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Enhancing the Geoscience Pedagogical Landscape: An Integrative Strategic Approach to Heighten Student Learning

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Outline of Presentation

- Introduction
- Motivation and Background
  - ✓ New pedagogical methods to enhance learning
  - ✓ 2-stage exams
  - ✓ Utilization and benefits
- Experimental Study 2-Stage Exam
  - ✓ Design & implementation
  - ✓ Tailorability
- Results & Discussion
  - ✓ Analysis of the trends in student performance for individual-group exam
  - ✓ Analysis of student learning from group exam
  - ✓ Evaluation of student survey assay
- Summary & Conclusions
- Next Steps & Future Work

Current Trend in Higher Education

- Employ active learning methods to enhance student learning
  (used in classroom & often used as Formative Assessment)
- Research Based Methods of collaborative learning
  - ✓ Peer instruction
  - ✓ Think-Pair-Share
  - ✓ Group problem solving
  - ✓ Interactive lectures
  - ✓ Engineered laboratory simulations
- Common Feature include
  - ✓ Intense student engagement
  - ✓ Instructor guidance
  - ✓ Collaborative learning
    (students develop thinking & learning via peer interaction-immediate feedback)

Identify New Pedagogical Methods to Enhance Student Learning

- Active learning STEM pedagogies are highly researched (publications) & becoming widely distributed (used)
- Most science classes incorporate testing (summative assessment)
- Exams as tool to gauge student achievement of the course learning objectives
  - ✓ Learning is not emphasized during exam
  - ✓ Takes place as a by-product after the exams
- Test methodologies still remain quite traditional
- Traditional testing format
  - ✓ Summative assessment of individual performance
  - ✓ Students works alone→ solves problems in isolation
  - ✓ Intense engagement with material with little contribution to learning (acquiring new ideas)
  - ✓ Receives delayed feedback
  - ✓ Does not support collaborative learning
  - ✓ Often promotes anxiety → false positive/negatives for performance

Motivation & Background

- **Active learning** methods **promotes enhanced student learning**
- Why not use test methods which foster learning

  Learning can take place during exams vs. recall of material or concepts
- Collaborative Testing (team based learning)

  Two Stage Exams/Group Test/Pyramid Exam
- Valuable for learning & **synergistic with in-class collaborative pedagogies**

What is a 2-Stage Exam?

- Goal is to turn test sessions into learning experiences
- Students take same test twice during class period but in different settings
  - ✓ 1st individual Exam
  - ✓ 2nd take exam collaboratively in pairs or groups
- Scoring calculate based on a weighted average of the individual part (90-60%) and the group part (10 - 40%) of the exam
- If group score is < individual score final score is based solely on individual exam

"Collaborative Part of Exam Will Not Lower Students Grade"

Motivation & Background: Characteristics of Exam Formats

Characteristics	Traditional Exam Format	Two-Stage Exam format
Nature of Exam	• Individual focused • Summative assessment of performance (individual)	• Individual + Group collaborative • Summative assessment of performance (individual)
Students	• Passive	• Active-intense engagement by students
Problem Solving	• Isolation	• Collaborative discussions
Ambience	• Quiet	• Noisy
Learning Environment	• Competitive	• Supportive , collaborative
Learning Opportunities	• Limited • Intense engagement with subject matter	• Multiple • Intense engagement in student learning, Share/discuss ideas/generate new ideas
Students Role	• Student (learner only)	• Learner (student) & Teacher (explain to others) – Students serve as facilitator
Feedback	• Delayed	• Immediate through interactions with peers
Results *Consequences & Benefits*	• Individual grade attained • Is learning really assessed???	• Improved learning (self + group-acquisition of knowledge by students) • Increased retention of subj. matter content • Decreased drop out rates • Higher course enjoyment • Increased collaborative skills • Reduced test anxiety • Improved perception of course

Motivation & Background

- Two-Stage Exams are **not a new idea**; but **utilization** is still **relatively rare**
- Few published studies measured the benefits on learning in science
- Research findings "Benefits" (Sterns. 1996; Gilley & Clarkston 2015; Light *et al.* 2012; Cortright *et al.*; 2003; Zipp 2007; Yuet *et al*. 2010; Weiman *et al*. 2014; Ives 2014)
  - ✓ Enhanced student learning
  - ✓ Decreased drop out rates
  - ✓ Increased attendance
  - ✓ Higher enjoyment if the course
  - ✓ Increased collaborative skills

  } *Benefits*
- Leaders in the field University of British Columbia, Vancouver, BC, Canada, *Carl Wieman*
- Used in physics, nursing, medical-related courses. biology courses

Experimental Study & Methodology

- Central New Mexico Community College, 2-year college; mission is to educate students & prepare students for transfer to four-year institutions.
- Student population studied (Introductory Physical Geology Course)
  - ✓ Freshman-sophomore level
  - ✓ Mostly local NM based (few/none foreign nationalist students)
  - ✓ Mix of mature & recent HS grads, life experiences, most working ~part time
  - ✓ Mix of geoscience majors and non-majors (need a lab science course)
- Class attendance is mandatory (students allowed to miss only 15% of classes)
- Administered 2-stage exam to two sections of intro. physical geology course
- Class period of 75 minutes (used time allocation 1:1)
- Total number of students: Test #3 (n=42), Test #4 (n=40), Retest (n=35)

- The 1st part of the semester all the students took 2 individual in-class exams
- Exams #3 & 4 were administered as 2-stage exams;
  - ✓ Exams problem solving & concept demonstration/evaluation based exams
  - ✓ **Test #3: relative-absolute time, earth history**
  - ✓ **Test #4: structural geology, seismology, oceanography**

Exam Methodology
Tailorable

Exam #3: Relative - Absolute Time & Earth History
Exam #4: Structural Geology, Seismology, Oceanography

Same Class Period

Individual Exam

1. First stage of Exam → Students takes exam solo
- 25 questions, 30 minutes

- *Collect Individual exams*
- *Students move into randomly pre-assigned groups (5 min)*

Group Exam

2. Second stage of Exam
- Groups of 3 - Randomly selected
- 25 questions, 30 minutes
- 1 exam per group
- 3 Student observers monitor effectiveness of exam

4 to 6 weeks later

- *Collect group exams*
- *Review exam interactively with participation from the student groups*
- *Student survey*

Grading Methodology→ Tailorable
- Score Final = Score $_{\text{Individual (I)}}$ + Score $_{\text{Group (II)}}$
- Scores are proportionally weighted to suit specific class/student situations
- *Ensures students take both components seriously*

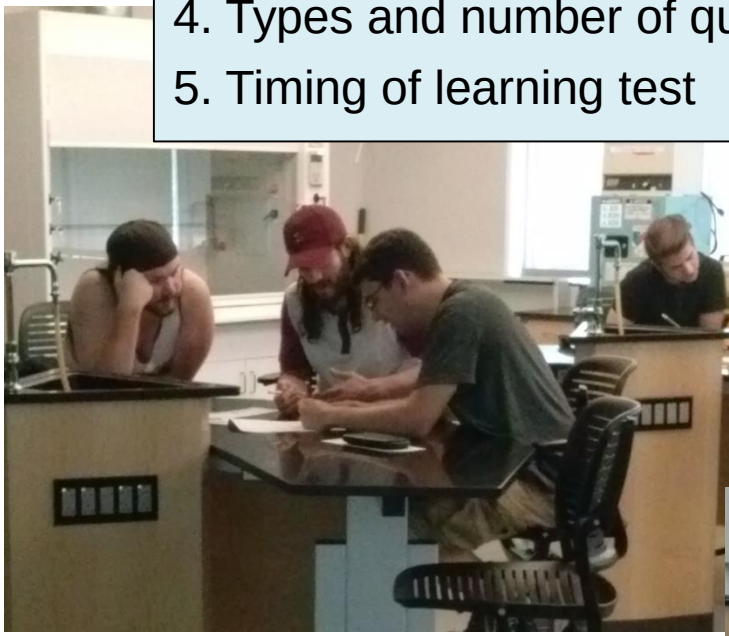
Individual Retest Learning Exam

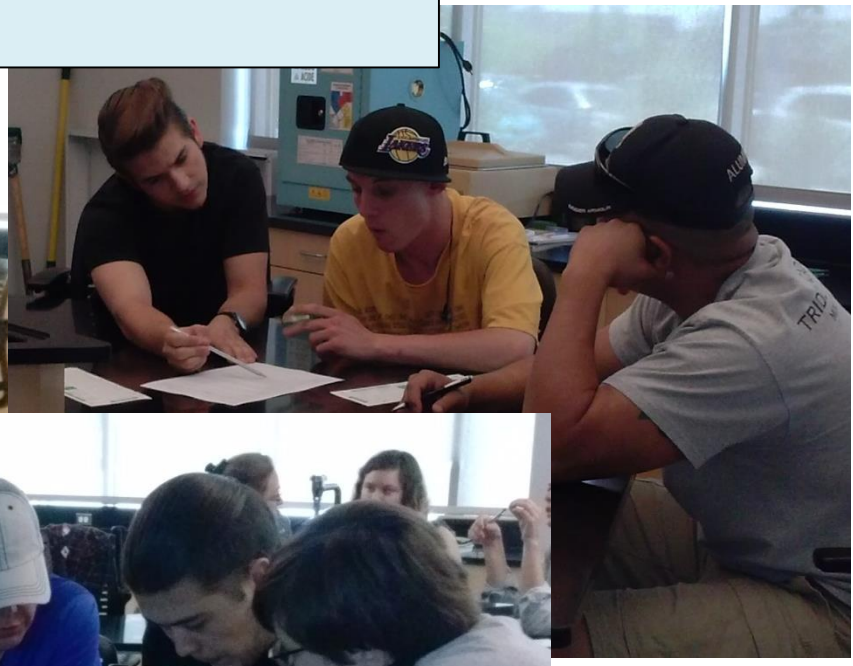
3. Learning Exam → Students takes same exam solo
- 25 questions, 30 minutes
- Administer 4-8 weeks after 2-stage test (this study 6 weeks)

Experimental Study & Methodology

Important Tailorable Considerations

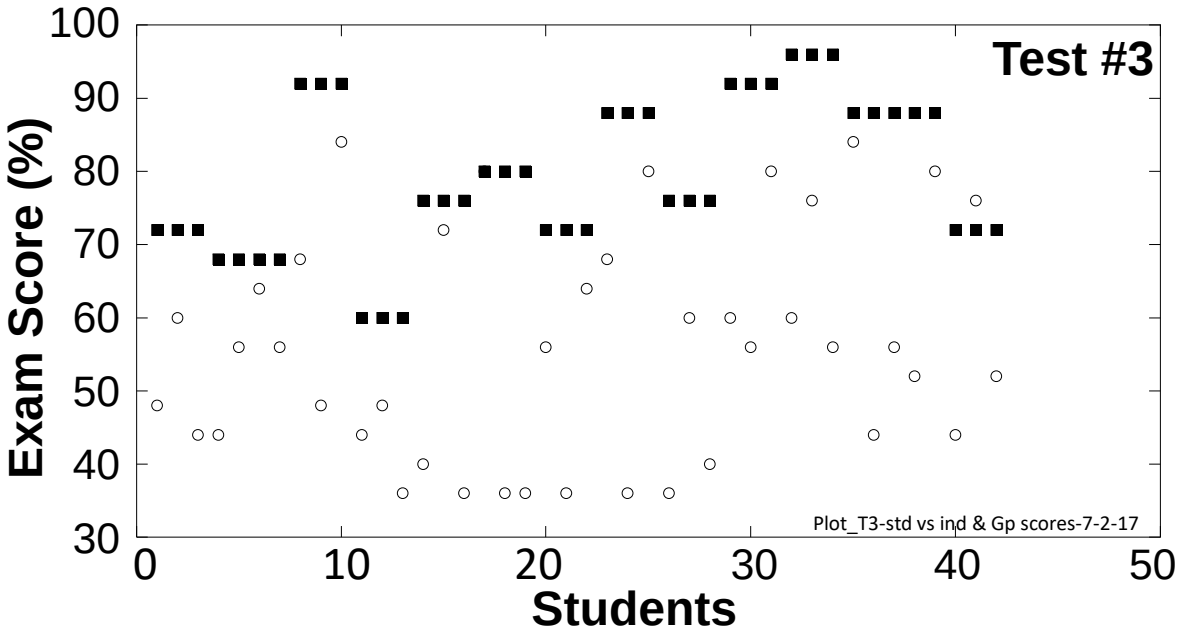
1. Group selection method & number of students per group
2. Timing of each exam component
3. Grading → weight (Indiv.: Group) 90:10, 80:20, 70:30 etc.)
4. Types and number of questions on exam etc.
5. Timing of learning test



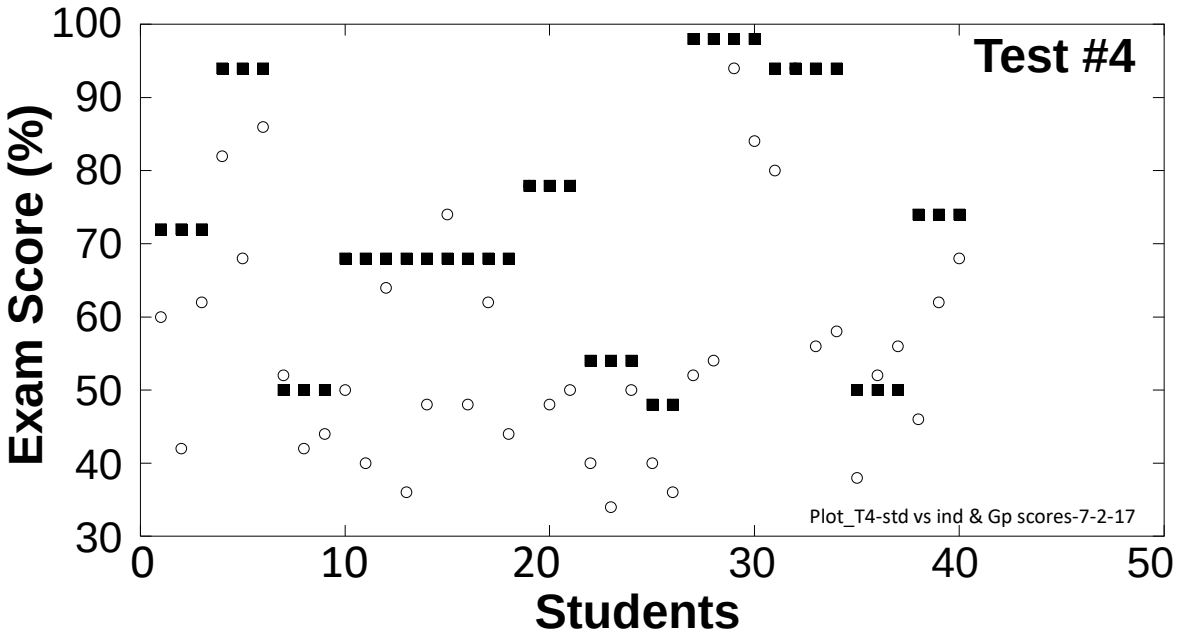


Students Taking Collaborative Exam

Results & Discussion: Comparison of Individual & Group Scores

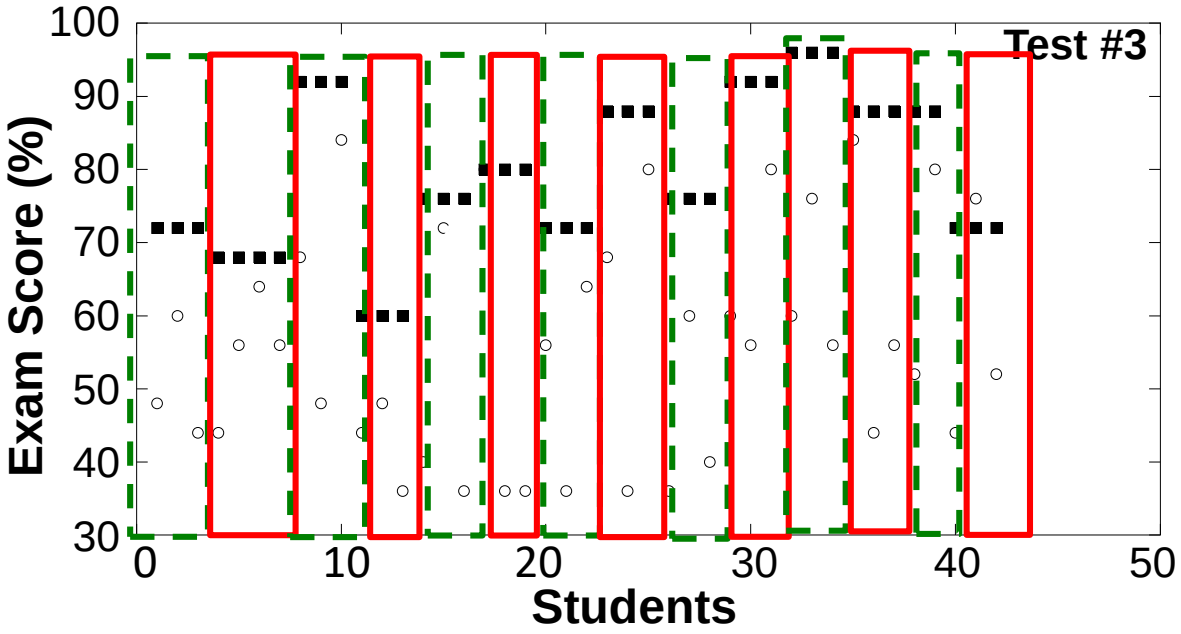


○ Individual Exam
■ Group Exam

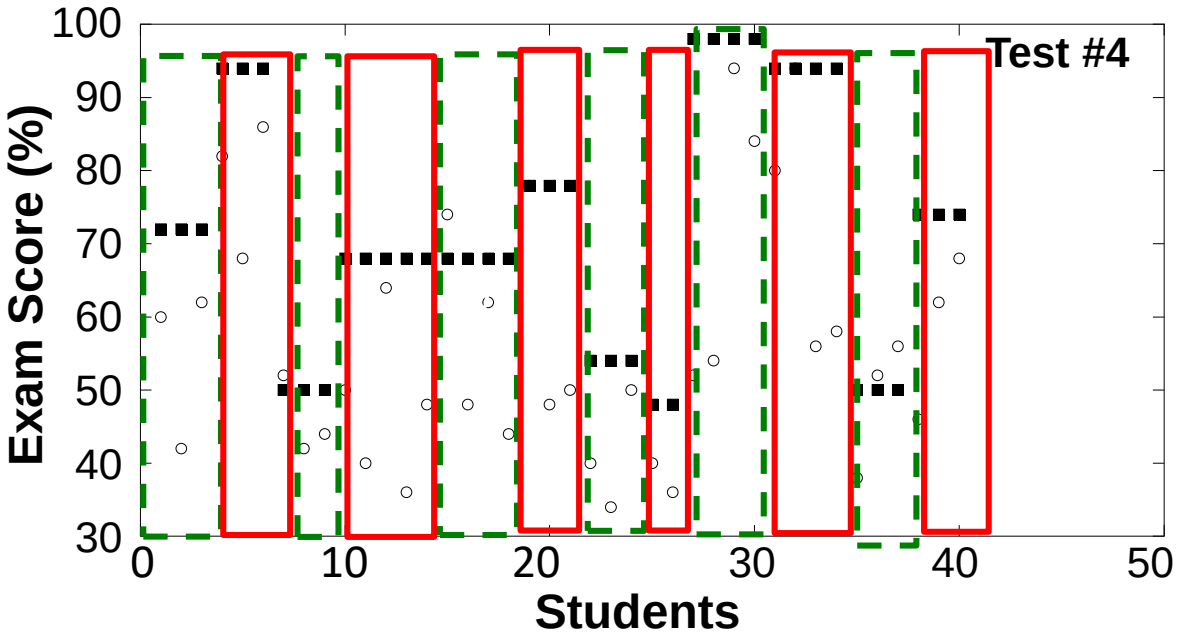


Observation
Group Score are higher

Results & Discussion: Comparison of Individual & Group Scores

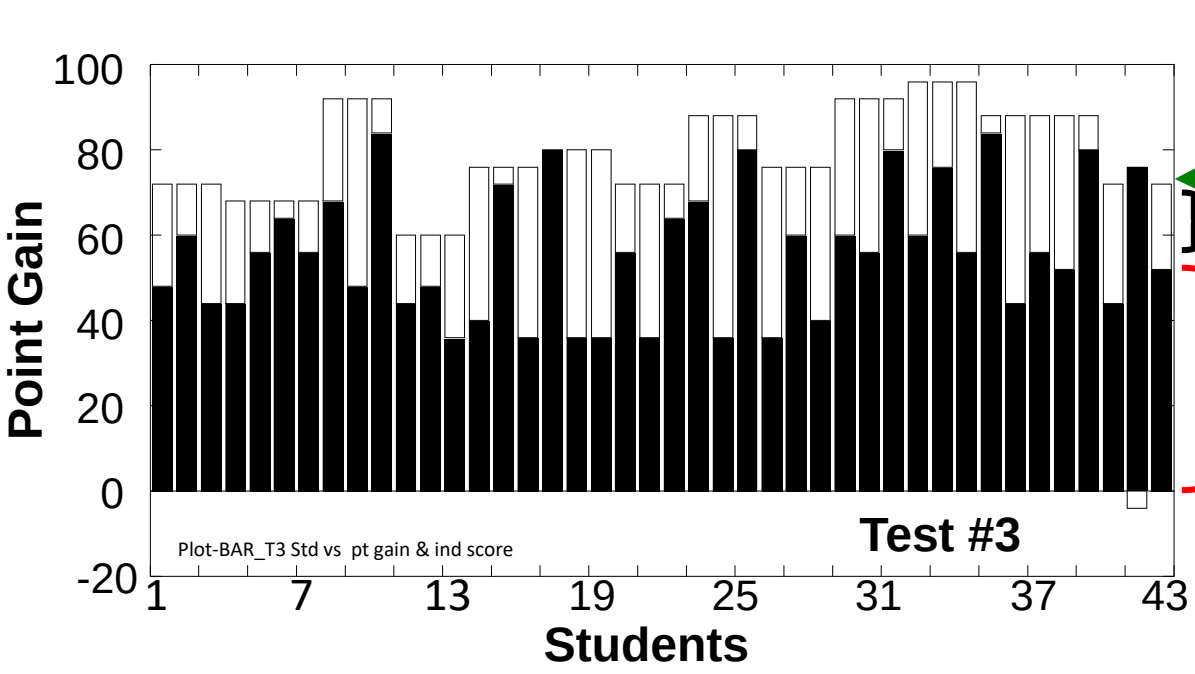


○ Individual Exam
■ Group Exam



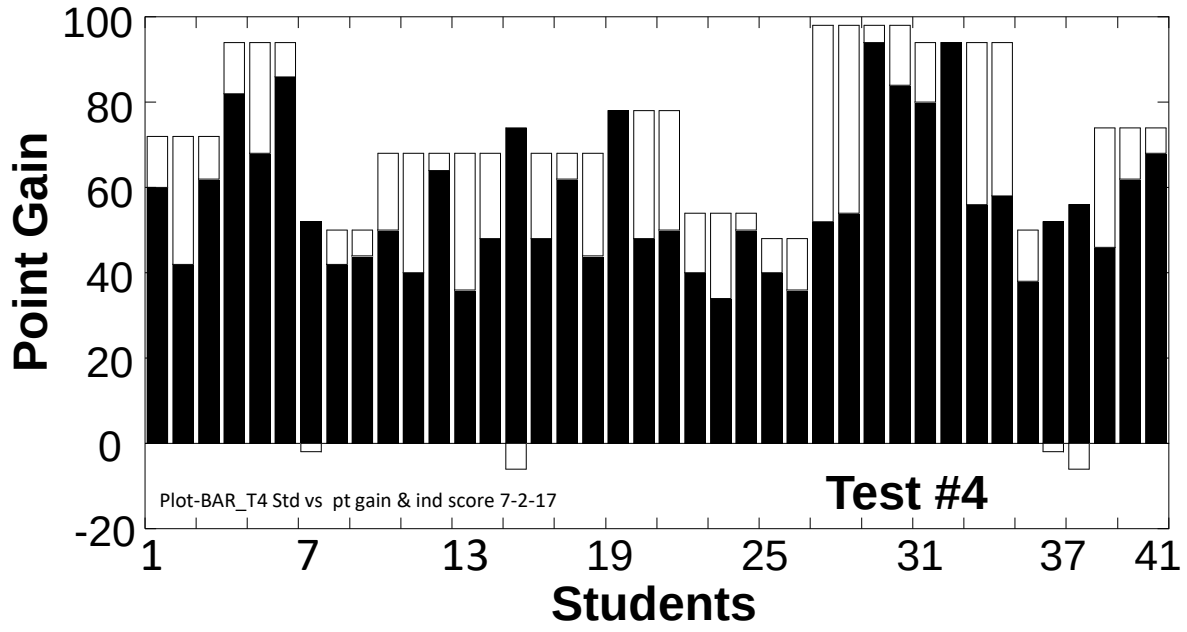
Observation
Group Score is higher than best Individual score

Results & Discussion: Point Gain Individual - Group Scores

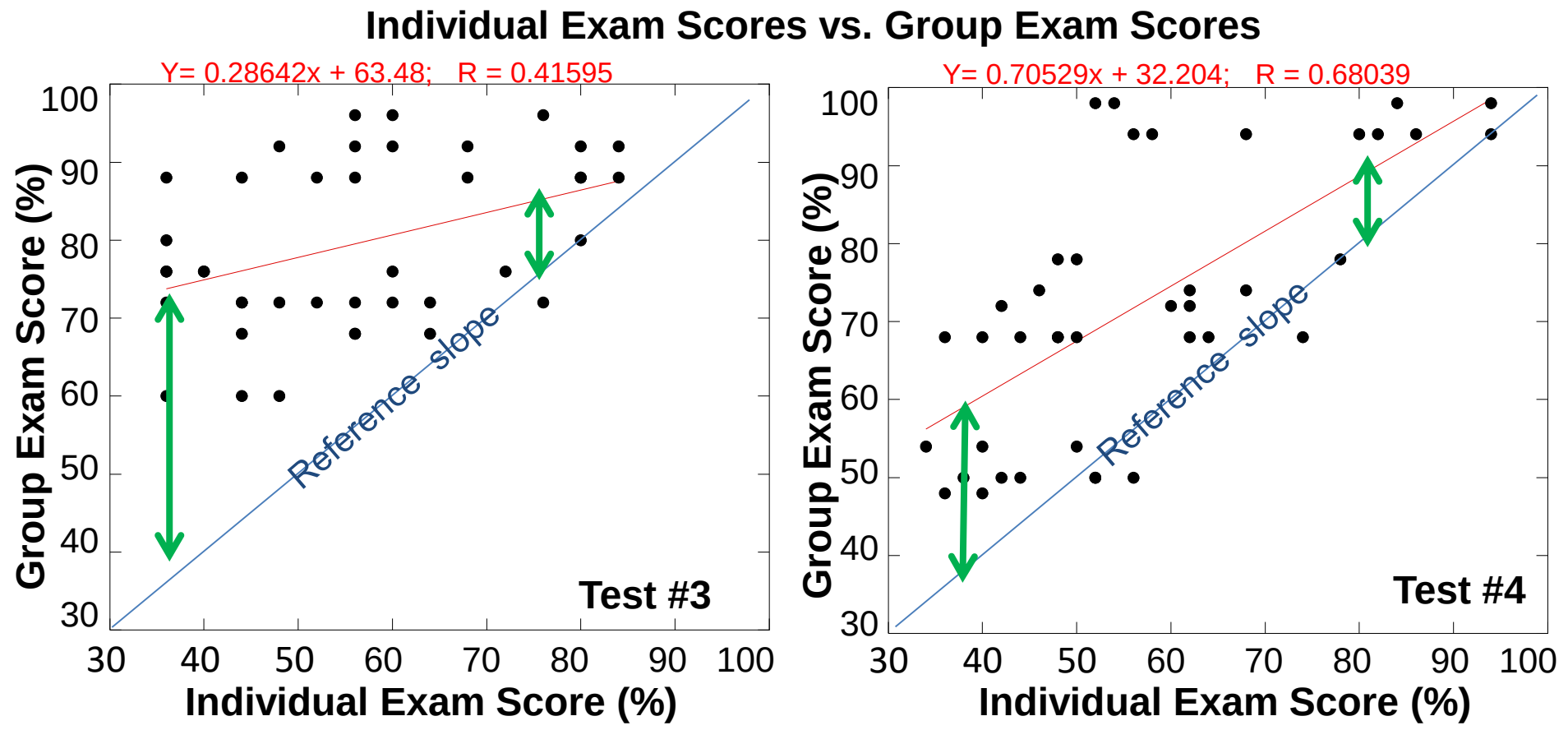


(Stacked Column Plot)

Group Exam → Improved Scores



Results & Discussion: Individual and Group Exam Scores



- Students plotted above ref. slope → showed improvement from Ind. to group exam
- Students with lower scores on Individual Exam gained more points in Group Exam
- Students with higher scores on Individual Exam gained less points in Group Exam

Results & Discussion: Paired t-test - Individual & Group Test Scores

Paired t-Test –

- ✓ Compare means on the same subjects over time or under different conditions
- ✓ Used to determine if two data sets are significantly different from each other

	Test #3 (n-42)		Test #4 (n=40)	
Values	Individual Exam	Group Exam	Individual Exam	Group Exam
Minimum	36	60	34	48
Maximum	84	96	94	98
Mean	56	79.52	56.85	72.3
Median	56	76	52	70
RMS	58.018	80.207	59.233	74.241
Std. Dev.	15.3528	10.572	16.479	17.082
Variance	235.71	111.77	271.57	291.81
Stnd. Error	2.369	1.6313	2.6056	2.7009
Skewness	0.33792	-0.054341	0.73771	0.13368
Kurtosis	-1.0392	-1.112	-0.39843	-1.2022

t-test results

	Test #3 (n-42)		Test #4 (n=40)	
	Individual Exam	Group Exam	Individual Exam	Group Exam
Mean	56	79.52	56.85	72.3
Variance	235.707	111.768	271.5667	291.805
Std. Dev.	15.3528	10.572	16.4793	17.0823
Std. Err.	2.36898	1.6313	2.6056	2.70095
Mean Difference	-23.5238		-15.45	
t-value	-10.459		-7.277	
t-Probability	**<0.0001**		**< 0.0001**	
Correlation	0.41595		0.68039	
Corr. Probability	0.00615		< 0.0001	

Student t-test

- Is there a statistical difference between individual & group scores (the means)?
- Did the group exam make a difference? t-test said yes!
- t-probability <0.0001
- t-test results demonstrated that the results are statistically different
- There is a statistically significant difference (improvement) in student performance between individual and the group test

Analysis of the trends in student performance level with respect to scores on group test

Who Benefited the Most?

Influence of Student Performance Level on Group Exam Scores

- Individual Exam → baseline for binning students by performance level

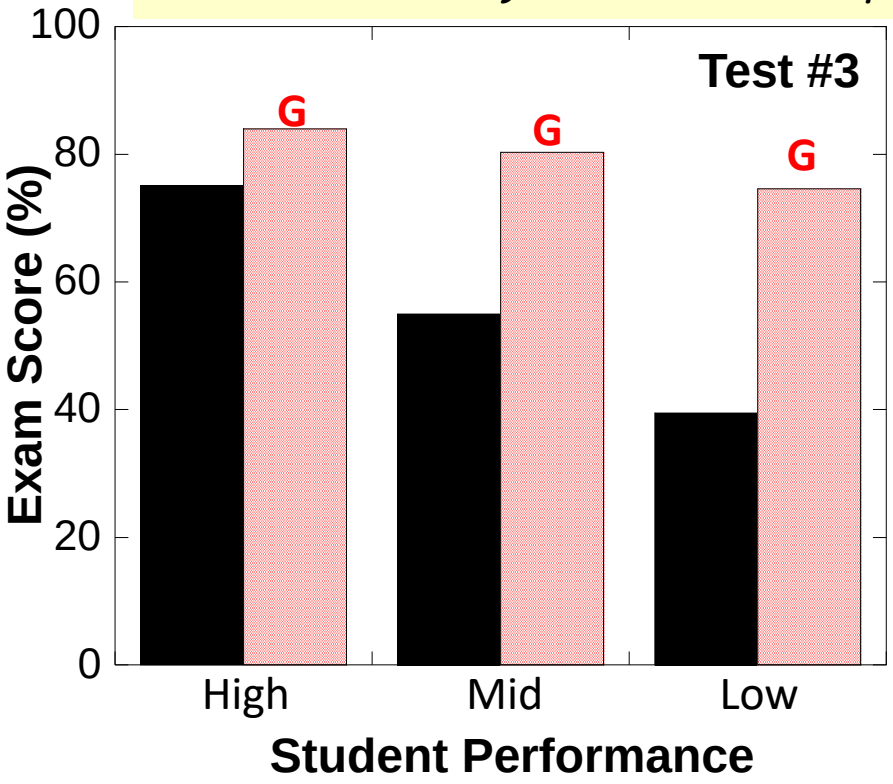
  Students → High, Mid & Low performance (Individual Exam scores)

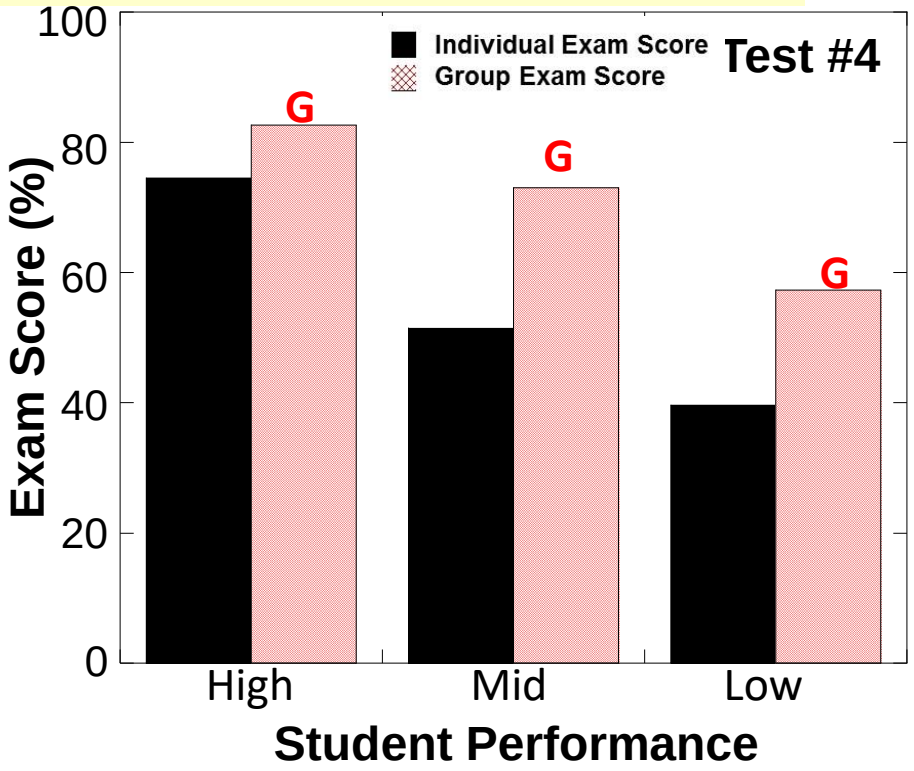
  ✓ Test #3: High ≥ 64%, Mid 63-48% , Low <48% (equal #s in each category)

  ✓ Test #4: High ≥ 60%, Mid 59-46% , Low <45%(equal #s in each category)

Influence of Student Performance Level on Group Exam Scores

Students → High, Mid & Low performance (Individual Exam scores)

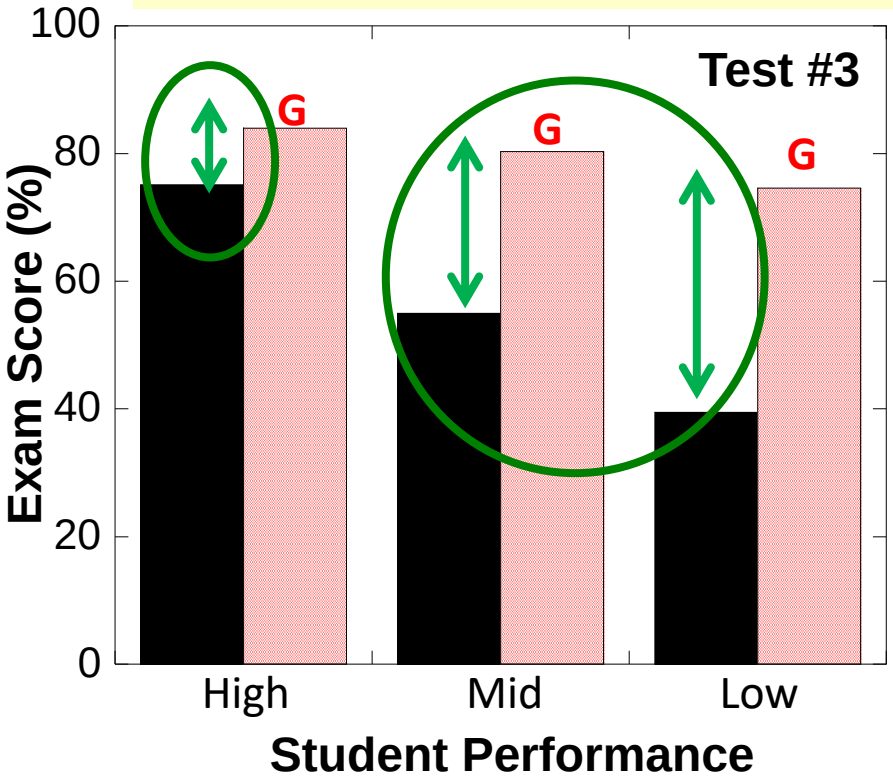


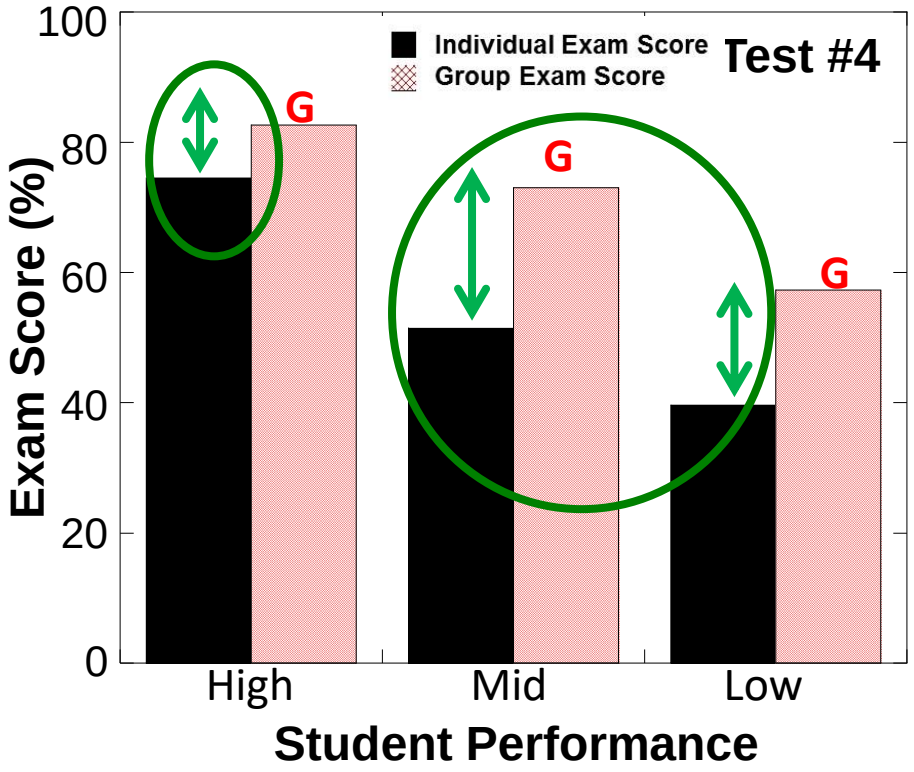


- Students binned by performance level based on Individual Exam Scores
  - ✓ Test #3: High ≥ 64%, Mid 63-48% , Low <48% (equal #s in each category)
  - ✓ Test #4: High ≥ 60%, Mid 59-46% , Low <45%(equal #s in each category)
- All students benefited from group exam (Score Improvement)

Influence of Student Performance Level on Group Exam Scores

Students → High, Mid & Low performance (Individual Exam scores)

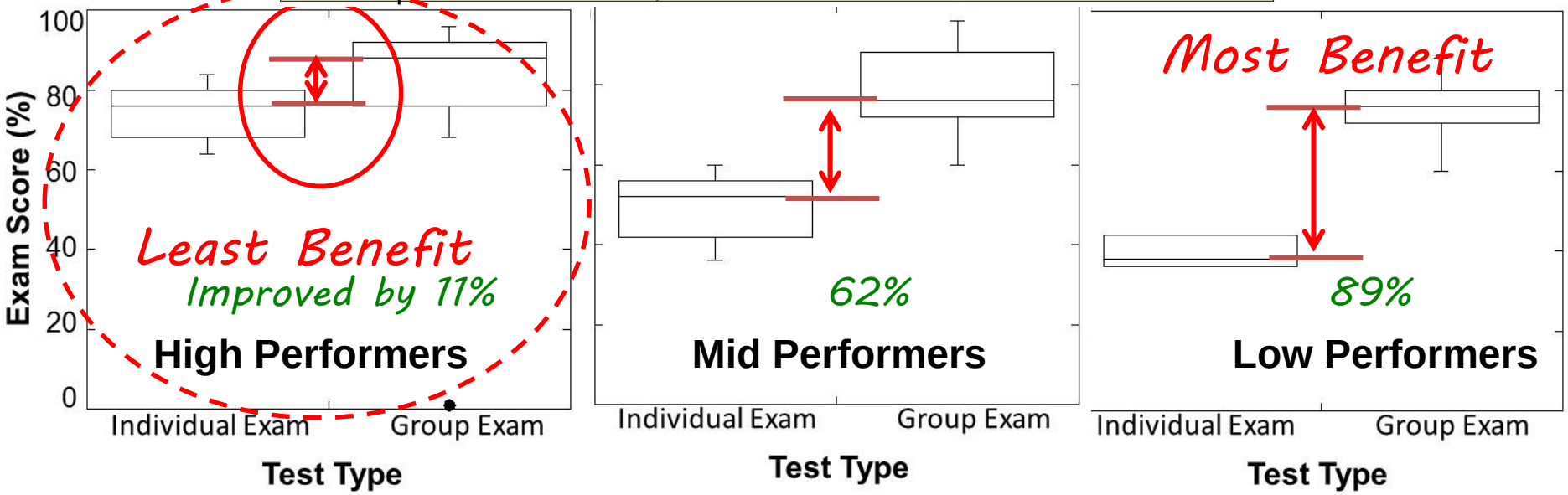




- Binned Students by performance level based on Individual Exam Scores
  - ✓ Test #3: High ≥ 64%, Mid 63-48% , Low <48% (equal # in each category)
  - ✓ Test #4: High ≥ 60%, Mid 59-46% , Low <45%
- All students benefited from group exam (Score Improvement)
- **Mid and Low Performers benefited most**

Student Benefit by Performance Level → Box Plot Test #3

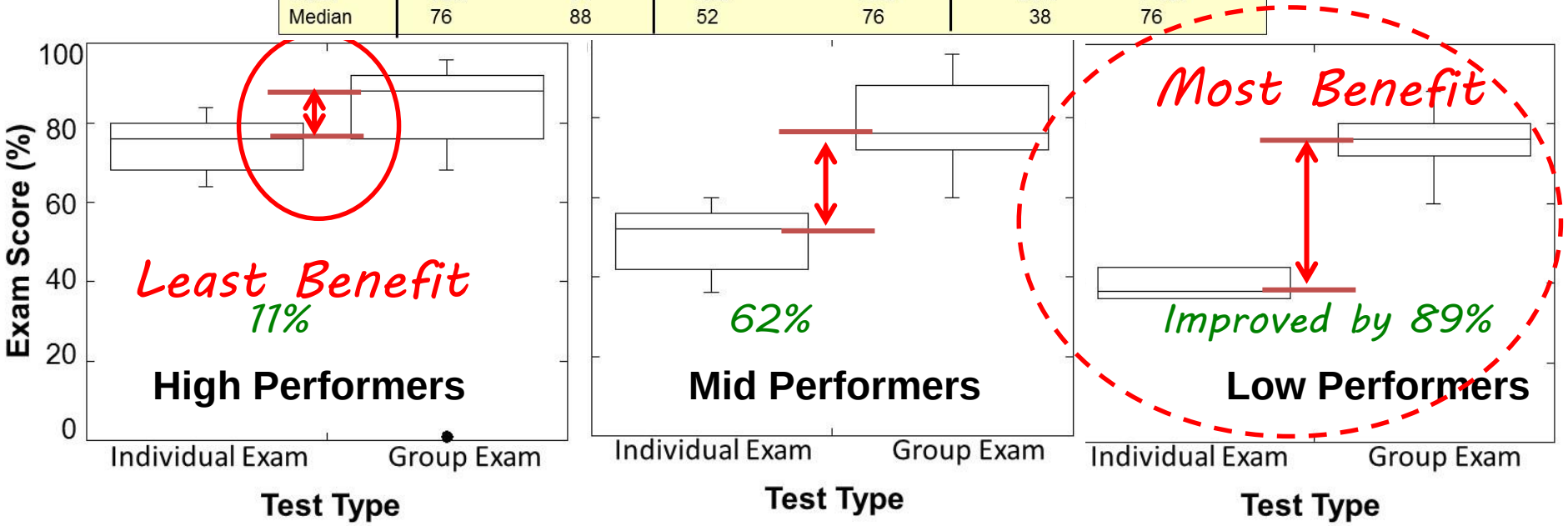
Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	75.6	84	49.2	79.8	39.4	74.57
Median	76	88	52	76	38	76



- High performers lower benefit from group exam
  - ✓ Improved mean score 11% (indiv. to group exam)
  - ✓ Moderate degree of dispersion (spread) in data (moderate box width)

Student Benefit by Performance Level → Box Plot Test #3

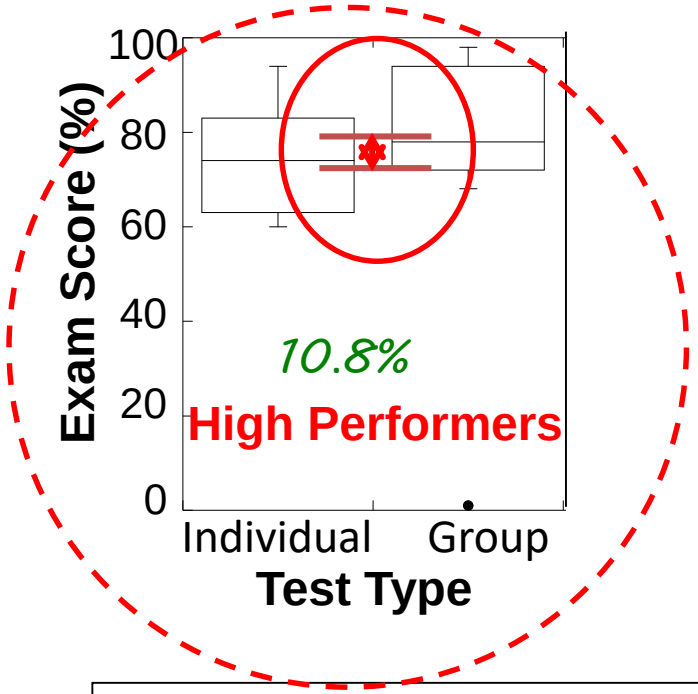
Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	75.6	84	49.2	79.8	39.4	74.57
Median	76	88	52	76	38	76

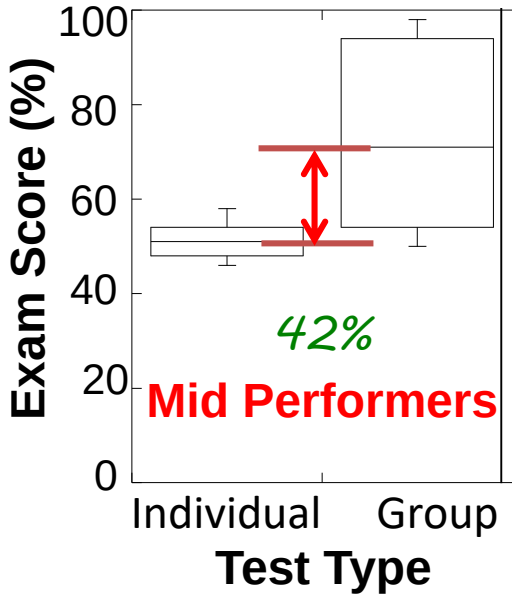


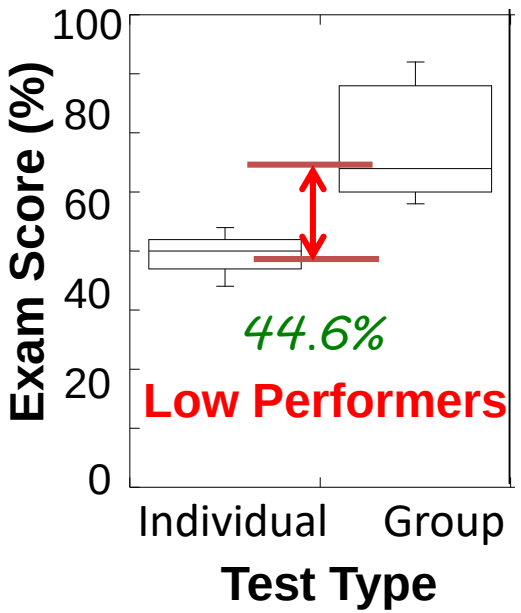
- High performers lower benefit from group exam
  - ✓ Improved mean score by 11% (indiv. to group exam)
  - ✓ Moderate degree of dispersion (spread) in data (moderate box width)
- Low Performers largest benefit from group exam
  - ✓ Improved mean score by 89% (indiv. to group exam)
  - ✓ Lowest degree of dispersion within test type data (narrow box width)
- Mid Level performers close to that of low performers
  - ✓ Improved mean score by 62% (indiv. to group exam)
  - ✓ Moderate degree of dispersion within test type data (moderate boxes width)

Student Benefit by Performance Level → Box Plot Test #4

Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	74.5	82.6	51.4	73	39.6	57.3
Median	74	78	51	71	40	54



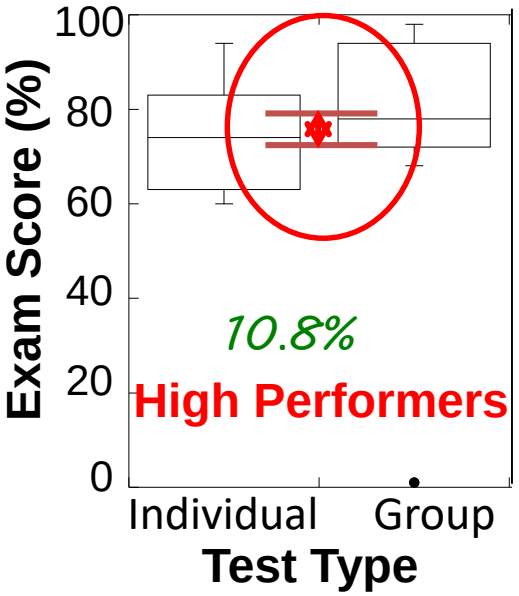


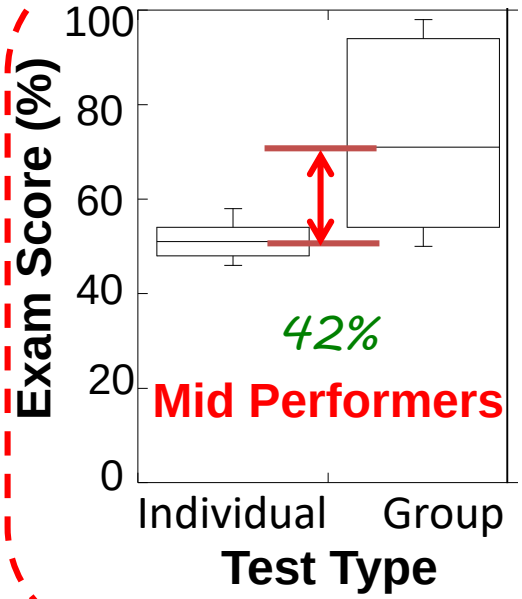


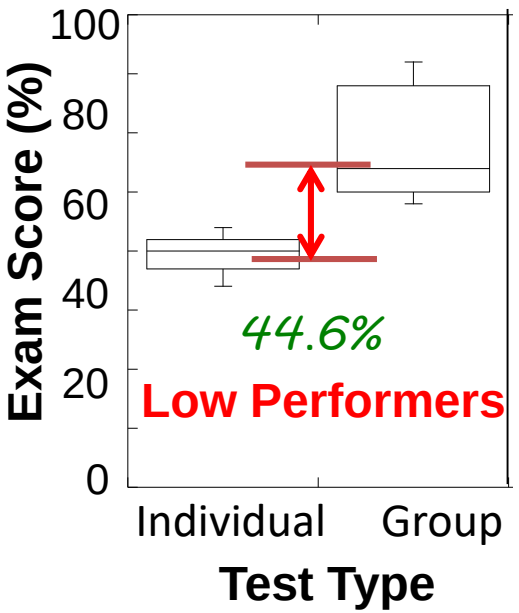
- High performers lower benefit from group exam
  - ✓ Improved mean score 10.8% (indiv. to group exam)
  - ✓ Moderate degree of dispersion (spread) in data (moderate box size)

Student Benefit by Performance Level → Box Plot (Test #4)

Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	74.5	82.6	51.4	73	39.6	57.3
Median	74	78	51	71	40	54







Box Plots - Test #4

- High performers lower benefit from group exam
  - ✓ Improved mean score 10.8% (indiv. to group exam)
  - ✓ Moderate degree of dispersion (spread) in data (moderate box size)
- Mid & Low Performers → largest benefit from group exam
  - ✓ Mid Performers improved mean score 42% (indiv. to group exam)
  - ✓ Low Performers improved mean score 44.6%
  - ✓ Both have larger dispersion with in group scores (Group Effect)
  - ✓ Both have minimal dispersion in the individual scores

All students benefited from group exam

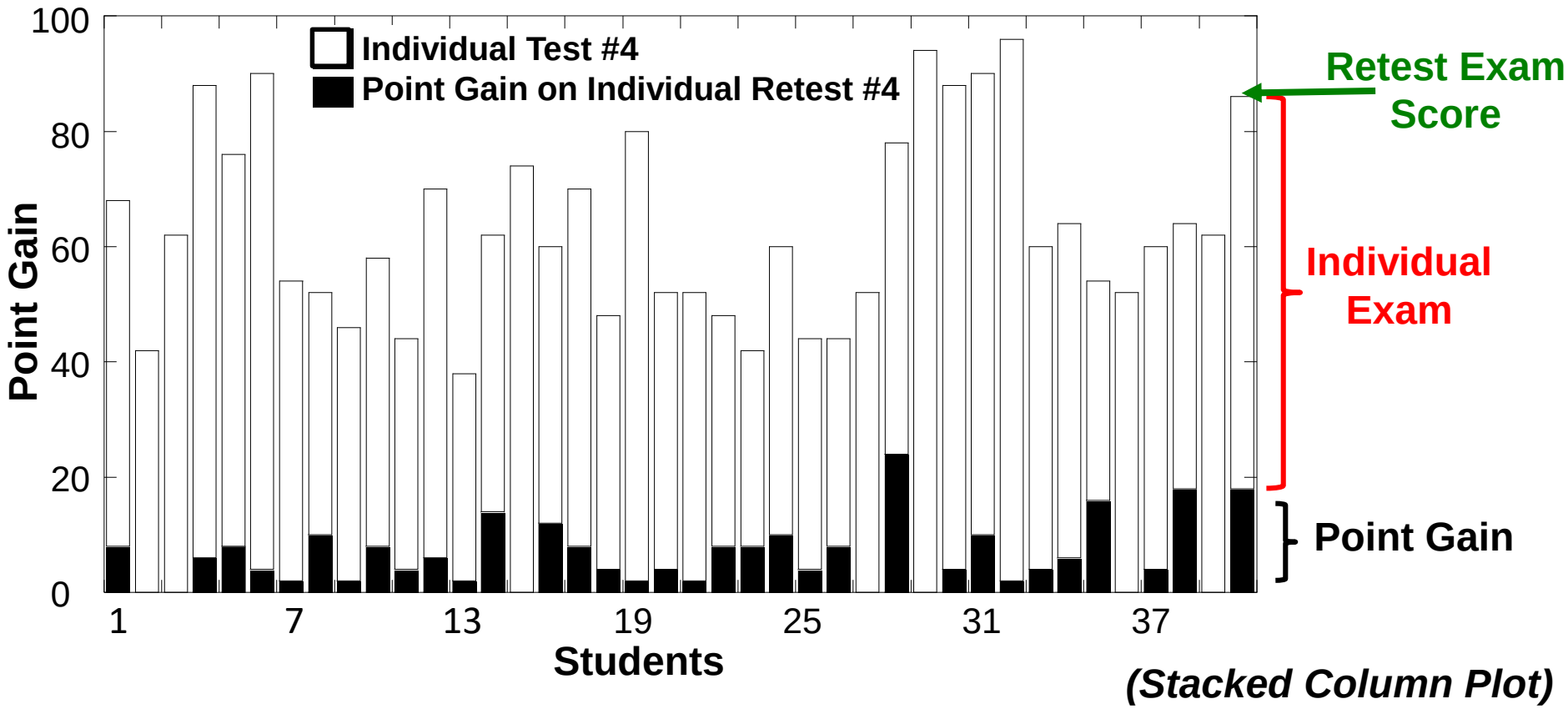
Next Questions to Ask (Answer)

1. Did the students really "Learn" as a result of group test?

2. Which students benefited most?
(high, mid-level or low performers)

- Retest administered 6 weeks after the 2-stage exam was given
- Individual test baseline assessment of student knowledge
- Retest (Learning Test) serves as a measure of student learning
- Did the collaborative part of the test improve individual student learning? (Knowledge Banking Effect)

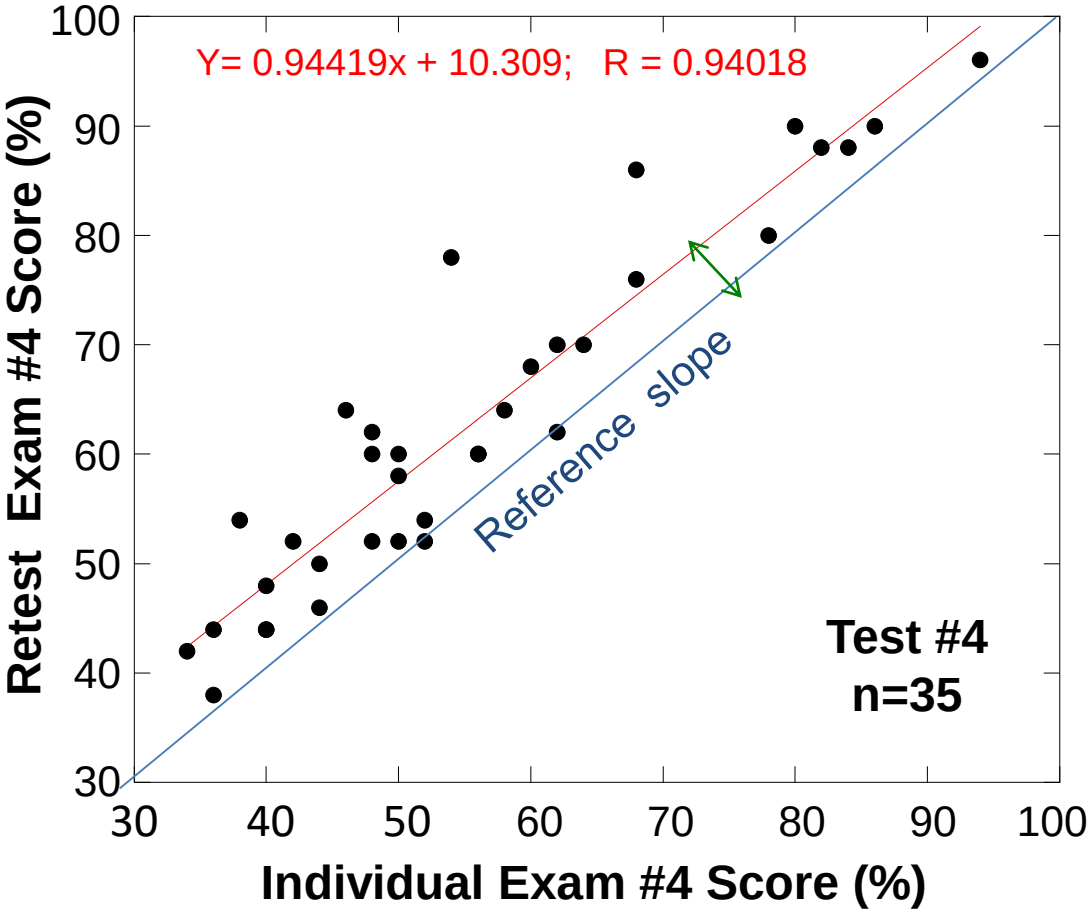
Student Learning: Point gain/loss between Retest & Individual Test



(Stacked Column Plot)

- Retest administered 6 weeks after the 2-scage exam was given
- Retest serves as a measure of student learning
- All Students improved their scores on retest (post 2-stage exam) vs. Individual Test

Student Learning: Individual Exam vs. Retest Exam Scores



- Retest serves as a measure of student learning
- Students plotted above ref. slope → showed improvement from Ind. to retest exam
- Same slope, different y- intercept→ most learning test scores moved upward
- Students improved their scores on retest (after 2-stage exam) vs. Individual Test

Paired t-Test - Individual & Retest Scores (test # 4)

Paired t-Test –

- ✓ Compare means on the same subjects over time or under different conditions
- ✓ Used to determine if two data sets are significantly different from each other

	Test #4 (n-35)	
	Individual Exam	**Retest Exam**
Mean	55.71	62.91
Variance	252.975	255.139
Std. Dev.	15.9052	15.9731
Std. Err.	2.68847	2.69994
Mean Difference	-7.2	
t-value	-7.7256	
t-Probability	**<0.0001**	
Correlation	0.94018	
Corr. Probability	0.0001	

t-test results

Student t-test

- Is there a statistical difference between Individual & Retest scores (means)?
- Did the group exam make a difference? t-test said yes!
- t-probability <0.0001 (demonstrates that the results are statistically different)
- There is a statistically significant difference (improvement) in student performance between individual and the retest scores
- Improvement on leaning test indicates
  - ✓ During the collaborative test the students acquired new knowledge
  - ✓ Learning was sufficient enough for students to remember it ~6 weeks later

All students benefited from group exam

Next Questions to Ask (Answer)

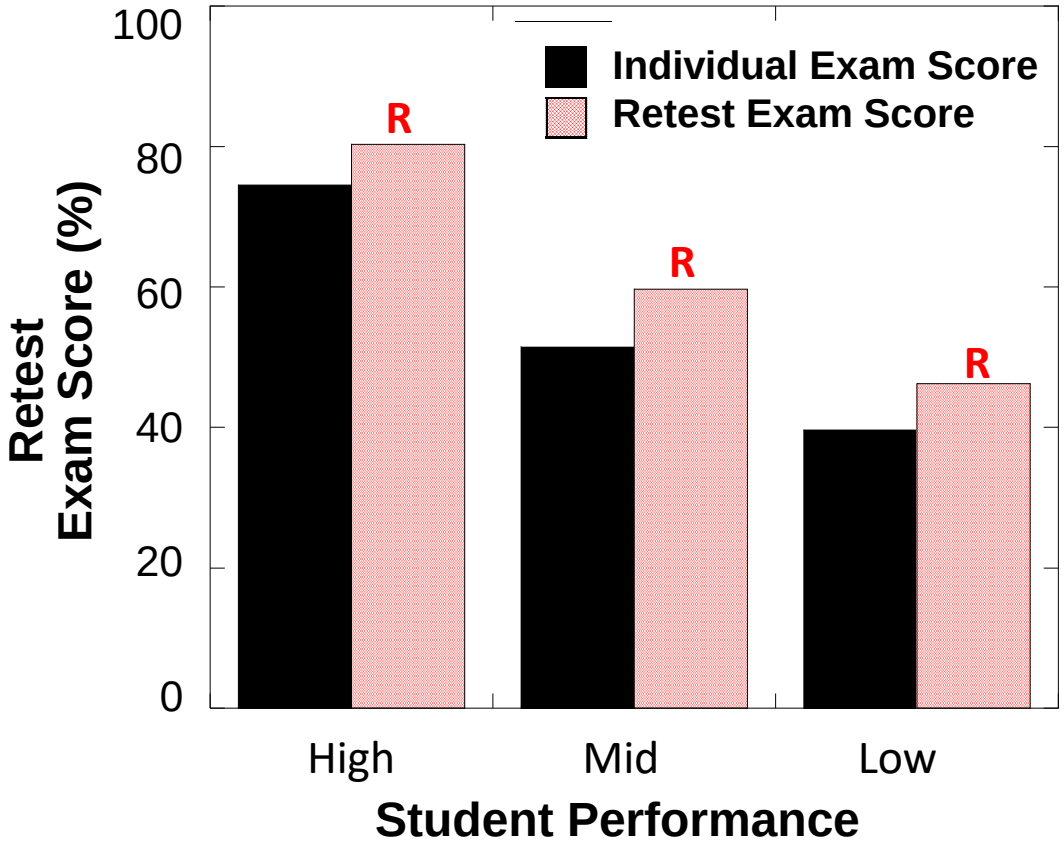
1. Did the students really Learn as a result of group test?

2. Which students benefited (learned) most?
(high, mid-level or low performers)

- Retest administered 6 weeks after the 2-stage exam was given
- Retest primary measure of student learning
- **Understand the <u>effect of 2-Stage Exam</u> on <u>Student Learning as a function of student performance level</u>**
- **Students binned by performance lever, high, Mid and Low**

Influence of Student Performance Level on Retest Exam Score

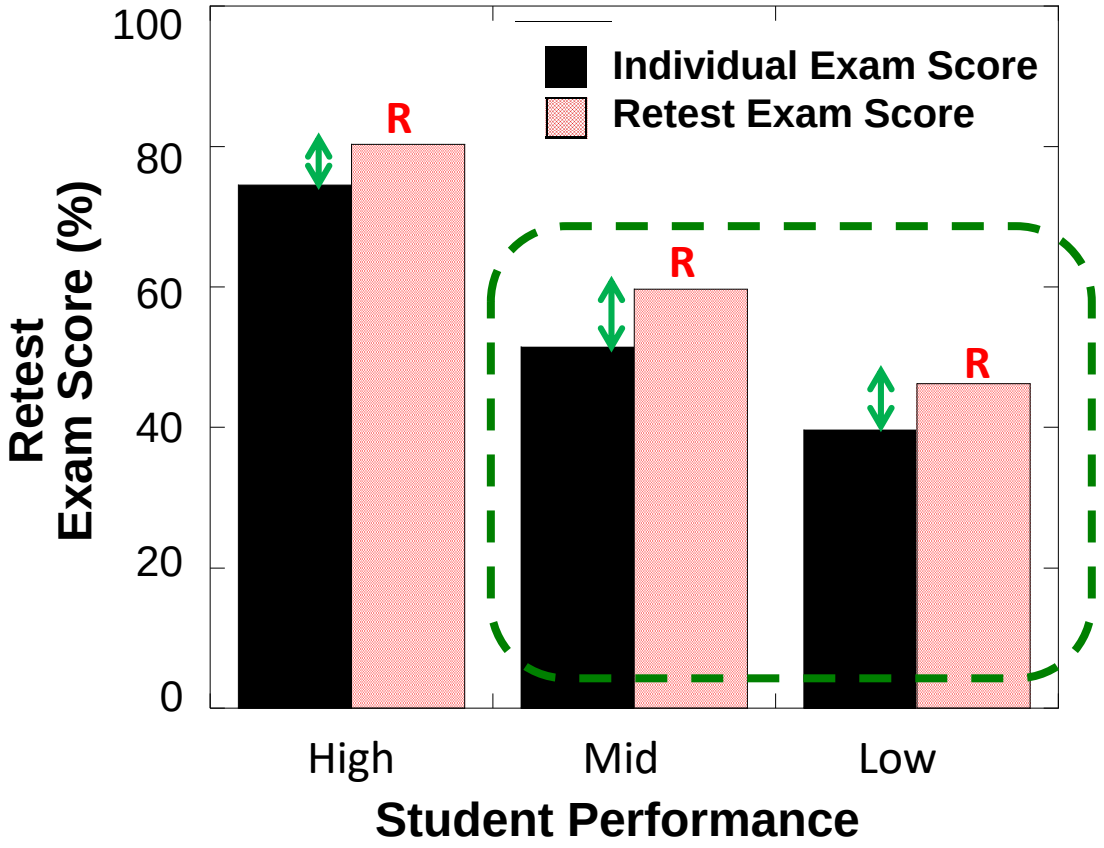
Students binned by High, Mid & Low performance from Individual Exam scores



- All students learned from group exam (score Improvement on retest)

Influence of Student Performance Level on Retest Exam Score

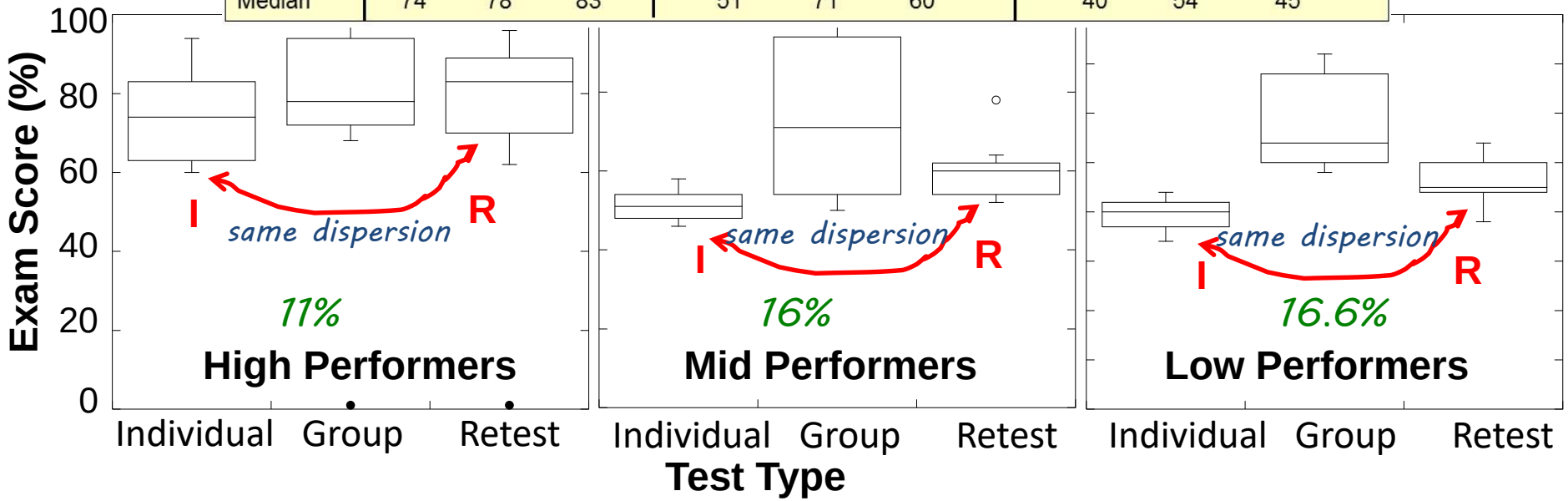
Students binned by High, Mid & Low performance from Individual Exam scores



- All students learned from group exam (score Improvement on retest)
- Mid and Low Performers benefited slightly more than high performing students

Student Benefit by Performance (Test #4)

Exam Type	Indiv.	Group	R-Test	Indiv.	Group	R-Test	Indiv.	Group	R-Test
Mean	74.5	82.6	80.3	51.4	73	59.6	39.6	57.2	46.2
Median	74	78	83	51	71	60	40	54	45



- <u>High performers</u> least difference between Individual and Retest exam scores
  - ✓ Moderate degree of dispersion (spread) in data
  - ✓ Mean score improved by 11% on Retest
- <u>Low & Mid Performers</u> largest difference between Individual & Retest exam scores
  - ✓ Low degree of dispersion in data
  - ✓ Mean score improved by ~16% (Mid) & 16.6%(Low)
- Methods to improve low and mid performers learning are critical in higher education
  - ✓ Benefit directly result of peer teaching
  - ✓ Benefit due to greater motivation to learn material (*better attitude about learning*)
  - ✓ Students better prepared- "*desire to look good amongst peers*"

Student Evaluations

Student Observer Comments

- Most students were being productive while working in their groups.
- When one student did not understand another would step in & try to explain the concept.
- ~90% of students were discussing, asking questions & analyzing the test questions. 10% either did not study or were just agreeing on the answer w/o discussing.
- Students seemed to be enjoying and learning from one another.
- The groups seemed to create a positive learning atmosphere.
- A few groups had a predominant figure that who conducting the discussion, most others were on a parallel level.
- Having peer evaluation while taking the exam is reinforcing both the material known and understood as well as pointing out mistakes originated because something was not entirely comprehended.
- Some cases the discussions were not long because all the students readily agreed to the same answer.

Student Participant Comments

- The group exam helped me learn from other students & made me question their answers while being able to discuss their reasoning.
- My partners all contributed to the discussion.
- Thought I knew this stuff pretty well but the group exam showed me that I needed to think a bit more on certain questions.
- This experience helped to get a better understanding of relative & absolute dating.
- As a student I found it easier to communicate with other students about what we are learning in class than in the regular class.
- I know I am not doing stellar on my tests but now I have a been exposed to a big positive learning style & you have really shown me that.
- The group test made me and my group more relaxed, sort of relived my test anxiety, seemed easier to learn from this group environment.
- Never had a group exam before, would like to see it used more, It was fun

Student Survey Questions

Question: The 2-stage Exam……..(*Geoscience*)	Agree	Disagree	Neutral
Impact on Learner			
1. Contributed to the development of my ability to critically analyze a problem related to the subject matter through group collaborative discussions.	88%	6%	6%
2. Group discussion often/sometimes caused me to re-evaluate some of the exam answers I had selected on the individual exam which I took prior to the group exam.	100%		
3. Aided my learning of the subject matter via the group discussion & information exchange amongst my group members.	100%		
4. Collaborative discussion between me and my group members, served to make the problem solving component of the subject matter more explicit to me.	82%	6%	12%
5. My group most always interacted in a collaborative manner arriving at the answers to the exam questions through group discussion and consensus.	94%		6%
6. Group part of exam helped me to formulate & explain my ideas.	94%	6%	
7. Answers to the questions were formulated through contributions from most all the group members.	100%		
8. My group members were respectful of the ideas and contributions put forward by others within the group.	94%		6%

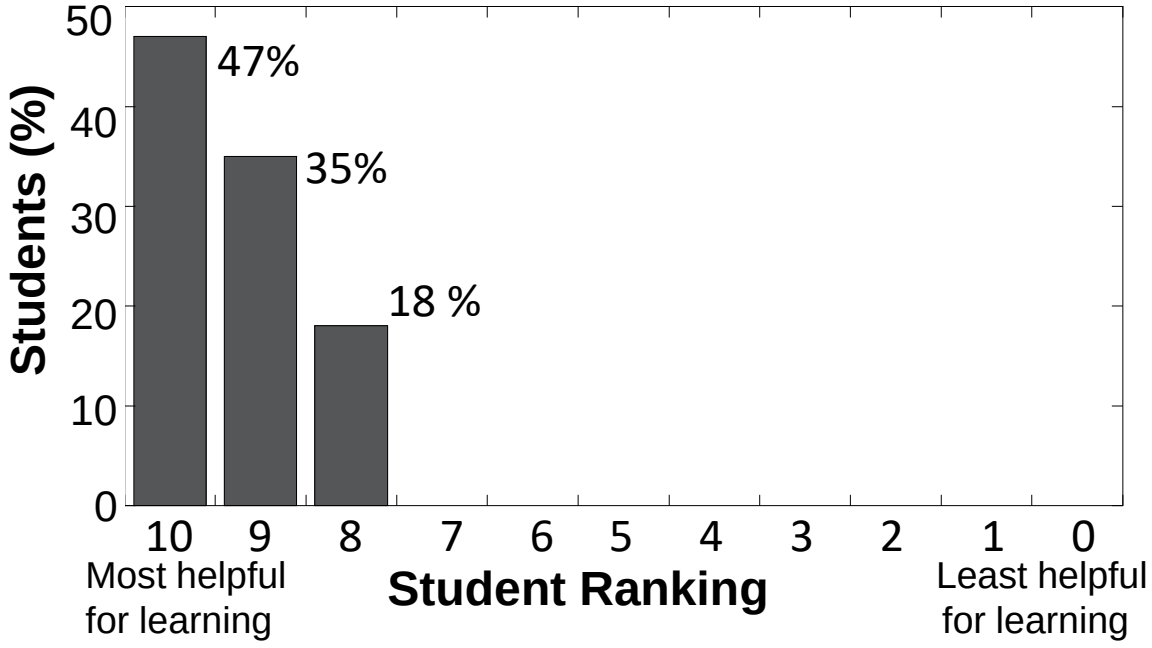
Student Survey Questions

Question- The 2-stage Exam…….Group part….	Agree	Disagree	Neutral
Generating Science Relationships			
1. Collaborative discussions amongst me and my group member's encouraged me to think critically, share my thoughts & construct explanations regarding the subject matter problem solving questions posed on the exam.	100%		
2. There are more opportunities to generate scientific ideas & inquiry with respect to the problem solving questions in the group part of the 2-stage exam than in other classes which use traditional individual written exams.	100%		
3. I find myself asking "*what would happen if…"* science-type questions more often than in other courses which use traditional individual written exams.	94%	6%	
4. I was able to discuss & modify my ideas about the subject matter because my group members had explained concepts to me that I did not fully understand prior to taking the exam.	88%	12%	
5. As a result of the group discussions, I found that I modified some of my initial ideas (*with respect to my answers on the individual exam*) regarding science relationships pertaining to the topic of absolute and relative time/oceanography, structural geol., seismology.	94%	6%	

Student Survey Questions

Question- The 2-stage Exam…….Group part….	Agree	Disagree	Neutral
Overall			
Provided a learning opportunity which enhanced my knowledge & understanding of the subject matter	88%		12%

Rate the help-fullness of this 2-stage exam towards aiding your understanding of **Relative & Absolute Time**	**Least Helpful** 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 **Most Helpful** *circle one number*



Summary and Conclusions

- **Designed, conducted, evaluated a 2-stage exam pedagogy for an introductory physical geology class**
- **Analysis of the trends in student performance for Individual-Group test components**
  - ✓ Independent of group composition most all students improved scores in the collaborative part of the exam
  - ✓ Statistically significant difference in student performance→ improved group exam
- **Analysis of trends in student performance-level with respect to group test scores**
  - ✓ High performers lower benefit from group exam (indiv. to group exam) (Improved mean score by 11% for both exams
  - ✓ Low & Mid level Performers largest benefit from group exam
    T#3 Improved mean score by 89% 62%, T #4 by 44.6%, 42%
- **Analysis of student learning from group exam component**
  - ✓ Statistical difference between Individual & Learning scores (means)
  - ✓ All students regardless of performance-level benefited from 2-stage exam
  - ✓ High performers benefited the least (Mean score improved by 11% on Retest)
  - ✓ Mid & Low performers benefited the most (Mean score improved by ~16%/Mid & 16.6%/Low)
- **2-Stage exams can be an assessment method + a learning tool**
  - ✓ Learning is most effective after students have studied the material
  - ✓ Students learn by both teaching & learning from one another
  - ✓ Students & Instructors both benefit

Where To Go → Next Steps

1. **Collect more data → more experiments**
2. **Test question design emphasize evaluation & analysis**
3. **Understand the repeat test effect**
   Differentiate learning effects as a function of "repeat test" and "collaboration"

   Did students do better on learning test because they saw the test before or was it the result of learning from collaboration
4. **Understand effect of student group dynamics on student learning**

   Random grouping vs. engineered grouping methods
5. **Determine the agility/robustness of the 2-stage test methodology**

   Examine effects across other courses & instructors

Final Question

Who Wants to do 2-Stage Exam Again...Show of Hands!

Thank You For Your Attention!

End of Presentation

New Mexico, the struggle of student success is perpetual

- state's high poverty rate
- low graduation rate
- NM students failing to meet goals in reading and math.
- According to **Education Week magazine's** latest **"Quality Counts**" study New Mexico ranked 49th (out of the 50 states and District of Columbia) for educational quality in a national review of measures such as high school graduation rates, advanced placement exam results, school finances and pre-K enrollment.

REFERENCE SLIDES AFTER THIS

Reference slide save

Summary and Conclusions + Next Steps

- Higher administrative efforts
- Group composition differences may limit effectiveness of approach (dominant student or groups with free-riders)

Reference slide save

Statistical Analysis for test # 3 (n=42) & #4 (n=40)

Individual and Group Test Scores

Back up slide

	Test #3 (n-42)		Test #4 (n=40)	
Values	**Individual Exam**	**Group Exam**	**Individual Exam**	**Group Exam**
Minimum	36	60	34	48
Maximum	84	96	94	98
Mean	56	79.52	56.85	72.3
Median	56	76	52	70
RMS	58.018	80.207	59.233	74.241
Std. Dev.	15.3528	10.572	16.479	17.082
Variance	235.71	111.77	271.57	291.81
Stnd. Error	2.369	1.6313	2.6056	2.7009
Skewness	0.33792	-0.054341	0.73771	0.13368
Kurtosis	-1.0392	-1.112	-0.39843	-1.2022

Reference slide save

Results: Paired t-Test for test # 3 (n=42) & #4 (n=40)

Paired t-Test – compare means on the same subjects over time or under different conditions

Individual and Group Test Scores

reference

	Test #3 (n-42)		Test #4 (n=40)	
	Individual Exam	**Group Exam**	**Individual Exam**	**Group Exam**
Mean	56	79.52	56.85	72.3
Variance	235.707	111.768	271.5667	291.805
Std. Dev.	15.3528	10.572	16.4793	17.0823
Std. Err.	2.36898	1.6313	2.6056	2.70095
Mean Difference	-23.5238		-15.45	
t-value	-10.459		-7.277	
t-Probability	**<0.0001**		**< 0.0001**	
Correlation	0.41595		0.68039	
Corr. Probability	0.00615		< 0.0001	

T probability value determines if there is a statistically significant difference between the two means. If this value is below a certain level (~0.05) the conclusion is that there is a difference between the two group means

T-probability <0.0001 → the probability of the two scores being the same is low (99.99 % that the two scores are different)

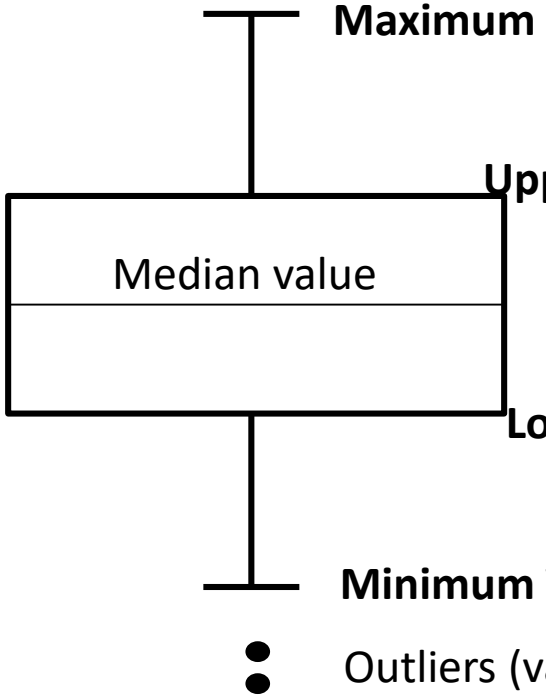
A Closer Look at the Data – Box Plots

Back up slide

- Box Plot quickly examine data and extract their major characteristics
- Global behavior
- Non-parametric (display variation in samples w/o making any assumptions of underlying stats)
  Does not tell you the distribution formula, dues not give you an indication of formula for the distribution
  i.e., Gousian has 2 parameters to define it (mean & std dev) box plot des not provide the distribution
- Spacing between different parts of box →
  degree of dispersion (spread) & skewness in data

Box represents each variable as a separate box

Y axis → range of data (scores)



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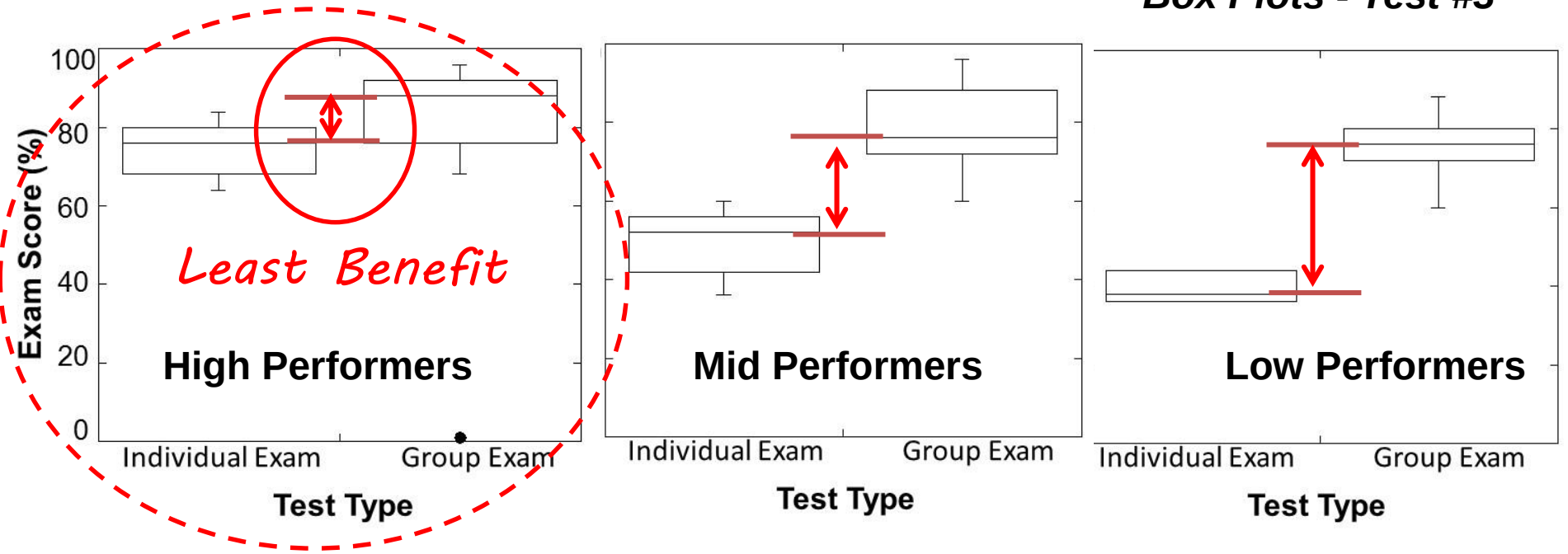
Influence of Student Performance Level on Group Exam Scores (7-7

Box Plots - Test #3

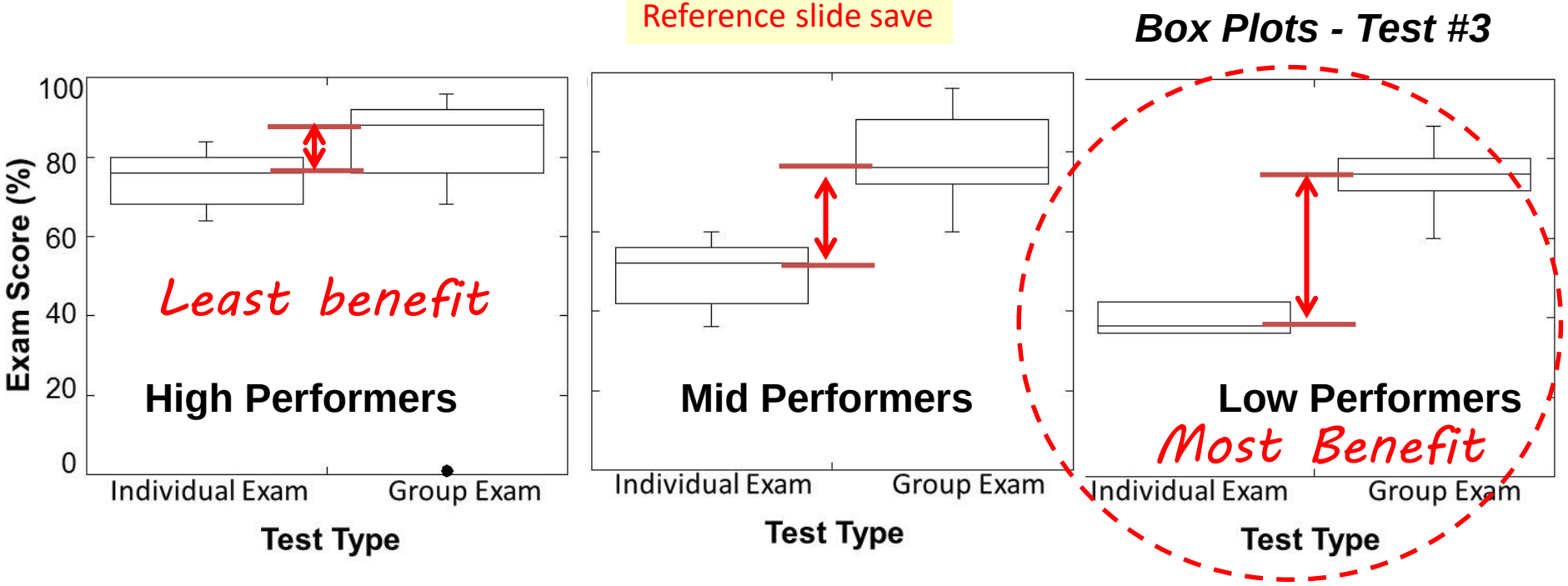


- High performers least difference between individual and group exam scores
- High performers lower benefit from group exam
  - More students scores below median value (skewed)
  - Moderate degree of dispersion (spread) in data (moderate box size)

Reference slide save

Influence of Student Performance Level on Group Exam Scores (7-7

Reference slide save

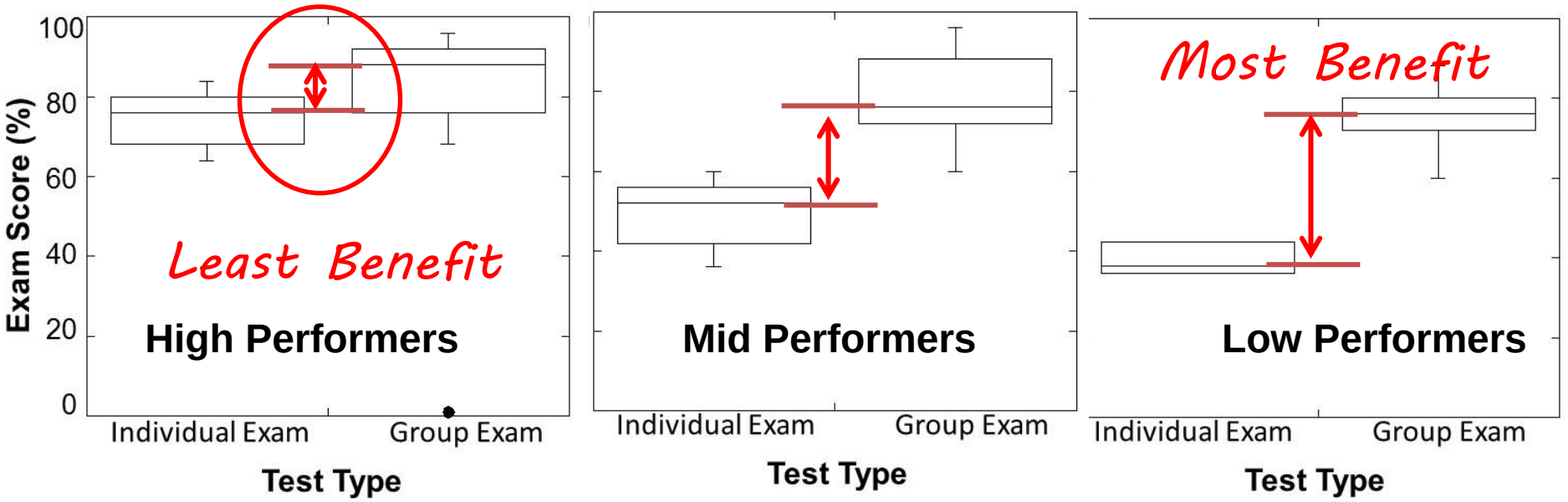


- <u>High performers</u> least difference between individual and group exam scores
- High performers lower benefit from group exam
  - More students scores below median value (skewed)
  - Moderate degree of dispersion (spread) in data (moderate box size)
- Low Performers largest difference between individual and group exam scores
  - Most benefit from group exam
  - Lowest degree of dispersion within test type data (narrow boxes)
- Mid Level performers close to that of low performers

Student Benefit by Performance Level → Box Plot Test #3 *(7-7-17)*

cked

Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	75.6	84	49.2	79.8	39.4	74.57
Median	76	88	52	76	38	76



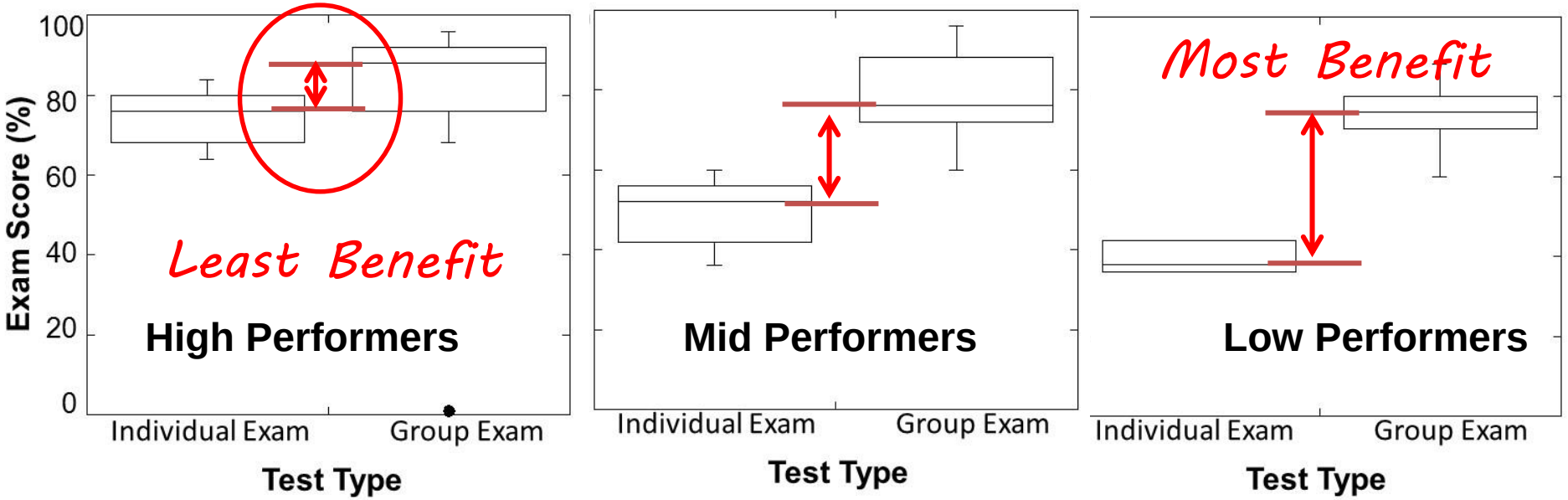
- High performers highest mean and median scores vs Mid & Low performers

Reference slide save

Student Benefit by Performance Level → Box Plot Test #3 *(7-7-17)*

cked

Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	75.6	84	49.2	79.8	39.4	74.57
Median	76	88	52	76	38	76
Std. Dev.	7.14	9.23	8.97	10.26	3.797	8.39
Min Score	64	68	36	60	36	60
Max Score	84	96	60	96	44	88



- High performers highest mean and median scores vs Mid & Low performers

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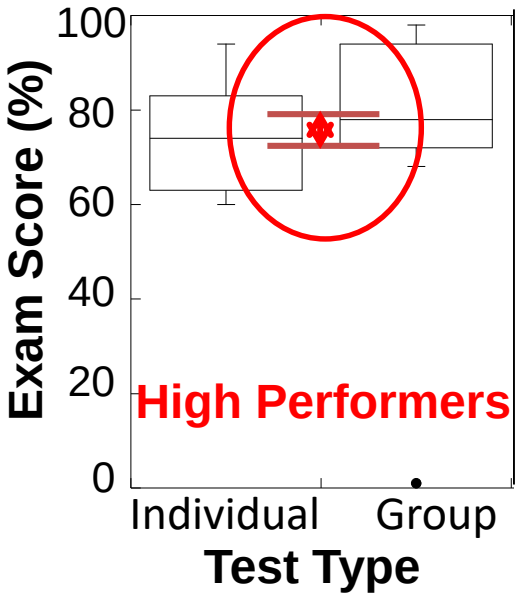
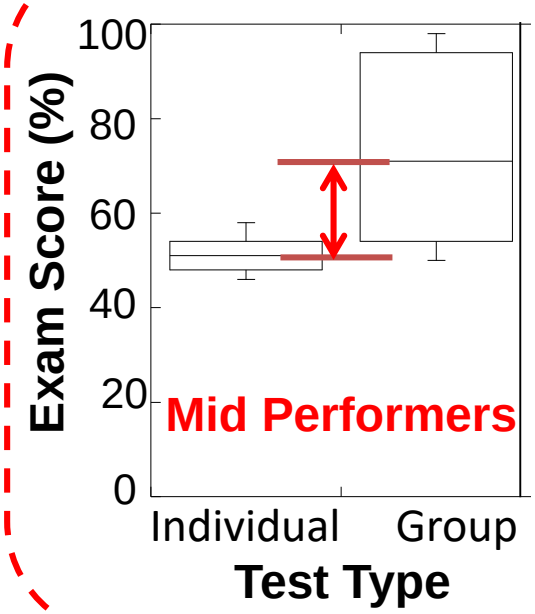
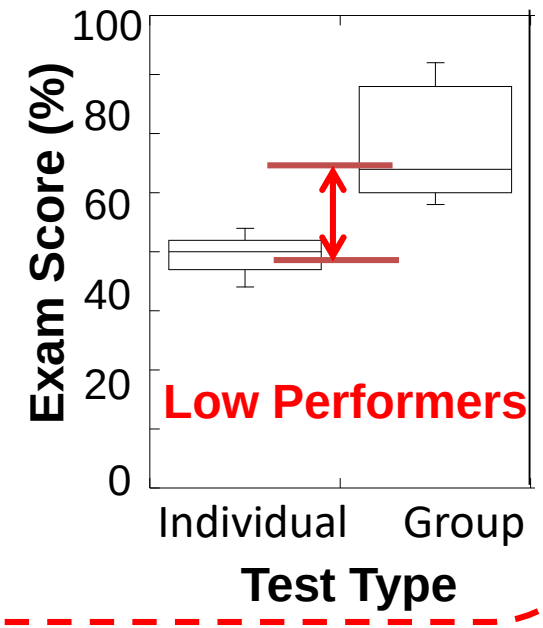
Student Benefit by Performance Level → Box Plot Test #4 (7-7-17)





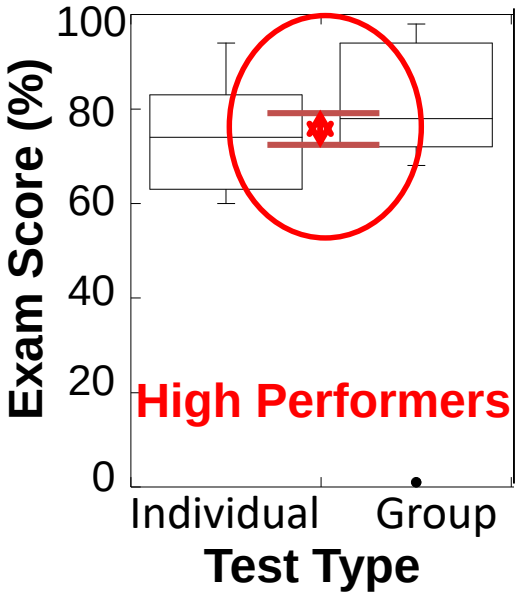


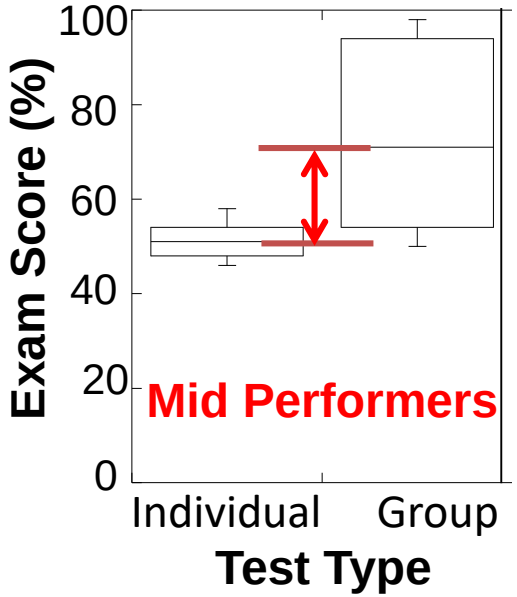
Individual vs. Group Scores (median/mean) **as a function of student performance**

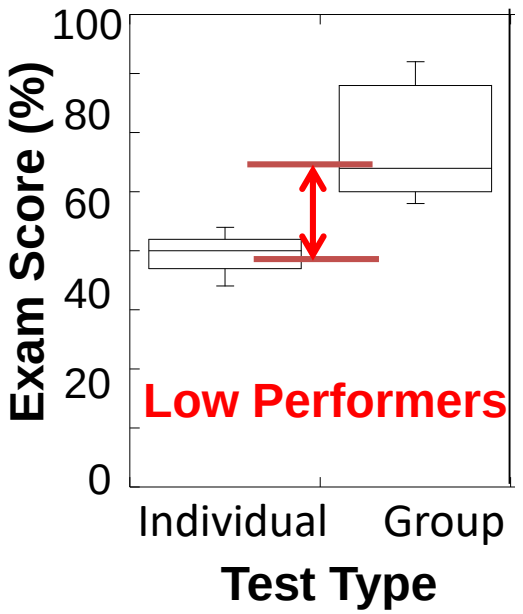
- <u>High performers</u> least difference in median (mean) scores between exams
  - ✓ More students scores below median value (skewed)
  - ✓ Moderate degree of dispersion (spread) in data
- Mid & low performers higher difference in median (mean) scores
  - ✓ Both have larger dispersion with in group scores (Group Effect)
  - ✓ Both have minimal dispersion in the individual scores

Reference slide save

Student Benefit by Performance Level → Box Plot Test #4 (7-7-17)







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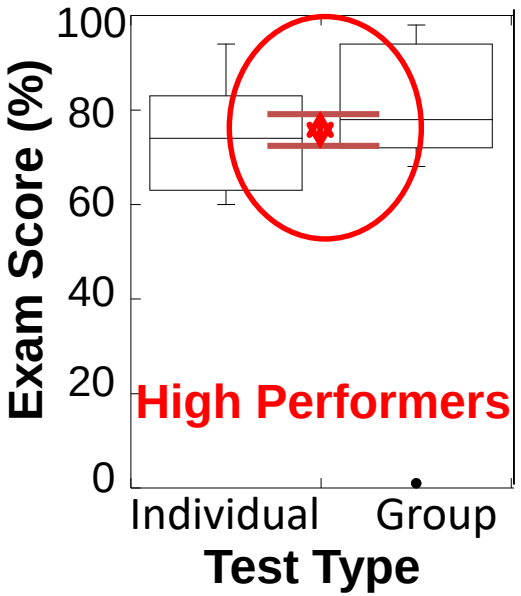
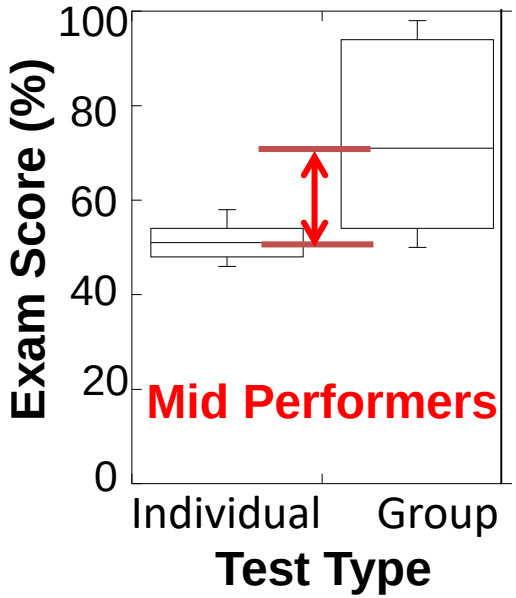
Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	74.5	82.6	51.4	73	39.6	57.3
Median	74	78	51	71	40	54

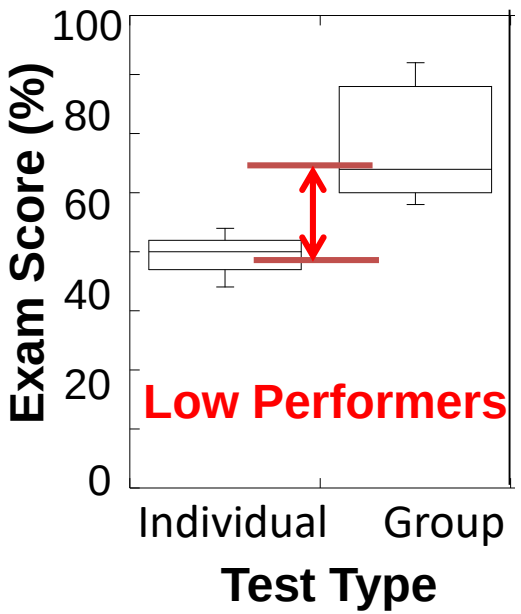
Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	74.5	82.6	51.4	73	39.6	57.3
Median	74	78	51	71	40	54

Reference slide save

Student Benefit by Performance Level → Box Plot Test #4 (7-7-17)







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Exam Type	Indiv.	Group	Indiv.	Group	Indiv.	Group
Mean	74.5	82.6	51.4	73	39.6	57.3
Median	74	78	51	71	40	54
Std. Dev.	11.81	12.41	3.54	17.98	3.32	9.56
Min Score	60	68	46	50	34	48
Max Score	94	98	58	98	44	72

Reference slide save

Paired t-Test for test # 4 individual & Retest

Individual and Retest Scores

Paired t-Test –

- ✓ Compare means on the same subjects over time or under different conditions
- ✓ Used to determine if two data sets are significantly different from each other

Variance	252.975	255.139
Std. Dev.	15.9052	15.9731
Std. Err.	2.68847	2.69994
Mean Difference	-7.2	
t-value	-7.7256	
t-Probability	**<0.0001**	
Correlation	0.94018	
Corr. Probability	0.0001	

Reference slide save

T-test

Determine if there is a statistical difference between Individual & restest scores (means)

t-probability >0.0001

T-test results demonstrated that the results are statistically different

There is a statistically significant improvement in student performance between individual and the learning test

Ind test serves as baseline assessment of students knowledge

Improvement on leaning test indicates

a) During the collaborative test the students acquitted knowledge they did not have previously
b) Learning was sufficient enough for studentsto remember it 56 weeks later

Paired t-Test for test # 4 individual & Retes

Save for reference

Individual and Retest Scores

	Test #4 (n-35)	
	Individual Exam	**Retest Exam**
Mean	55.71	62.91
Variance	252.975	255.139
Std. Dev.	15.9052	15.9731
Std. Err.	2.68847	2.69994
Mean Difference	-7.2	
t-value	-7.7256	
t-Probability	**<0.0001**	
Correlation	0.94018	
Corr. Probability	0.0001	

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Reference slide save

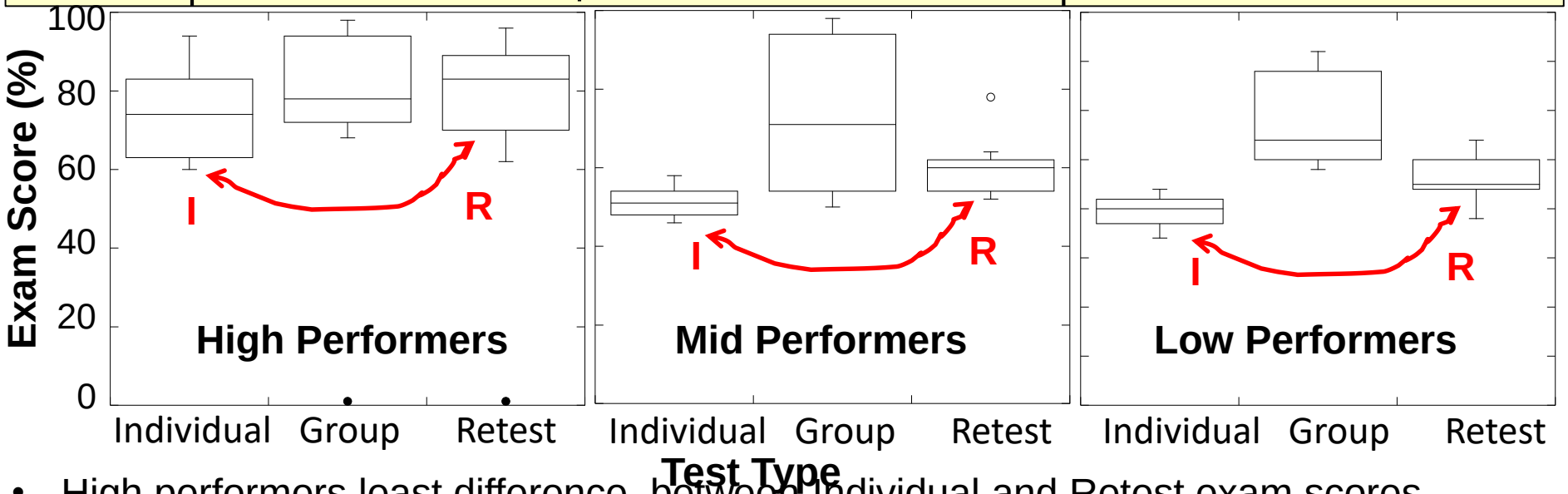
T probability value determines if there is a statistically significant difference between the two means. If this value is below a certain level (~0.05) the conclusion is that there is a difference between the two group means

T-probability <0.0001 → the probability of the two scores being the same is low (99.99 % that the two scores are different)

Student Benefit by Performance (Test #4) *(7-7-17)*

cked

Exam Type	Indiv.	Group	R-Test	Indiv.	Group	R-Test	Indiv.	Group	R-Test
Mean	74.5	82.6	80.3	51.4	73	59.6	39.6	57.2	46.2
Median	74	78	83	51	71	60	40	54	45



- High performers least difference between Individual and Retest exam scores
  - ✓ Moderate degree of dispersion (spread) in data
  - ✓ Mean score improved by 11% on Retest

Reference slide save

- Low & Mid Performers largest difference between Individual & Retest exam scores
  - ✓ Low degree of dispersion in data
  - ✓ Mean score improved by ~16% (Mid) & 16.6%(Low)
- Methods to improve Low and Mid performers learning are critical in higher education
  - ✓ Benefit directly result of peer teaching
  - ✓ Benefit due to greater motivation to learn material (better attitude about learning)
  - ✓ Student better prepared- “desire to look good amongst peers”

Keep slide for refere