

**Introduction:**

# Group-Formation Tools for LEARN

**WU**

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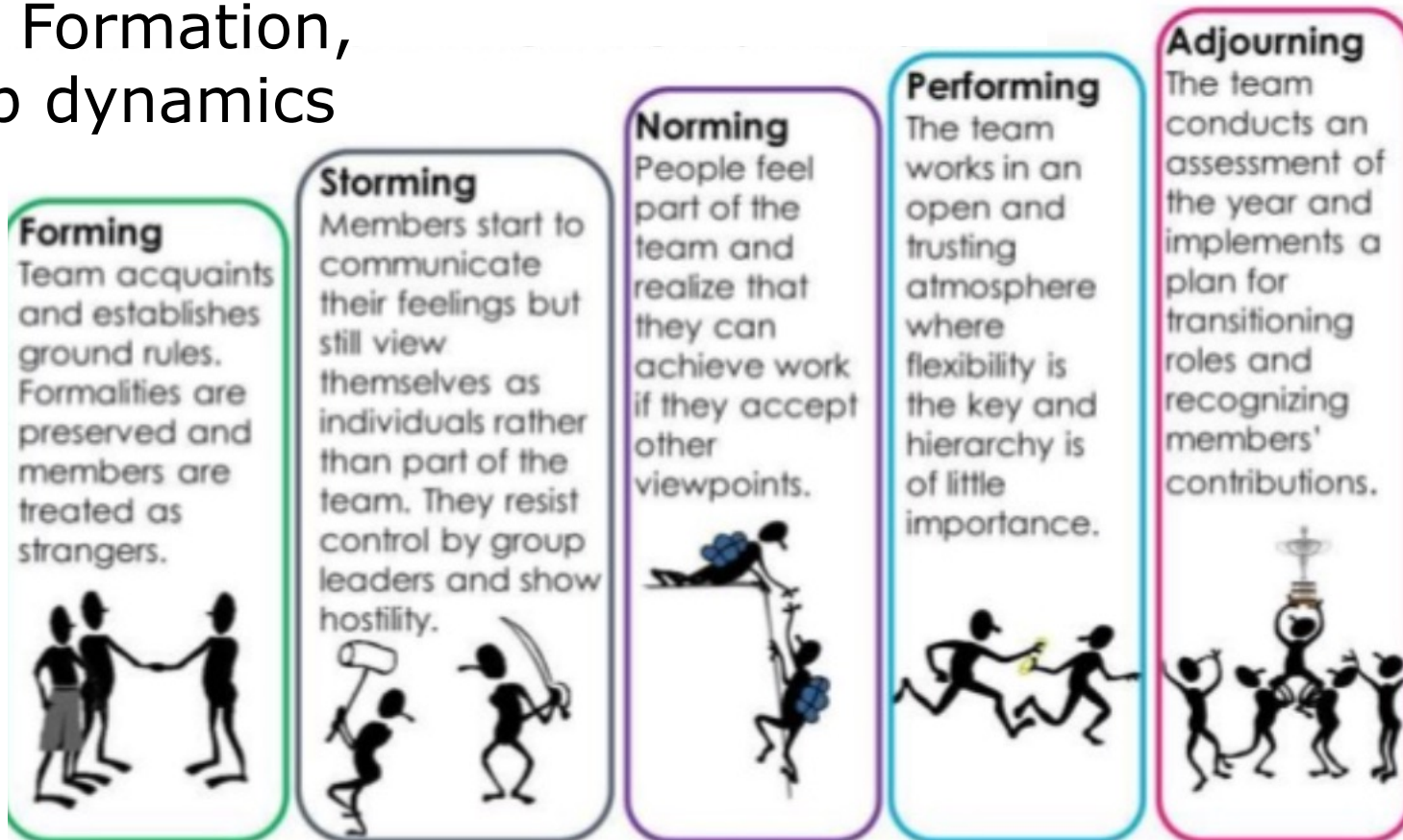
MAR 2021



- Learning Group formation
- Learning Group formation based on Optimzation
- Optimization criteria
- Group formation based on infrastructure of inclass exam
- Discussion

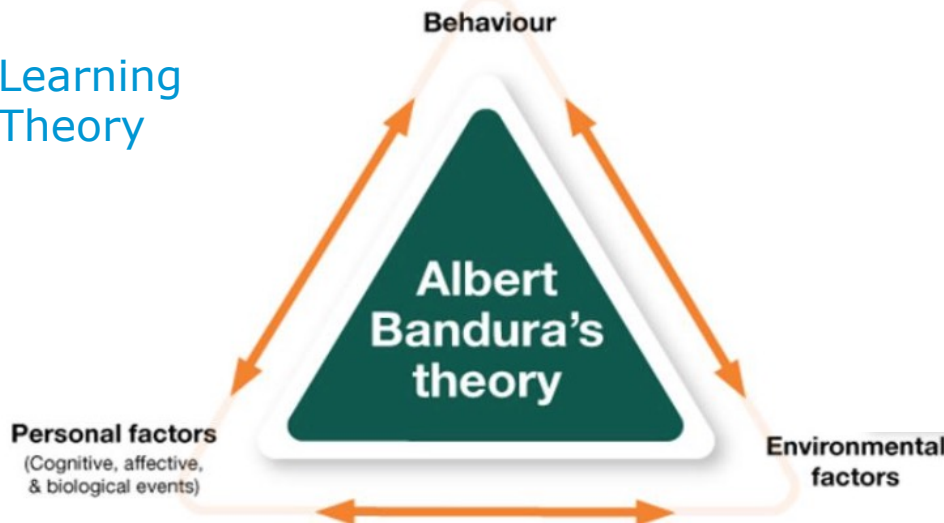
# Tuckman's Group Development Stages (1965)

## Team Formation, Group dynamics

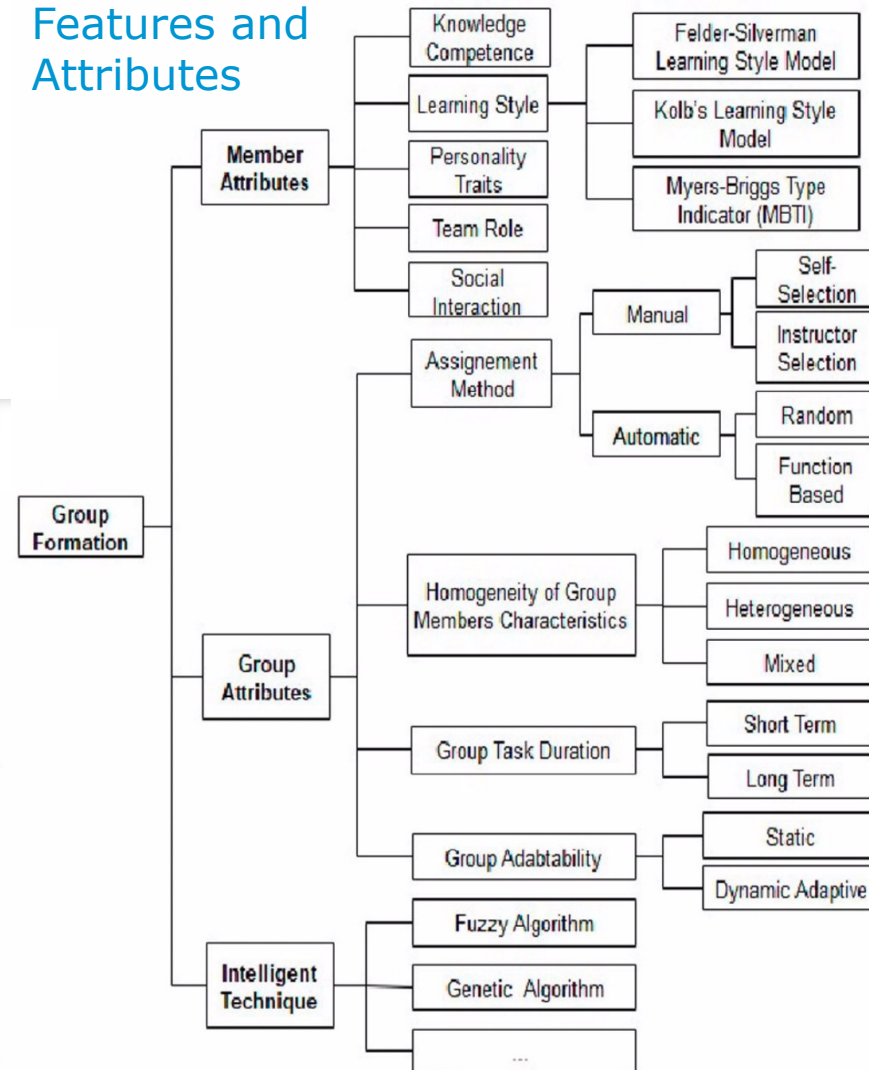


# Learning Group-Formation - A wide field

## Learning Theory



## Features and Attributes



## Quality criteria

Metrics to measure Group Formation		Student	Group	Class
Efficiency	Group formation time		✓	✓
Optimization	All students can be distributed to the group		✓	✓
	Collaboration performance (CO)	✓	✓	✓
Productivity	Knowledge	✓	✓	✓
	Skills	✓	✓	✓

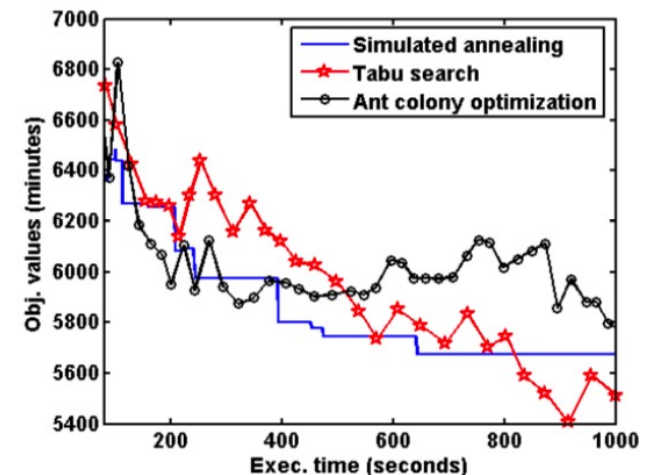
# Real-World Approaches for Learning Group Formation

- **Low-Tech Approaches**
  - **Random assignment:** quick, students have no choice
  - **Self-selection:** students can join groups (first comes, first served)
- **Optimized Groups based on**
  - **Student Preferences**
    - Topic Preferences (subjects)
    - Learning groups, friends
  - **Didactic Preferences, learning objectives**
    - Reciprocal learning
    - Group performance
    - Homogeneous vs heterogeneous groups
  - **Group Sizes:**
    - Min, max, size variability, optionality,

# Defining “good” Groups

- **Criteria**
  - Different variables in different approaches relevant
  - Different criteria
  - Required criteria vs. preferences
- **Data sources**
  - System: learner performance, learner choices
  - Student survey: preferences, self-assessment
- **Optimization**
  - Complex formulation as e.g. linear program
  - Problems have
    - Often multiple solutions
    - Sometimes no solutions (over-constraint)
  - Heuristics
    - Biology: Ant-colony
    - Physics: Particle swarm optimization
    - Business administration: tabu search

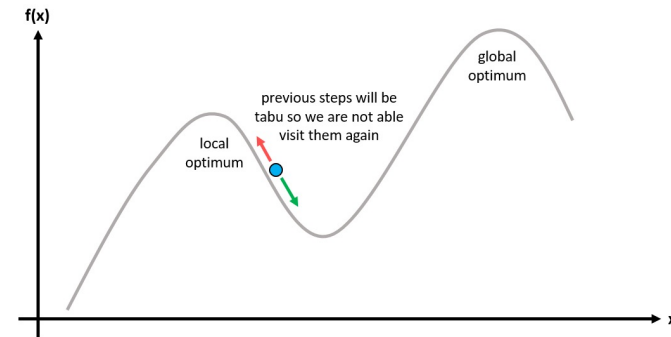
Example applicaton



# Tabu Search

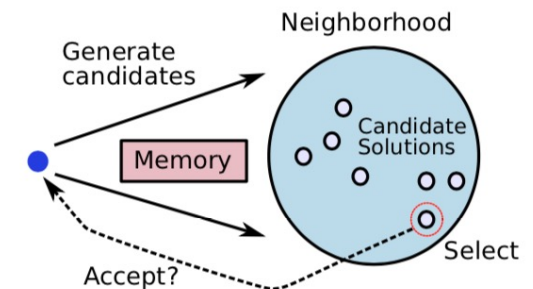
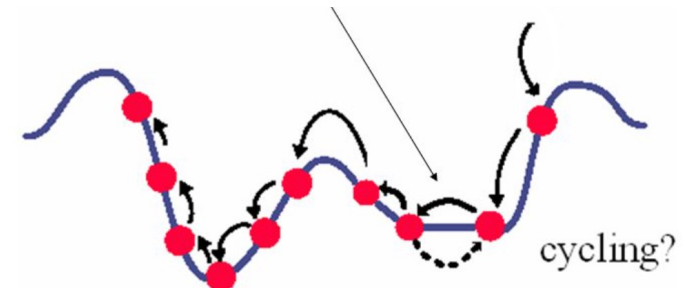
## Original Problem

- Traveling salesman (Glover 1986)
- Used for e.g. resource planning, telecommunications, VLSI design, financial analysis, scheduling, molecular engineering, logistics, ...



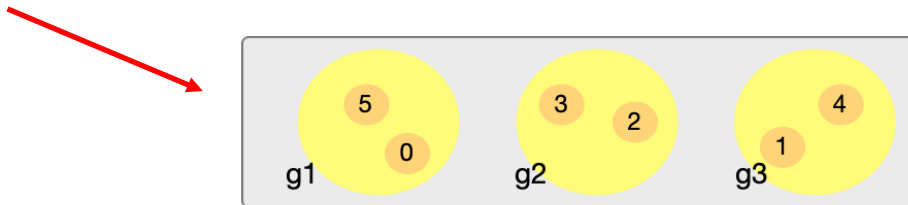
## Basic Idea:

- Initial Solution
  - Typically based on random numbers
- Compute "neighborhoods"
- Iterative improvement while avoiding
  - local maxima
  - Computing in circles
- Using a "short-term" memory of solutions which are "tabu"



# Tabu search for group formation

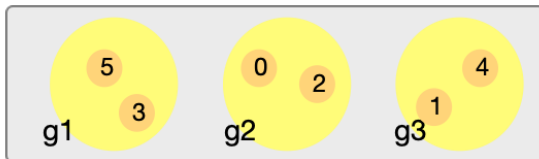
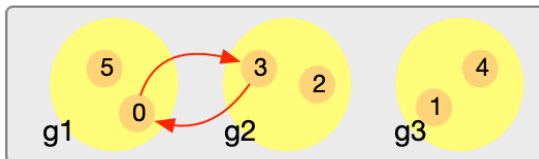
(1) Randomized initial solution:  
members assigned randomly to groups



(2) Iterative improvement  
based on valid operations  
to define neighborhoods

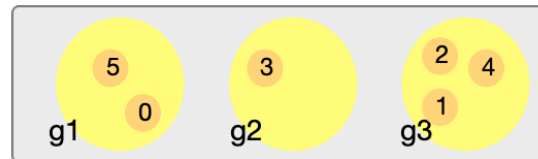
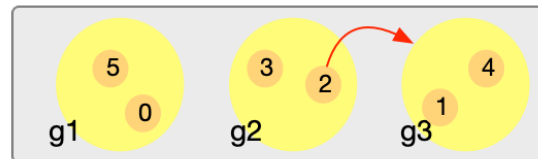
## Swap

(two members change group)



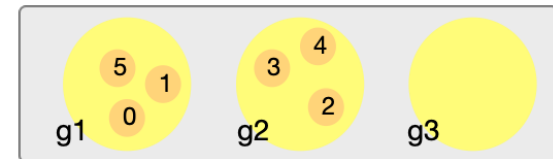
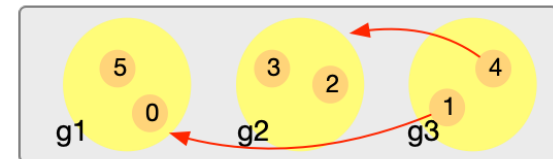
## Move

(a member moves to an other group)



## Resolve

(all members of one group join an other group)



(3) Evaluate potentially large neighborhood for better solution

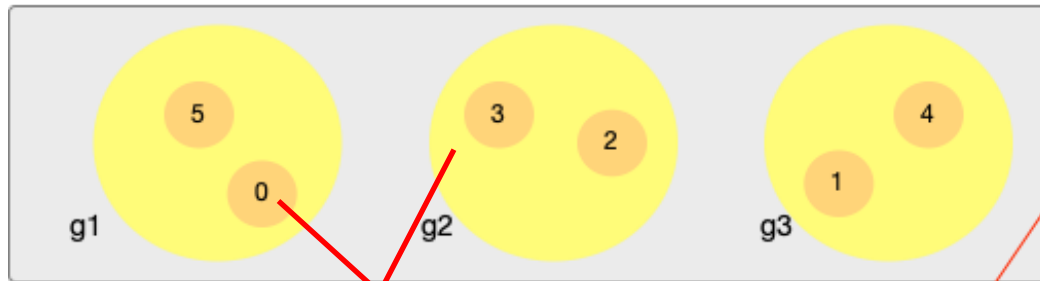
(4) Chosen solution from neighborhood is base for next iteration.

(5) When no improvement can be found (after many iteration),  
tabu search stops

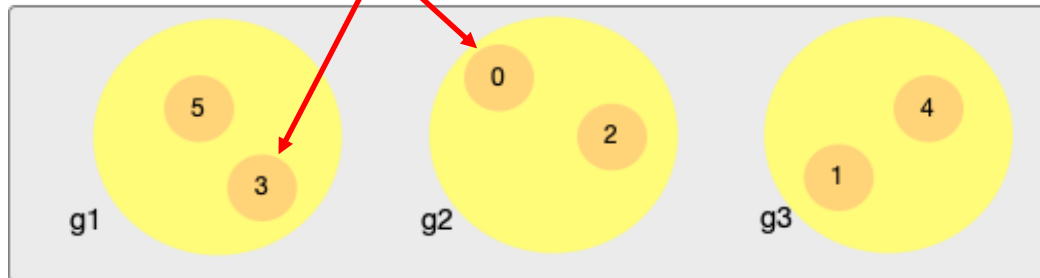
# Cost-based optimization

- Groups have “costs” derived from criteria (e.g. student preferences)
- Goal: minimize costs

Initial solution: cost 9



Solution 1: cost 7



• • •

After swap of 0 and 3

- swap 0 1
- swap 0 2
- swap 0 3
- swap 0 4
- swap 0 5
- swap 1 2
- swap 1 3
- swap 1 4
- swap 1 5
- swap 2 3
- swap 2 4
- swap 2 5
- swap 3 4
- swap 3 5
- swap 4 5

Neighbourhood  
tabu:

Improvement for two operations Possible. Apply e.g. “swap 0 3”

Neighbourhood  
tabu: 0 3

- Iterate based on operations “swap”, “move” and “resolve” until no improvement can be achieved.

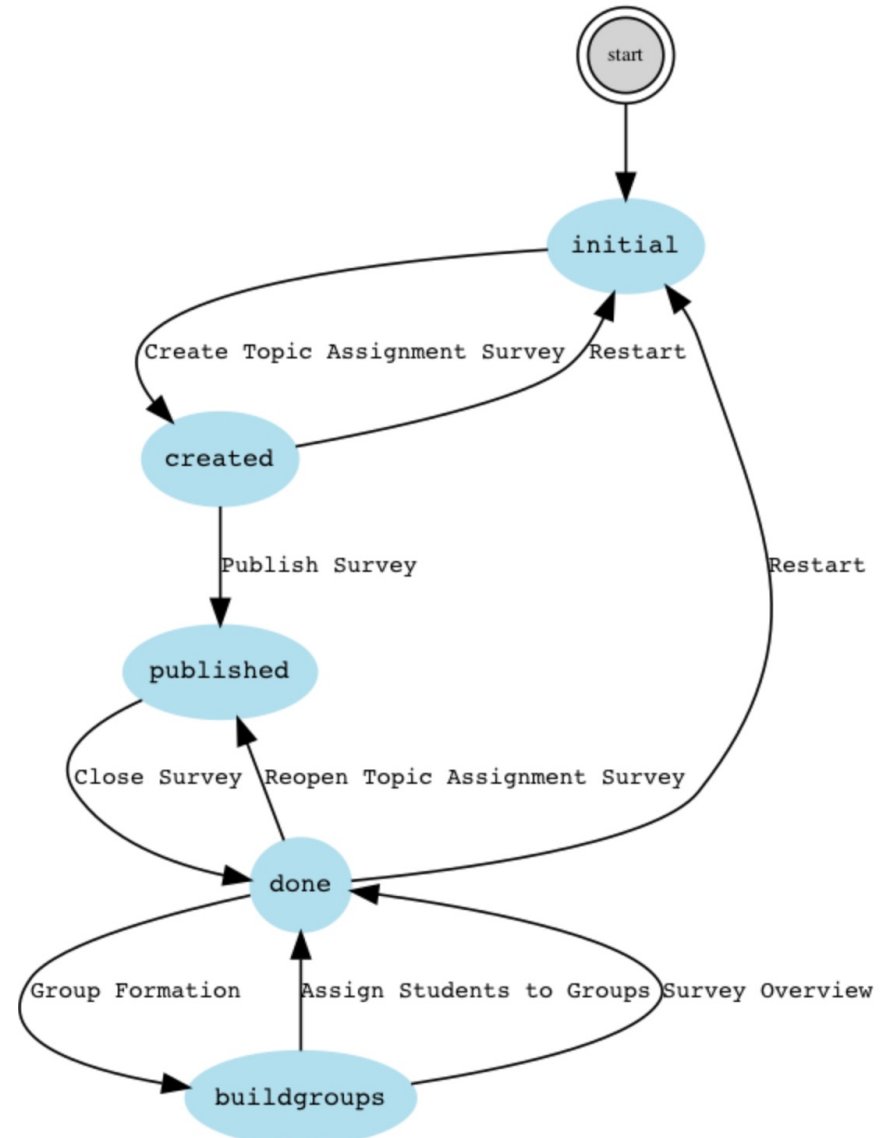
# Typical Steps from Lecturer Perspective

## Typical Steps

1. Create topic assignment
2. Publish survey (students can file preferences)
3. Close survey
4. Provide parameters for group formation
5. Based on parameters and survey data groups are generated
6. Assign student to groups

Later, manual adjustments on groups can be performed.

For group formation without student input, steps 2 and 3 can be omitted.



# Implemented Group Formation Types based on Tabu Search

## Currently Supported Group Formation Types

### 1. Random assignment

### 2. Student-cost minimization

- Topic preferences based on ranks
  - Use case: Seminar, student can choose a topics
  - More topics than planned groups are presented
  - Currently costs linear to preference rank, often e.g. quadratic costs are used
  - Using an ordering exercise (students get the topics presented in a shuffled way to avoid to high preferences on the first topic)
- Team preferences
  - Form teams when there is a **mutual preference** of the candidates
  - Can be combined with topics preferences

### 3. Formation based on **group quality** criteria

- Creation of **evenly skilled groups**
- Reciprocal learning (unexperienced students learn from experienced ones)
- Every group should have at least one person with a high skill in every skill dimension
- Use case Data-Science: every group should have a good statics person and a good programmer
- Optimization:
  - **Skill of a group = maximum skill value per dimension in the group**
  - **Goal: maximize the minimal skill for each group**
- Arbitrary numbers of skills can be provided

Also possible:  
e.g. Maximally Diverse Groups,

...

# Implemented Features and Parameters

## Parameters controlling number of participants

1. Number of students
  2. Number of groups
  3. Minimal number of participants per group (default: 2)
  4. Maximal number of participants per group (default unlimited)
  5. Allow optionally empty groups (sometimes better to have fewer larger groups)
- > groups can have different sizes

## Parameters controlling tabu search

1. Number of iterations
2. Number of iterations without improvement
3. Tabu size (size of short-time memory)

## Operations for neighborhood definition

1. Swap of students between groups (group sizes are not affected)
2. Move one student to some other group (must respect min and max group size)
3. Resolve a group: all students of one group are distributed to other groups

## Initial Solution

- ... based on consistency criteria
- Criteria are extensible

# 2 Examples

## 1. Group formation via students' topic preferences

- Lecturer create list for topics via "Ordering Exercise"
- Lecturer publishes topic preferences survey (like in in-class exam)
- When the survey is closed, lecturer provides parameter to group formation and creates groups

## 2. Group formation via students' topic preferences and team preferences

- Like above, but before publishing, lecturer can activate team preferences
- Students get a 2 page survey consisting of topic preferences and the option to select preferred team members via drag and drop
- Only reciprocal team member preferences are taken into account during groups formation
- Team and topic preferences can be weighted

# Example 1: Seminar with Topic Preferences

## Provide Topics as ordering exercise

- Syllabus
- Kalender
- Ankündigungen
- Lernen & Üben**
- Lernaktivitäten
  - BBB Online Sessions
  - Contents and Goals
  - The Seminar in the Context of Your Study
  - The Seminar Workflow in Details
  - Course Calendar
  - Milestones
  - Performance Evaluation and Grading
  - Important Notes
- Topics
- Assignment 1 - two-pager & project plan

### List of Topics

[Ansehen](#) · [Verlauf](#) · [Löschen](#) · [Verwalten](#) · [Suche](#) · [Index](#)

Please order the topics according to your preferences (starting with most wanted topic):

- ◆ Topic 4: Testing the Implementation of the GDPR
- ◆ Topic 5: Human-centricity, Sustainability, Accountability, and Ethicality: Conceptual and Applied Frameworks
- ◆ Topic 1: Detecting xenophobic messages in Social Media
- ◆ Topic 3: [How] Do Users Benefit From Giving Consent?
- ◆ Topic 2: Student Perspectives and Satisfaction with Technology Enhanced Learning in Higher Education
- ◆ Topic 8: Human-centric Evaluation of Third-party Consent Intermediaries: A User-based Study
- ◆ Topic 7: The Emerging Application of Blockchain-based Traceability Technologies in Online Shopping: A Human-centric Evaluation
- ◆ Topic 6: Documenting Consent Dialogue Violations through Legal Clauses

- Presentation of topics in randomized order.
- Student can reorder topics with drag&drop according to her preferences

# Example 1: Seminar with Topic Preferences

## Survey is closed, preferences are available

Provide parameters for groups formation:

- Ankündigungen
- Lernen & Üben**
- Lernaktivitäten
  - BBB Online Sessions
  - Contents and Goals
  - The Seminar in the Context of Your Study
  - The Seminar Workflow in Details
  - Course Calendar
  - Milestones
  - Performance Evaluation and Grading
  - Important Notes
- Topics
- Assignment 1 - two-pager & project plan
- Assignment 2 - Research questions & Methodology
- Assignment 3 - Study design & Paper structure

### Topic Assignment Survey is closed

Non-Synchronized Exam

Survey published: 11. März 2021, 19:03 - 19:13

Submitted Preferences

15/15 Preferences provided by students

Topics ▾

### Group formation parameters

Max Students per group

4

Min Students per group

2

Allow empty groups

Ja  Nein

[\[Teilnehmer/innen\]](#), [Prüfungsprotokoll](#), [Ergebnisse](#)

Reopen Topic Assignment Survey

Group Formation

# Example 1: Seminar with Topic Preferences

## Results of tabu search

### Group assignment parameters

```
nrParticipants=15
nrGroups=8
maxgroupsize: 4
mingroupsize: 2
allowemptygroups: t
```

```
== Result:
Group g1: Topic 1: Detecting xenophobic messages in Social Media
  3 cost:0 {user .....} 1 7 2 5 6 4 8 3
  7 cost:0 {user .....} 1 3 2 6 5 4 8 7
  9 cost:0 {user .....} 1 3 2 4 5 6 8 7
 11 cost:0 {user .....} 1 5 3 4 7 8 6 2

Group g2: Topic 2: Student Perspectives and Satisfaction with Technology Enhanced Learning
  0 cost:1 {user .....} 1 2 5 3 4 8 7 6
  8 cost:0 {user .....} 2 7 1 5 4 3 8 6
 12 cost:2 {user .....} 6 1 2 3 8 4 5 7

Group g4: Topic 4: Testing the Implementation of the GDPR
  4 cost:1 {user .....} 2 4 3 7 8 5 1 6
  5 cost:0 {user .....} 4 3 1 2 5 7 8 6

Group g5: Topic 5: Human-centricity, Sustainability, Accountability, and Ethicality: Concep
 10 cost:1 {user .....} 1 5 3 4 6 7 8 2
 14 cost:1 {user .....} 1 5 3 7 4 2 8 6

Group g7: Topic 7: The Emerging Application of Blockchain-based Traceability Technologies :
  1 cost:0 {user .....} 7 4 3 5 6 8 2 1
  2 cost:0 {user .....} 7 2 3 5 6 8 1 4
  6 cost:0 {user .....} 7 4 3 1 2 5 8 6
 13 cost:0 {user .....} 7 8 5 1 2 3 4 6

Number of students per group: g1 4 g2 3 g4 2 g5 2 g7 4
Cost: 6
```

Topic 1 was very popular:  
- first preference of 7 students

Only student 12 got 3rd preference, since  
- group 6 (1st pref) was not possible  
- second preference was the most common

Stronger weighting of preference ranks would change results

# Example 2: Seminar with Topic Preferences and Team Preferences

## Activate team preferences

WU LEARN MyLearn Courses Your search 5

4096 - BIS Seminar

XoWiki Workflow New Clipboard This page...

### Testing Topic assignments

View · Edit · View history · Delete · Manage · Search · Index

Title: Testing Topic assignments

Topics\*

Selection	Candidates
List of Topics	Topics - for testing

Select Topic List via Drag and Drop

**Team preferences**

Yes  No

Allow students to select team preferences

Time Management

Create Topic Assignment Survey

Lecturer can activate optionally team preferences when creating the topic assignment survey

# Example 2: Seminar with Topic Preferences and Team Preferences

## Student selects preferred group members

WU LEARN MyLearn Courses Your search 5

4096 - BIS Seminar

### Testing Topic assignments

Preferred group members

Selection	Candidates
<input type="text"/>	<input type="text"/>
	<input type="text"/>
	<input type="text"/>
	<input type="text"/>
	<input type="text"/>
	<input type="text"/>
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	<input type="text"/>
	<input type="text"/>

Select preferred group members via Drag and Drop. Only reciprocal preferences are honored.

1 2 Submit Preferences

After topic preferences, students can select preferred group members via drag&drop.

Only reciprocal preferences are honored.

# Conclusions

1. Basic mechanism is flexible and extensible
2. Due to heuristic search, it is straightforward to implement other group formation schemes
3. Different questionnaires for e.g. self-assessment of skills could be provided
4. Questionnaires should be probably not freely defined by teachers, since the queried data should be directly processed by tabu search
5. Current workflow implementation uses for topic preferences "ordering questions" and allows only these
6. Skill-Data could also be obtained from the grading data-warehouse on LEARN
7. Experience in Seminar in March 2021 was positive (online lecture); essentially a proof of concept
8. Components of inclass-exam proved to be quite handy for topic selection (publishing process, timer, live-updates for incoming preferences, ...).



Questions? Suggestions?