

# ICOTS 7: Forming Small Class Groups Using Multidimensional Scaling

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## Overview

1. The problem
2. Example to fix ideas
3. A solution—multidimensional scaling
4. Class implementation
5. Results
6. Discussion

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## 1. The problem

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### Cooperative learning and groups

- Cooperative learning: students work together to solve a problem or complete an assignment.
- Research has shown:
  - when students work together, they often accomplish more, and at a higher level, than they could individually (Johnson et al., 1991);
  - use of small group learning activities leads to better group productivity, improved attitudes, and sometimes, increased achievement (Garfield, 1993).
- My classes (undergraduate business statistics):
  - total 60 students;
  - 15 groups of 4 students each;
  - 18–33% of grade based on group work.

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### How to form class groups?

- Allow students to self-select groups.
  - Problem: groups of friends with little diversity.
- Randomly assign students to groups.
  - Problem: students within groups sometimes have conflicting schedules.
- Suggestion from Garfield (1993): instructor forms groups to be either homogeneous or heterogeneous on particular characteristics.
  - Example: homogeneous on schedule, heterogeneous on diversity.
  - Added constraint: each group needs someone with computer/quantitative skills.

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## 2. Example to fix ideas

### Six student schedules—“yes” if busy

Student	Mon.4p	Mon.6p	Mon.8p	Tue.4p	Tue.6p
S1	Yes	Yes	Yes	No	No
S2	Yes	Yes	No	Yes	Yes
S3	Yes	No	Yes	No	Yes
S4	Yes	Yes	No	No	Yes
S5	Yes	Yes	Yes	Yes	No
S6	Yes	No	No	No	Yes

Student	Tue.8p	Wed.4p	Wed.6p	Wed.8p	skills
S1	Yes	Yes	No	Yes	1
S2	No	Yes	No	No	0
S3	No	Yes	Yes	Yes	0
S4	No	Yes	No	No	1
S5	Yes	Yes	No	Yes	0
S6	No	Yes	Yes	Yes	1

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### Find matching schedules

<b>S1</b>	4-6	6-8	8-10		<b>S2</b>	4-6	6-8	8-10		<b>S3</b>	4-6	6-8	8-10
Mon	X	X	X		Mon	X	X			Mon	X		X
Tue			X		Tue	X	X			Tue		X	
Wed	X		X		Wed	X				Wed	X	X	X
<b>S4</b>	4-6	6-8	8-10		<b>S5</b>	4-6	6-8	8-10		<b>S6</b>	4-6	6-8	8-10
Mon	X	X			Mon	X	X	X		Mon	X		
Tue		X			Tue	X		X		Tue		X	
Wed	X	X	X		Wed	X		X		Wed	X	X	X

- S1 and S5 can meet for group work two times.
- S2 and S4 can meet two times.
- S3 and S6 can meet three times.
- Imagine doing this for 60 students and 49 time slots!
- Is there a better way?

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#### Multidimensional Scaling (MDS)

- MDS: methods for displaying set of objects in low-dimensional space (often 2D) to reflect object similarities (see Kruskal and Wish, 1978).
- Input: matrix of pairwise similarities between objects (e.g., associations between student schedules).
- Analysis:
  - Metric MDS—eigenvalue decomposition similar to principal components;
  - Nonmetric MDS—optimization algorithm to minimize “stress” (badness of fit) between object similarities and map distances.
- Output: object coordinates in reduced-dimension space (e.g., reduce 9 time slots to 2 dimensions):
  - Use 2 dimensions to produce map where distances match student schedule similarities.

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#### Example revisited

- Recall 6 students with mix of schedules (9 time slots).
- Pairwise correlations (equivalent to Kendall’s tau in this case):

	S1	S2	S3	S4	S5	S6
S1	.	-0.16	0.00	0.16	<b>0.76</b>	-0.16
S2	.	.	-0.16	<b>0.80</b>	0.06	0.10
S3	.	.	.	0.16	-0.38	<b>0.79</b>
S4	.	.	.	.	-0.06	0.35
S5	.	.	.	.	.	-0.48

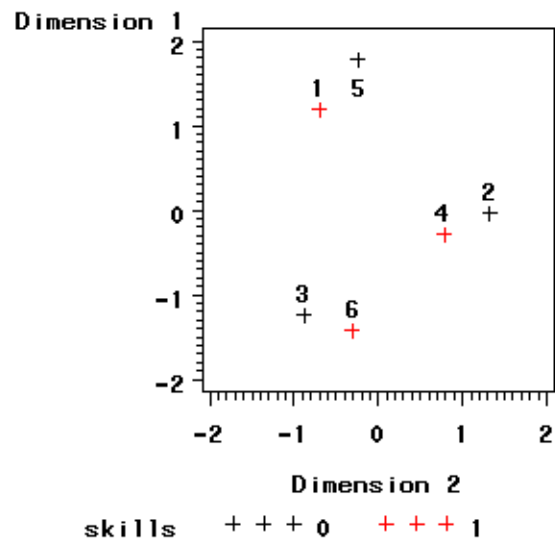
- Translate correlations into “dissimilarities” and feed into metric MDS.
- Analysis produces the following map . . .

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## Perceptual map

MDS of student schedules produces expected groupings:



### Online survey

Select the time periods when you absolutely cannot meet with your group because you are in class, work, or other scheduled activity for most or all of the period during the quarter. For example, you should select Mondays and Wednesdays 10-12am since you have class then. I will try to put you in a group with a similar schedule to yours. Be careful to select times when you CANNOT meet (not times when you can meet).

	8-10am	10-12am	12-2pm	2-4pm	4-6pm	6-8pm	8-10pm
Monday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tuesday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wednesday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Thursday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Friday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Saturday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sunday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Are you good with computers?  
 No  Yes

Are you good at analytical thinking?  
 No  Yes

Please carefully check your responses before submitting the survey by clicking the button below.

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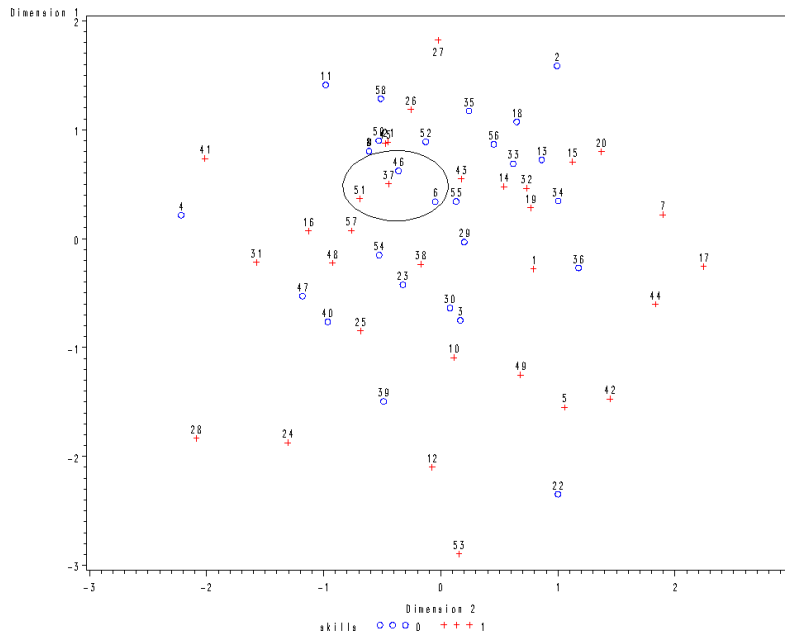
### Use SAS to analyze survey data

- Online survey results fed into SAS.
- Use PROC CORR to calculate correlations.
- Use PROC MDS to run metric MDS.
- Use PROC GPLOT to produce map.
- All code available at my website (see end slide).
- Example: 60 students, 49 time slots from a recent quarter.
- Eyeball map to group “close” students (making sure each group has a member with computer/analytical skills) . . .

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## Perceptual map



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## 5. Results

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### Results

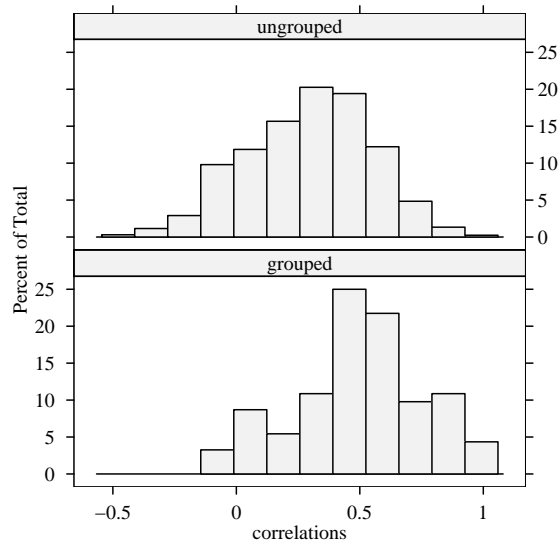
- Schedule correlations across whole class range from  $-0.5$  to  $1.0$  (mean of  $0.29$ ).
- Within-group correlations for circled group on map range from  $0.5$  to  $0.8$ .
- Within-group correlations for all 15 selected groups range from  $-0.10$  to  $1.0$  (mean of  $0.50$ ).
- Histograms on next slide summarize overall improvement.
- However, some students (on edge of map) don't match anyone else—hard to place them in groups.

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## Histograms of schedule correlations

Before (upper) and after (lower) forming groups:



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## 6. Discussion

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### Discussion

- Problem: self-selected groups inhibit diversity, but randomly selected groups create scheduling problems.
- A solution: multidimensional scaling (MDS).
- Costs: SAS code, survey design and administration, eyeballing map.
- Benefit: increased group schedule compatibility, improved group effectiveness, fewer student complaints!
- Side-benefits: opportunities to explore concepts in class (surveys, association measures, MDS, statistical graphics).
- More information and SAS code at <http://lcb1.uoregon.edu/ipardoe/research.htm>.

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