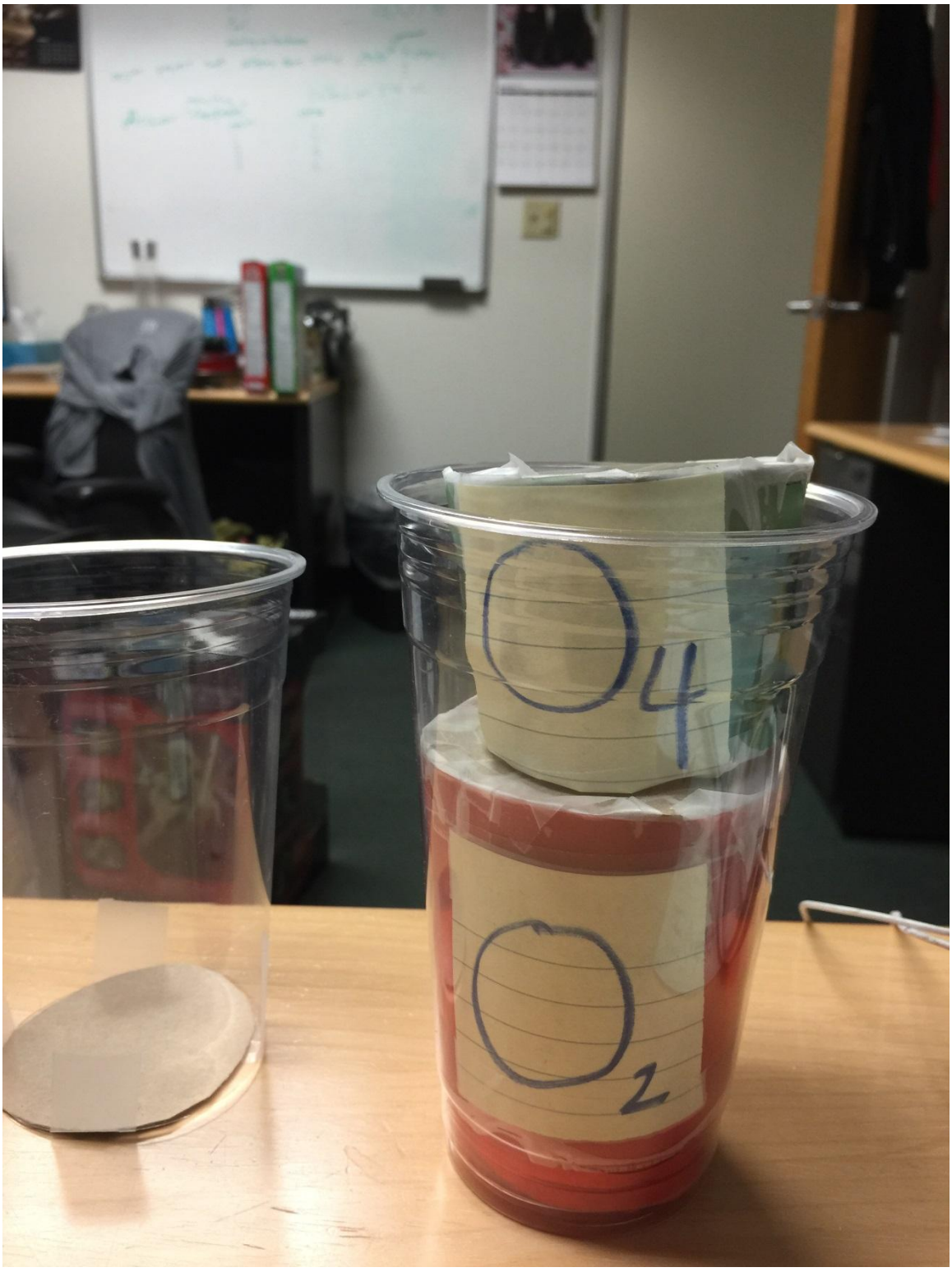
0/1 KNAPSACK KLA PROPS




O_1
O_2
O_3
O_4

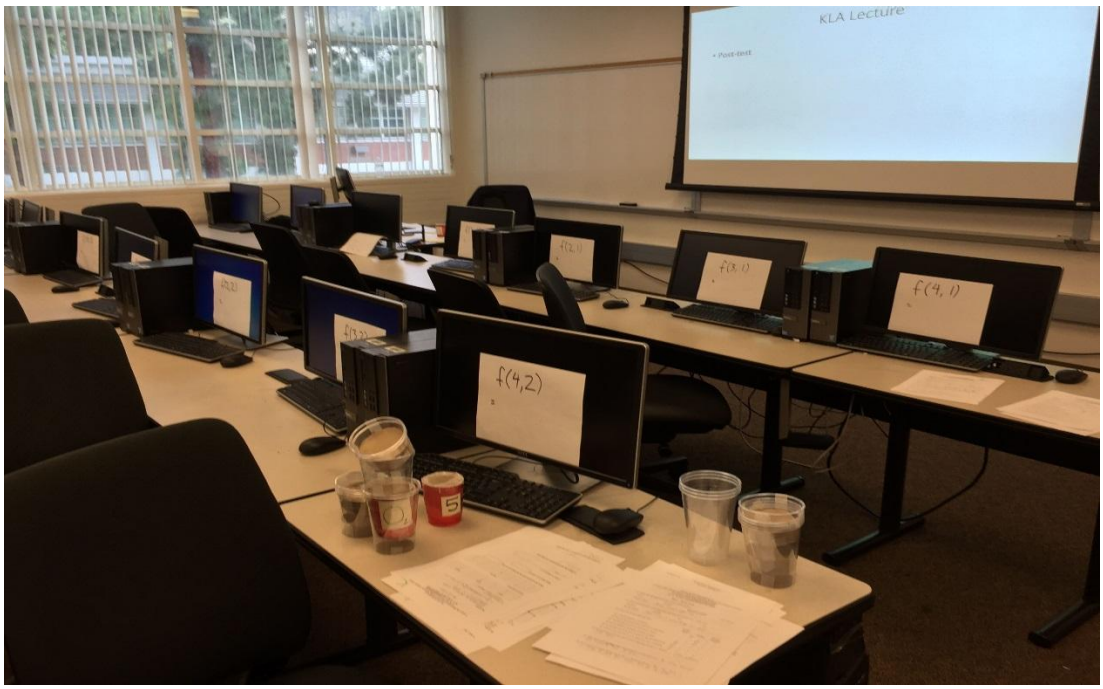

ACCO
SIX
6
2
5
4


STAR WARS
O3


O_4
O_2

APPENDIX K

0/1 KNAPSACK KLA CLASSROOM SETUP



APPENDIX L
FULL PRE/POST TEST RESULTS

Dijkstra's (Appendix D)

- 1a – 2 points per blank, for a total of 12 points
- 1b – 1 point per each correctly listed node, for a total of 3 points
- 2 – a total of 5 points, the responses must mention: which nodes are considered for exploring, how the candidate node is selected, the node with the next shortest path is selected, and that nodes are not considered again after they are explored
- Total possible score of 20 points

0/1 Knapsack (Appendix F)

- 1a – 1 point per each blank, for a total of 24 points
- 1b – 2 points if the answer is correct and they have the correct corresponding value from part 1a
- 1c – 4 points if they have the correct answer and correct corresponding value from part 1a.
- 2 – 2 points if each half of the equation is correct for a total of 4 points
- 3 – 2 points if they have both variables of the Big-O notation.
- Total possible score of 36 points.

Table 3 Dijkstra's Traditional Lecture Pre/Post-test Results

Pre-test	Post-test
7	11

	18	16
	18	14
	4	17
	18	8
	13	10
	14	11
	9	9
	13	10
	13	19
	12	11
	11	18
	15	8
	10	17
	1	16
	12	16
	5	18
Total Students	17	17
Mean	11.35 (56.75%)	13.47 (67.35%)
Median	12 (60.00%)	14 (70.00%)
Max	18 (90.00%)	19 (95.00%)
Min	1 (5.00%)	8 (40.00%)
Out of	20	20
Difference of medians		2.12

Table 4 Dijkstra's KLA Lecture Pre/Post-test Results

	Pre-test	Post-test
	12	14
	8	0
	10	10
	6	17
	11	11
	13	13
	14	14
	5	17
	15	9
	6	14
	2	11
	5	18
	8	16
	5	15
	0	13
Total Students	15	15
Mean	8 (40.00%)	12.8 (64.00%)
Median	8 (40.00%)	14 (70.00%)
Max	15 (75.00%)	18 (90.00%)
Min	0 (0.00%)	0 (0.00%)
Out of	20	20
Difference of Medians	4.80	

Table 5 Knapsack Traditional Lecture Pre/Post-test Results

	Pre-test	Post-test
	0	25
	0	34
	3	30
	30	34
	0	15
	11	10
	3	33
	9	33
	10	30
	0	27
	11	34
	5	30
	11	23
Total Students	13	13
Mean	7.15 (19.86%)	27.54 (76.50%)
Median	5 (13.89%)	30 (83.33%)
Max	30 (83.33%)	34 (94.44%)
Min	0 (0.00%)	10 (27.78%)
Out of	36	36
Diff between	20.38	

Table 6 KLA Lecture Pre/Post-test Results

	Pre-test	Post-test
	0	32
	0	26
	18	27
	3	23
	0	30
	17	30
	14	22
	3	24
	3	30
	3	32
	0	30
	3	30
	15	33
	3	30
	0	32
	30	-*
Total Students	16	15
Mean	7 (19.44%)	28.73 (79.81%)
Median	3 (8.33%)	30 (83.33%)
Max	30 (83.33%)	33 (91.67%)
Min	0 (0.00%)	22 (83.11%)
Out of	36	36
Diff mean	21.73	

* *one student left class prior to post-test*

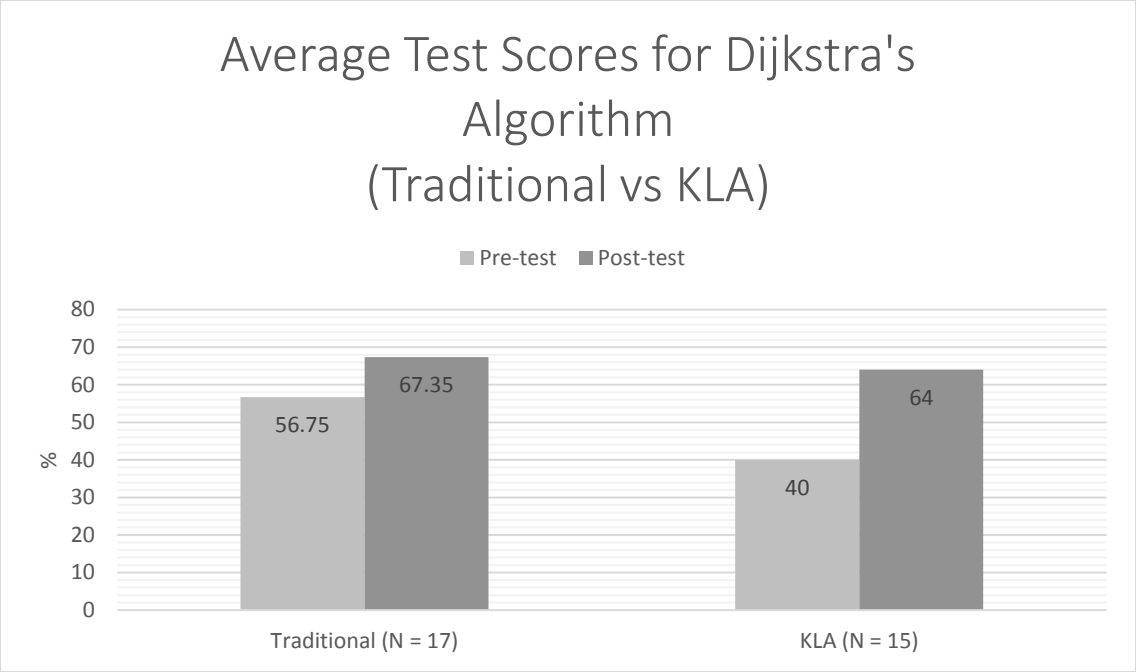


Figure 3 Average Test Scores for Dijkstra's Algorithm

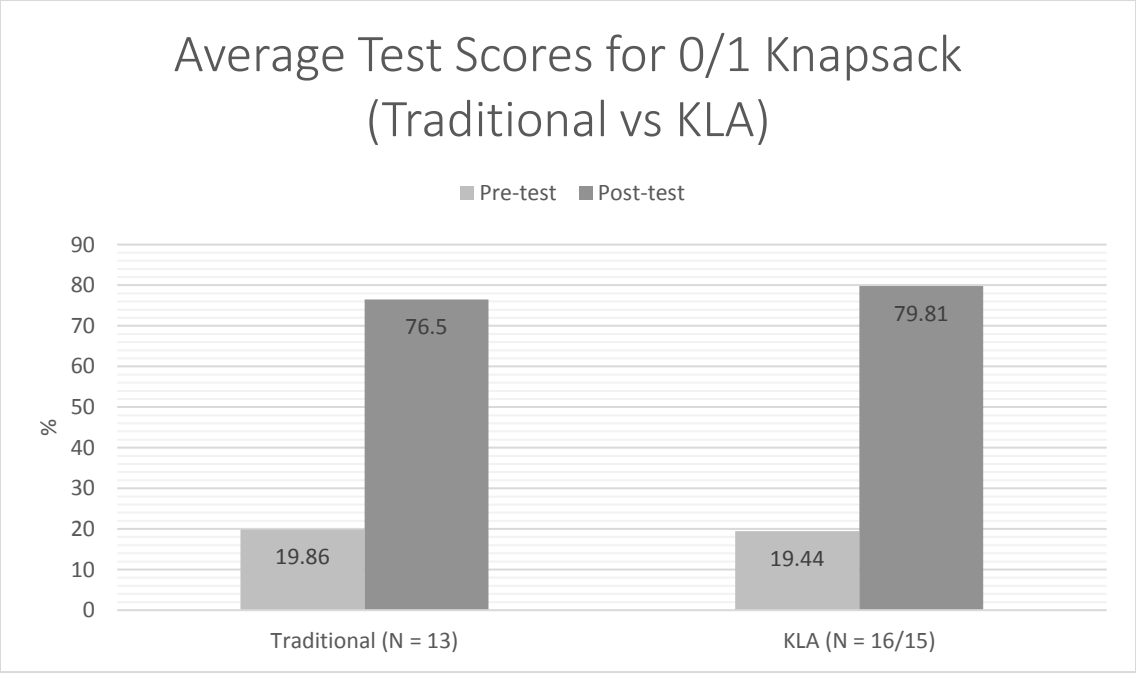


Figure 4 Average Test Scores for 0/1 Knapsack

Table 7 Average Test Scores and Learning Gains of Dijkstra's Algorithm

Teaching Method	*Traditional*	*KLA*
A: Avg Pre-test %	56.75	40.0
B: Avg Post-test %	67.35	64.0
B – A: Score Improvement (learning gains)	10.6	24.0

Table 8 Average Test Scores and Learning Gains of 0/1 Knapsack

Teaching Method	*Traditional*	*KLA*
A: Avg Pre-test %	19.86	19.44
B: Avg Post-test %	76.50	79.81
B – A: Score Improvement (learning gains)	56.64	60.37

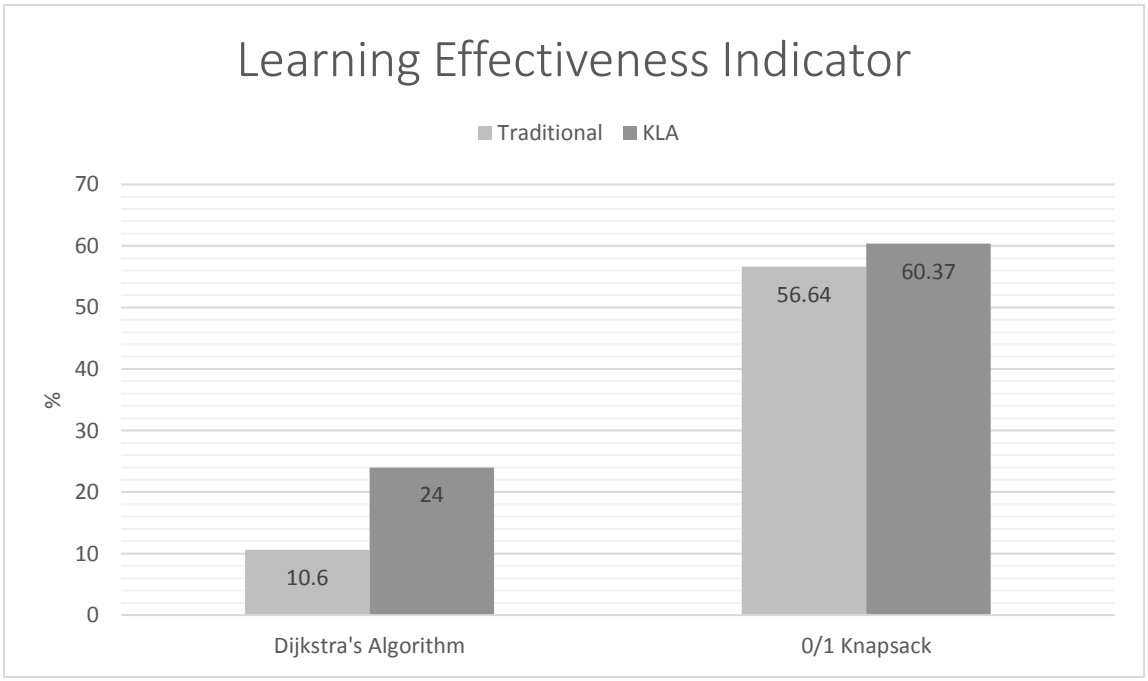


Figure 5 Percentages of the Learning Effectiveness Indicator (Learning Gain)

Table 9 Ratios on the Learning Gains of KLA / Traditional

Learning Gains Through	Dijkstra's Algorithm	0/1 Knapsack
Traditional	10.6	56.64
KLA	24.0	60.37
Ratio: KLA/Traditional	2.26	1.07

APPENDIX M

FULL SURVEY RESULTS

Table 10: Summary of survey responses

student	Q1	Q2	Q3a	Q3b	Q3c	Q3d	Q3e	Q3f
1	V	F	3	2	2	2	4	n/a
2	V	G	1	1	1	2	3	3
3	K	G	2	2	2	1	1	1
4	V	G	3	2	2	3	2	2
5	K	F	2	2	2	2	2	2
6	V	F	3	3	3	3	3	3
7	VK	G	1	1	1	1	1	1
8	D	E	1	1	1	1	1	1
9	VAK	E	4	5	5	4	4	4
10	VAK	F	3	2	2	3	2	3
11	VK	G	2	1	2	2	1	1
12	V	G	2	2	1	2	2	2
13	V	F	2	3	3	3	2	2
14	V	F	3	3	3	3	4	3
15	D	F	3	2	3	3	3	3
16	K	G	2	3	3	1	1	1
17	VA	F	1	2	2	4	1	2
18	VA	F	3	2	2	3	1	2
19	K	E	1	1	1	1	1	1
20	K	F	1	2	2	2	2	1
21	VK	G	2	2	2	2	2	2

22	V	G	3	2	2	2	4	2
23	V	G	1	1	1	2	1	1
24	A	F	3	3	5	3	2	3
25	V	F	3	1	2	3	3	4
26	VK	G	1	1	1	1	1	1
27	VAK	G	1	1	1	1	3	2
28	VK	G	4	4	4	4	4	4
29	VK	E	1	1	2	2	1	1

The results of Question 1 are summarized in Table 11:

Table 11: Question 1

Learning Style	**# of Students**	**%**
Visual(V)	10	34.5
Auditory(A)	1	3.4
Tactile/Kinesthetic(K)	5	17.2

I don’t know(D)	2	6.9
V-K	6	20.7
V-A	2	6.9
V-A-K	3	10.3
	29	

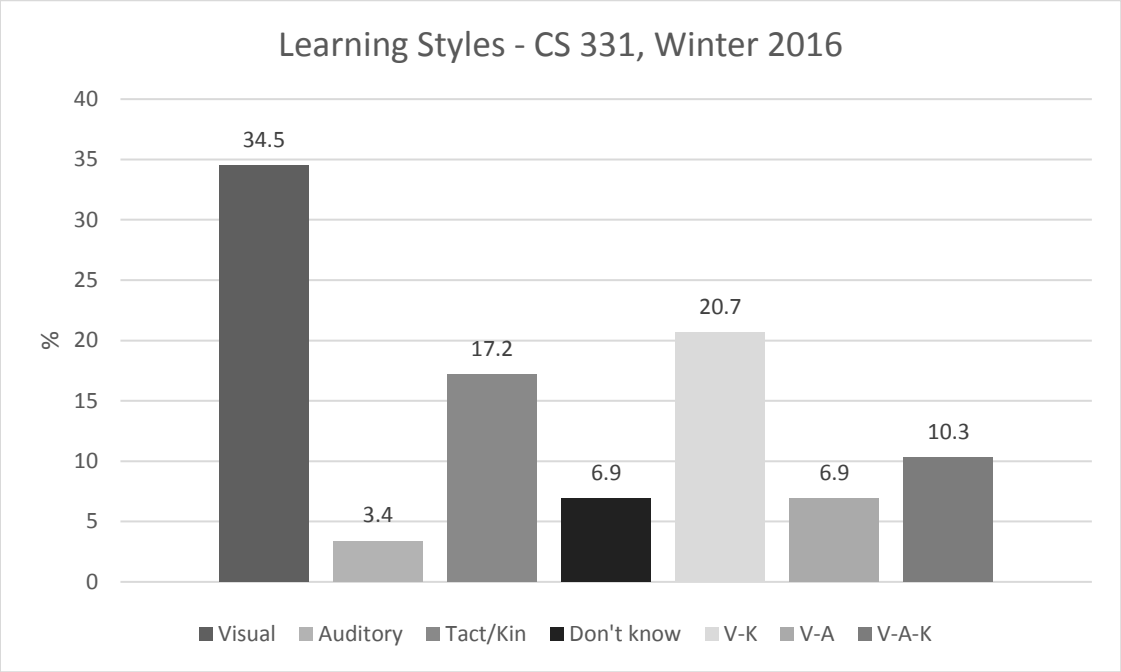


Figure 6: Learning Styles – CS 331,Winter 2016

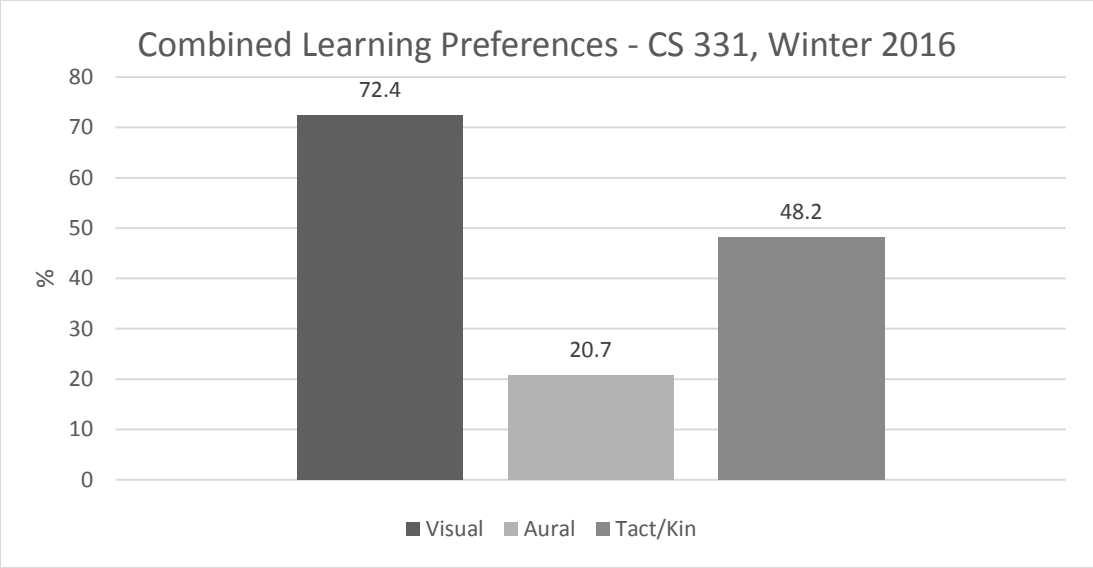


Figure 7 Combined Learning Preferences – CS 331, Winter 2016

Question 2 is summarized in Table 12

Table 12: Q2 summary

Selection	# of respondents
Excellent	4
Good	13
Fair	12
Poor	0

Table 13: Question 3 - Responses

Question	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree	No Answer

a	10	7	10	2	0	0
b	10	12	5	1	1	0
c	8	13	5	1	2	0
d	7	10	9	3	0	0
e	11	8	5	5	0	0
f	10	9	6	3	0	1

Table 14: Question 3a

	Percentage
Strongly Agree – 1	34.4
Agree – 2	24.1
Neither – 3	34.4
Disagree – 4	6.9
Strongly Disagree - 5	0.0

Table 15: Question 3b

	Percentage
Strongly Agree – 1	34.4
Agree – 2	41.4
Neither – 3	17.2
Disagree – 4	3.4
Strongly Disagree - 5	3.4

Table 16: Question 3c

	Percentage
Strongly Agree – 1	27.6
Agree – 2	44.8
Neither – 3	17.2
Disagree – 4	3.4
Strongly Disagree - 5	6.9

Table 17: Question 3d

	Percentage
Strongly Agree – 1	24.1
Agree – 2	34.5
Neither – 3	31.0
Disagree – 4	10.3
Strongly Disagree - 5	0.0

Table 18: Question 3e

	Percentage
Strongly Agree – 1	37.9
Agree – 2	27.6
Neither – 3	17.2
Disagree – 4	17.2
Strongly Disagree – 5	0.0

Table 19: Question 3f

	Percentage
Strongly Agree – 1	34.5
Agree – 2	31.0
Neither – 3	20.7
Disagree – 4	10.3
Strongly Disagree – 5	0.0
No Answer	3.4