32nd Annual INCOSE international symposium

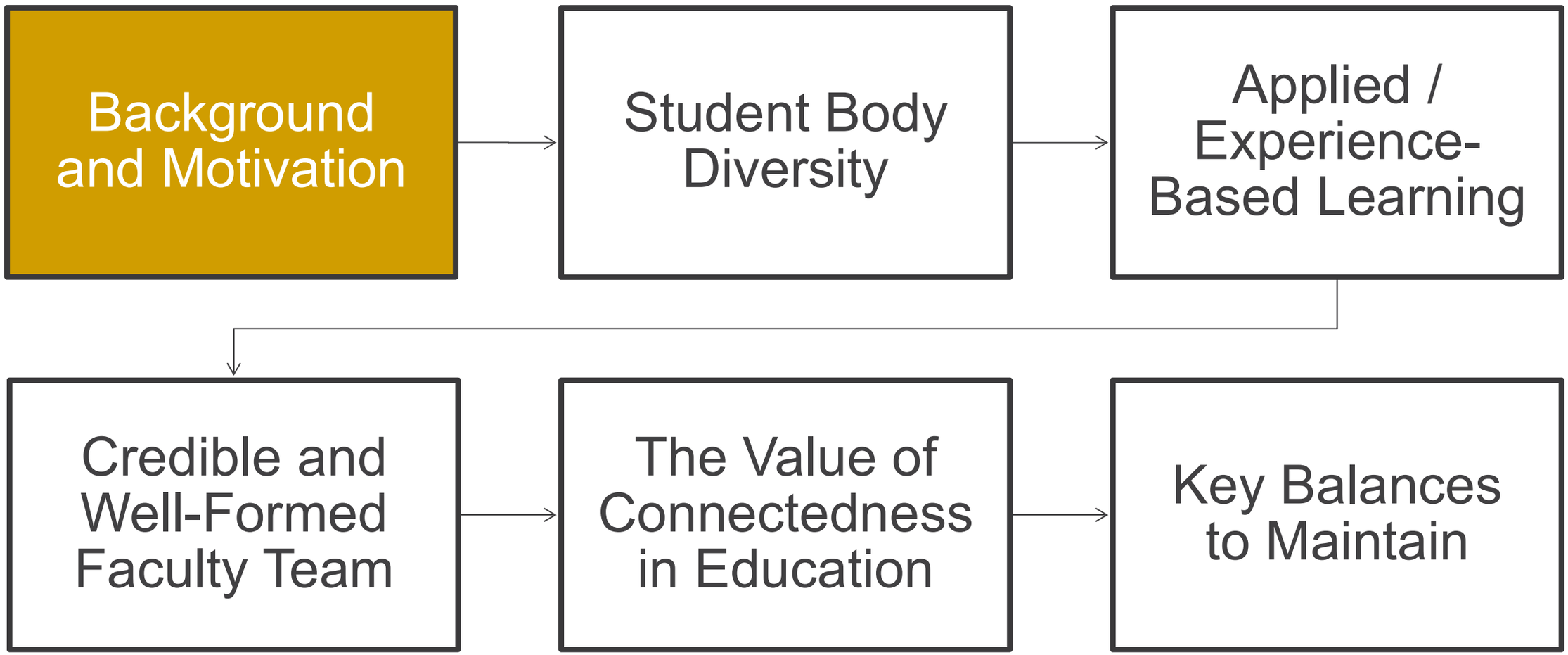
hybrid event

Detroit, MI, USA
June 25 - 30, 2022

Crafting an Experience-Based Master's Program in Systems Engineering

www.incose.org/symp2022

Agenda


Background and Motivation
Student Body Diversity
Applied / Experience-Based Learning
Credible and Well-Formed Faculty Team
The Value of Connectedness in Education
Key Balances to Maintain

Background – Industry Need

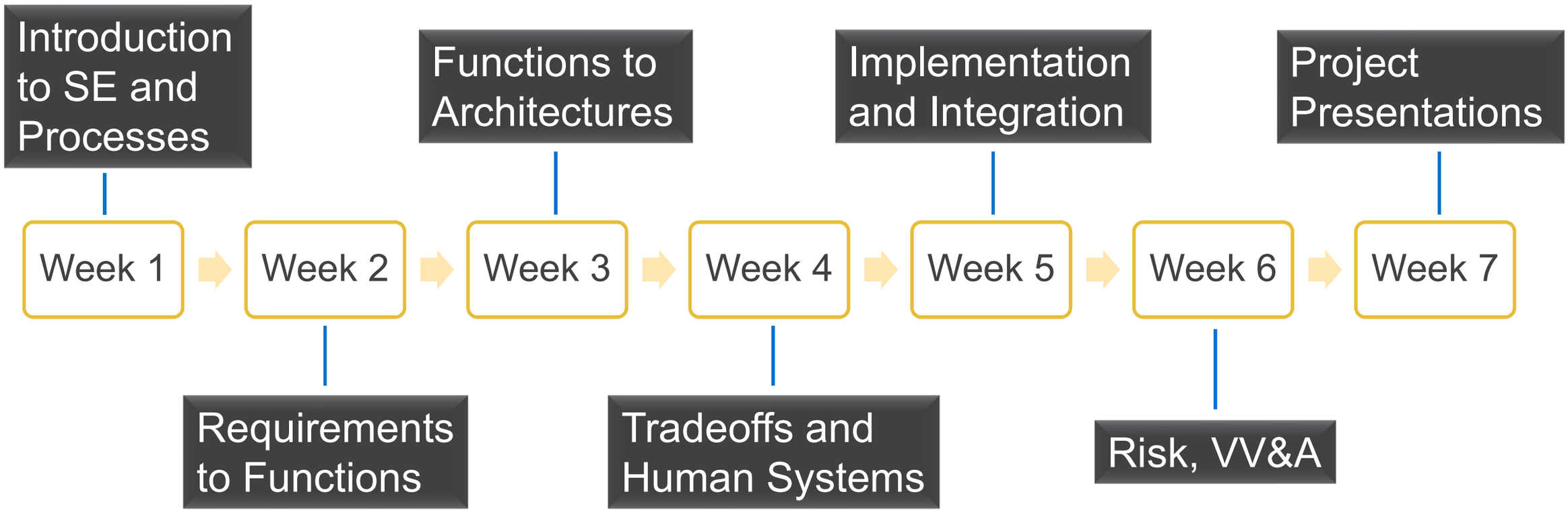
- Increasing complexity = increasing need for SEs
- Lack of SEs to meet demand
- Lack of dedicated training to create new SEs

The PMASE Motivation

- Respond to industry need by accelerating creation of quality SEs:
  - Applied nature of the learning needs and process
  - Cohort model to promote team aspects of systems engineering
  - Compressed 7-week formats with an immersive focus

- 2-year, 10-course master's
- SACS-accredited
- Active project work in every course
- Case study-based examples

First Course Overview

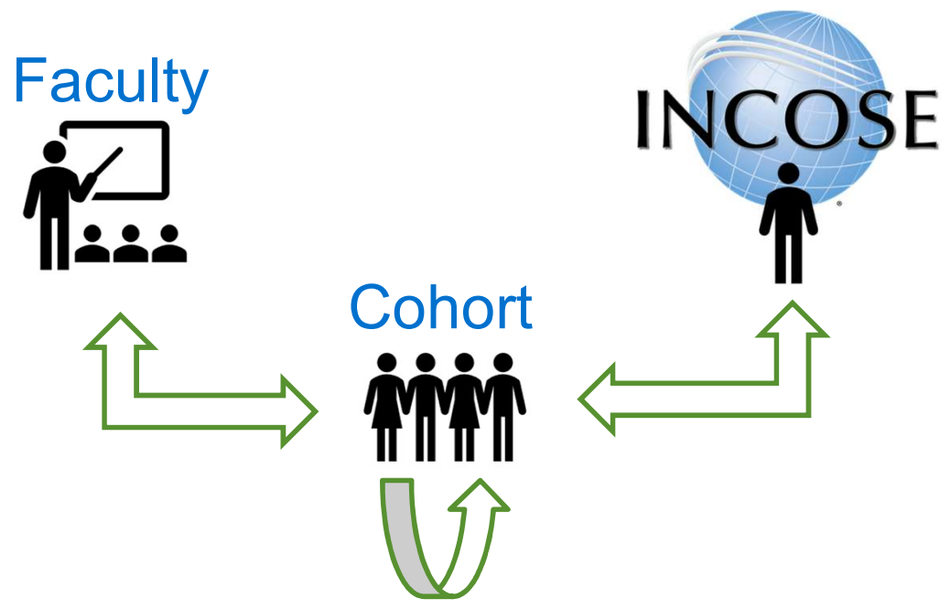


Kickoff Week

Activities

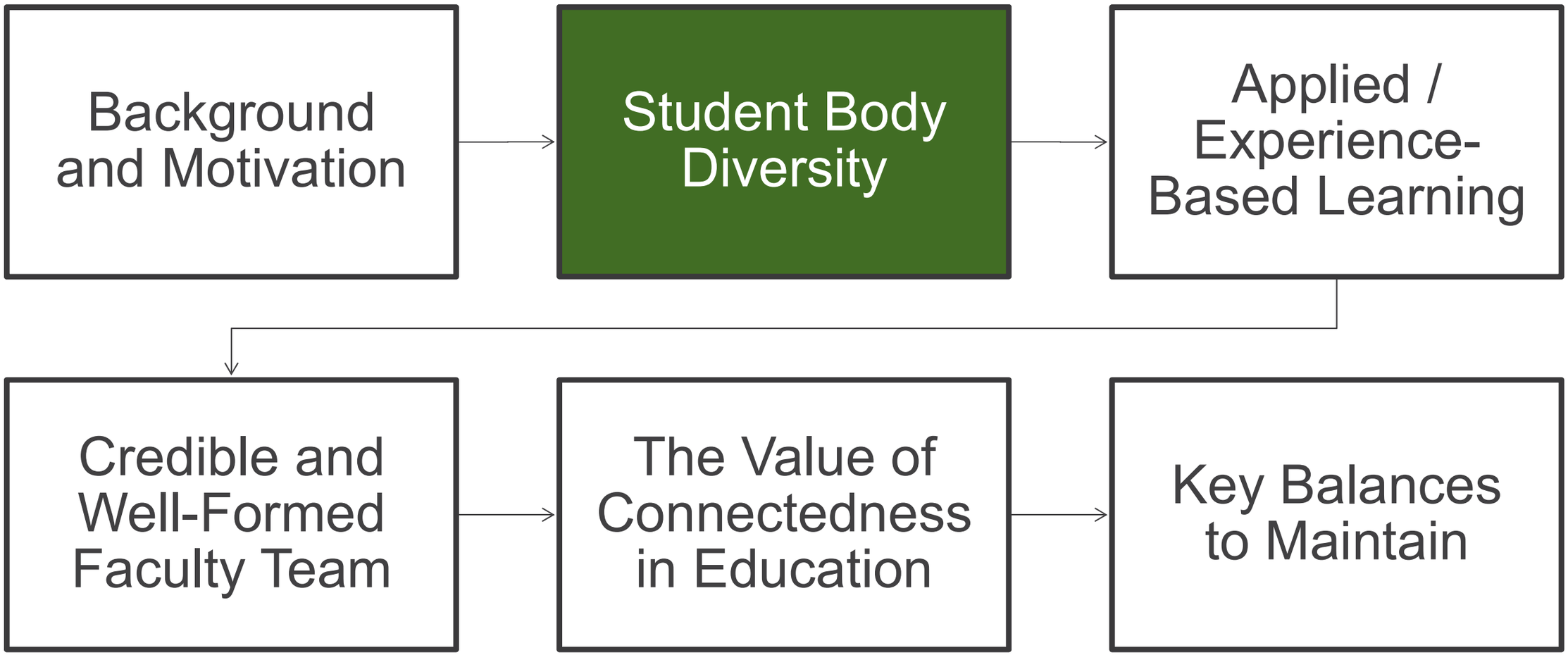
- Administrative access and onboarding
- Intro to faculty and local INCOSE chapter
- Lecture modules
- Project proposals
- Team formation and mentor assignment
- 1st team assignment due

- Interactions



"Group work. I had a fantastic group and they motivated me to do my best."
Written feedback from a PMASE student, October 9th 2021

Agenda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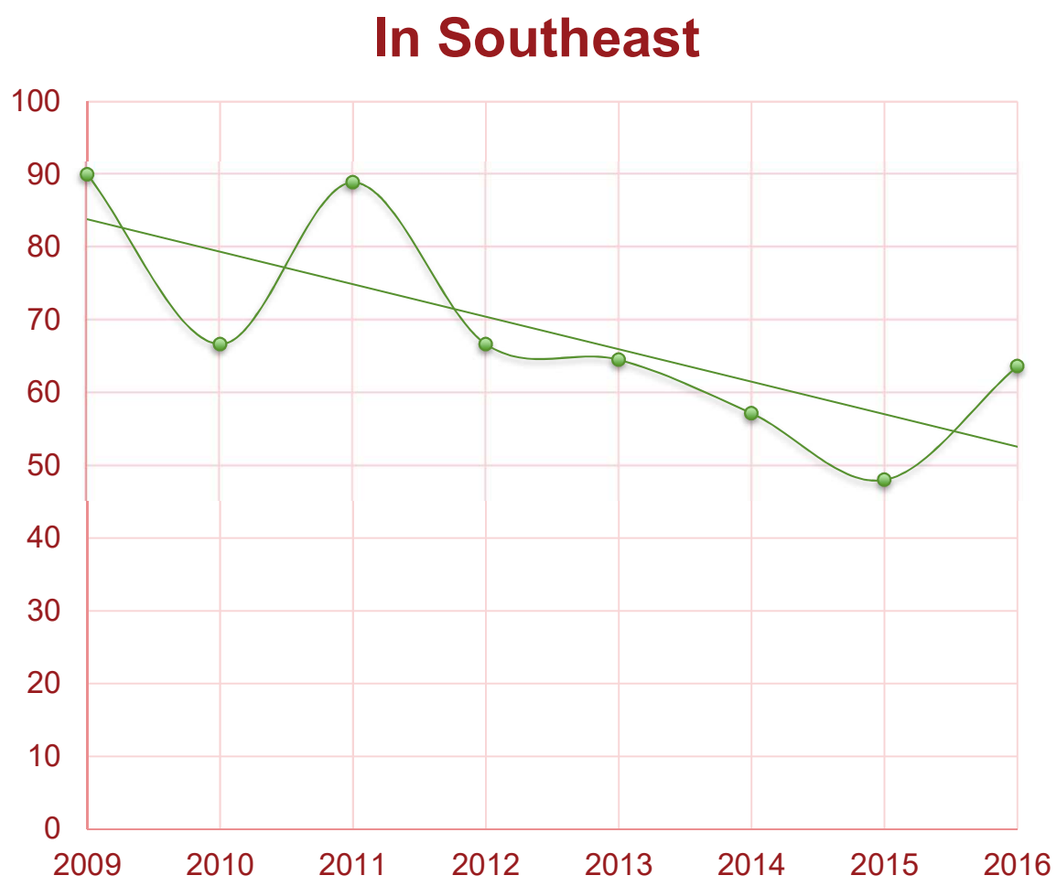
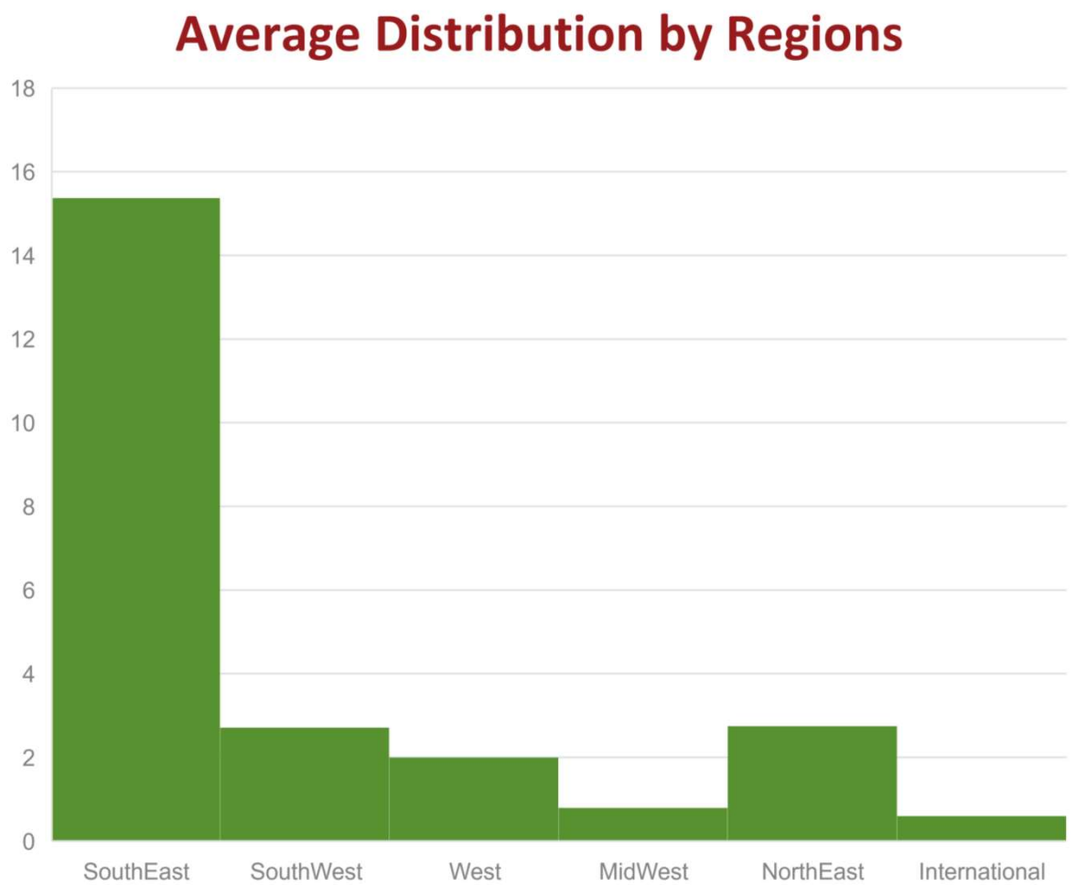
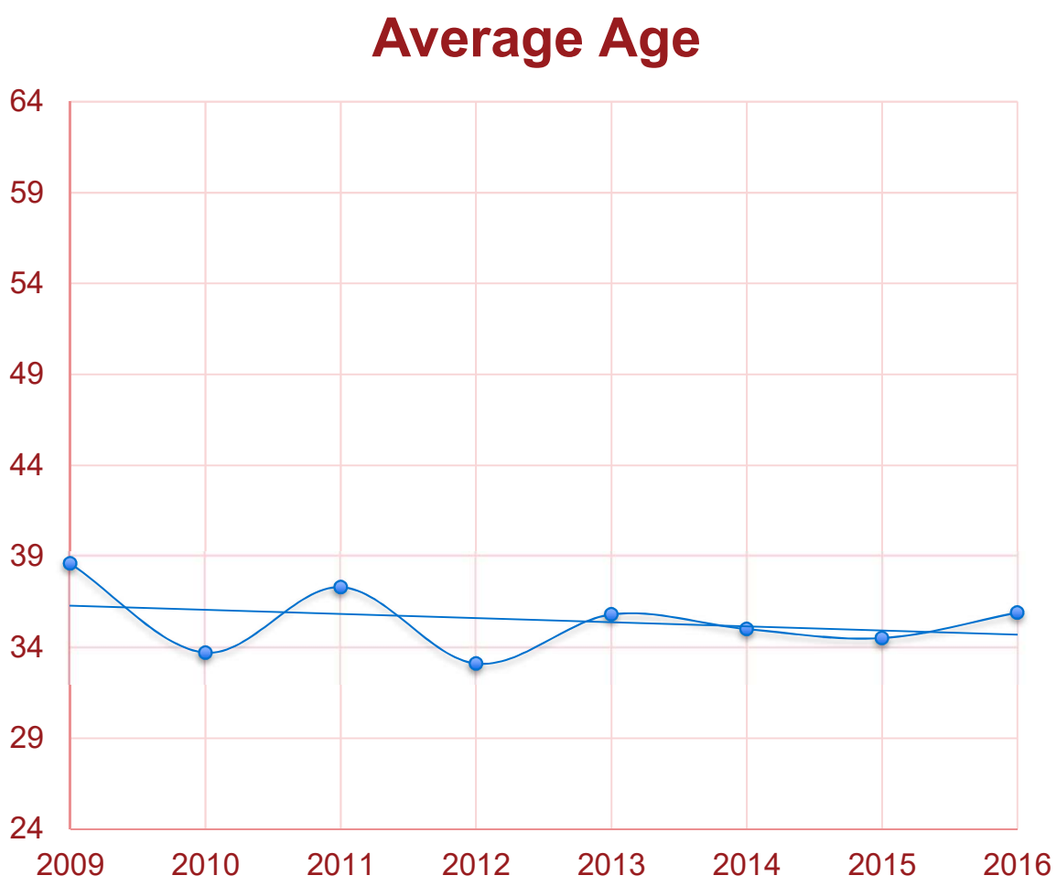
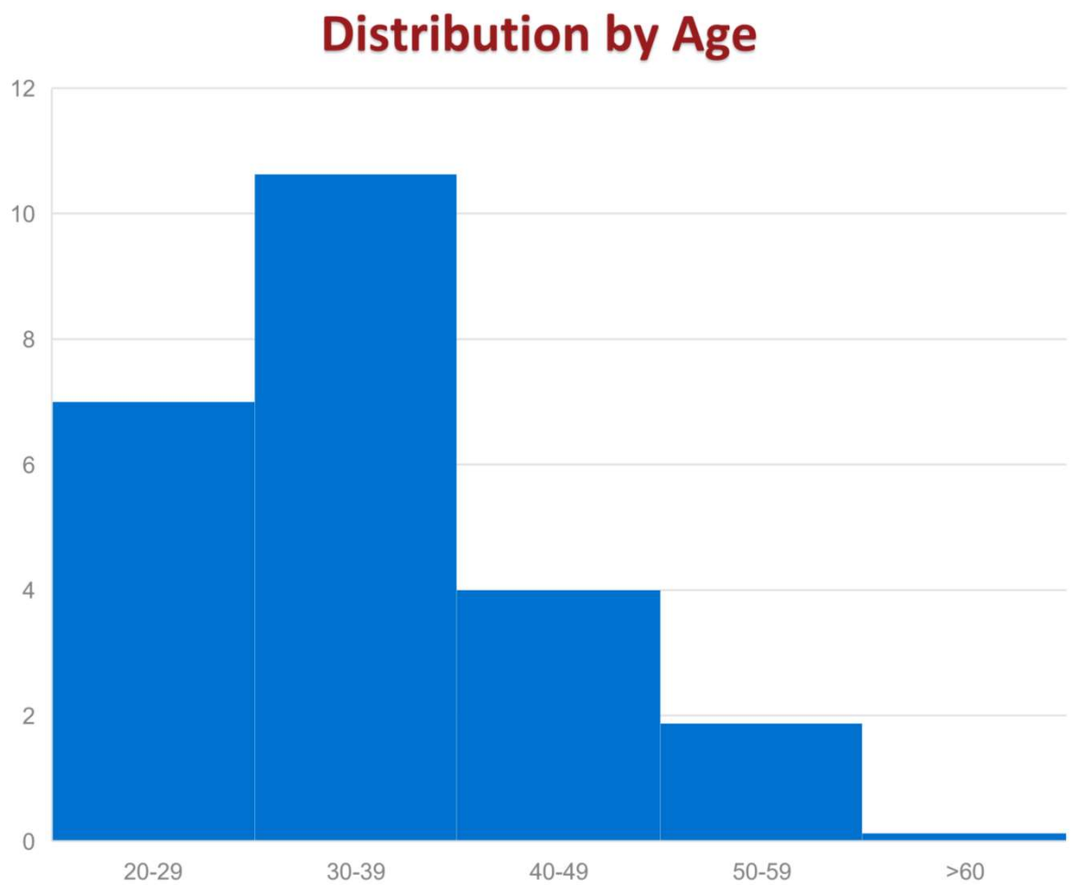
Diversity of Location



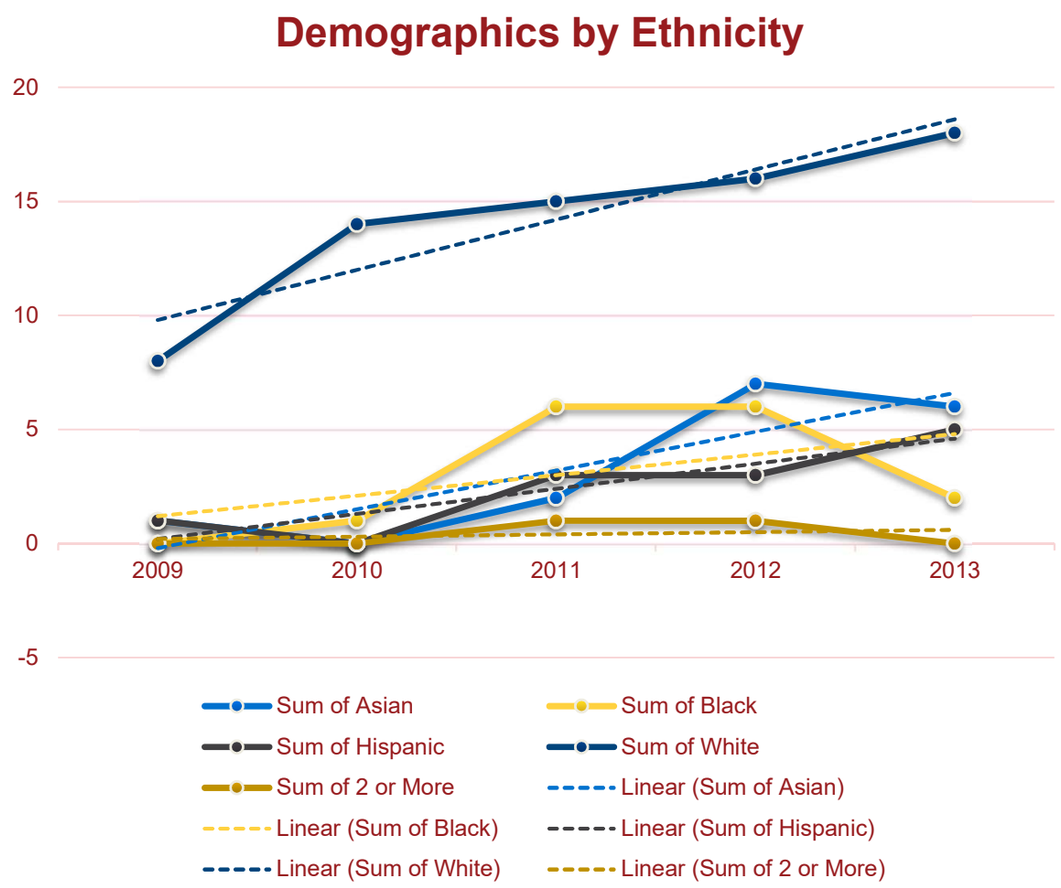


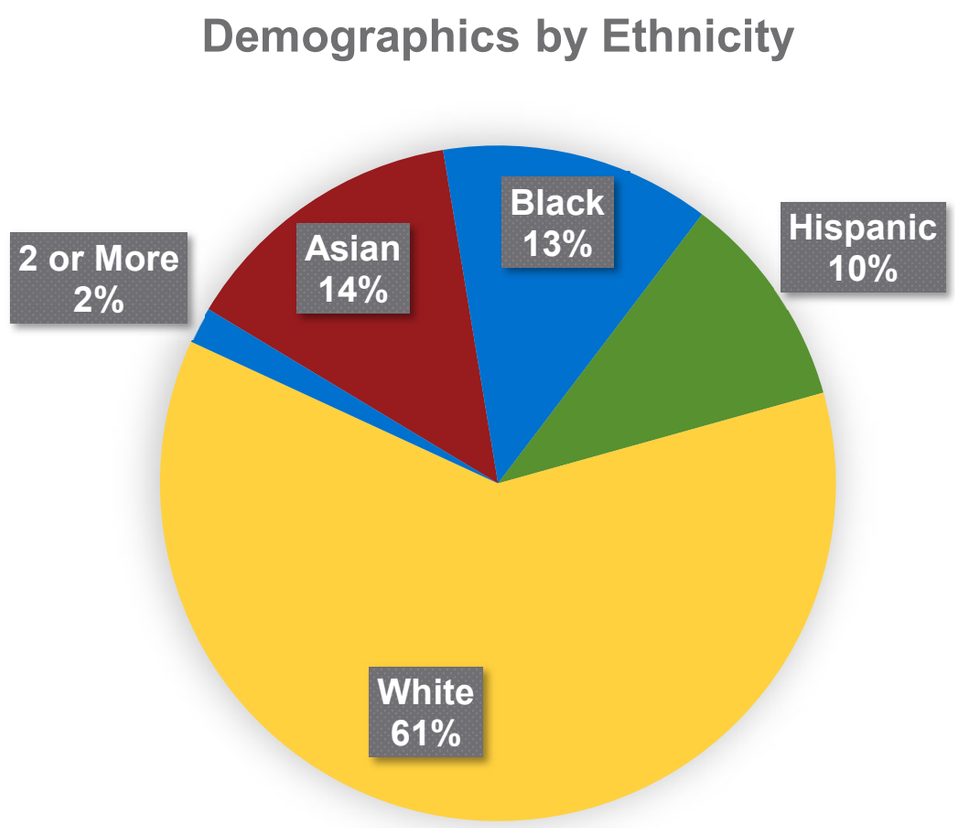
Diversity of Age



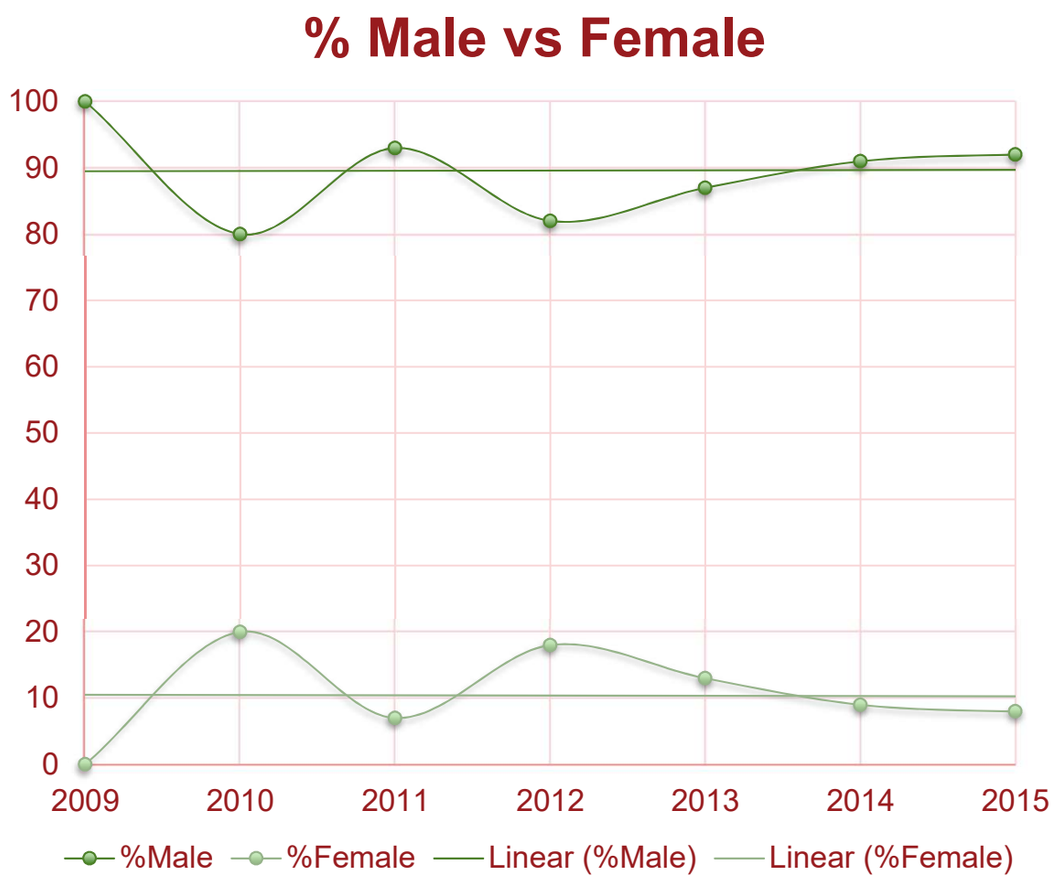


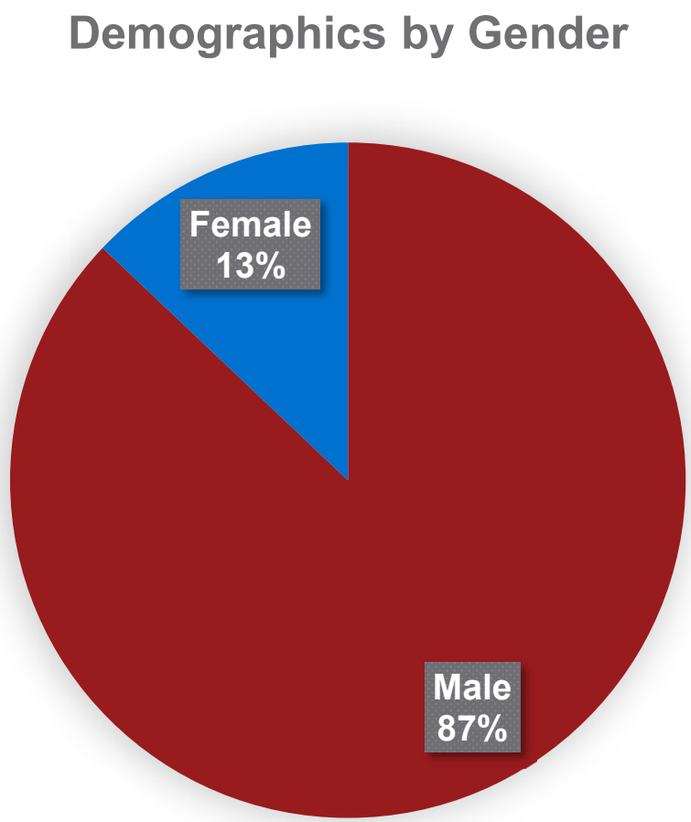
Diversity of Ethnicity



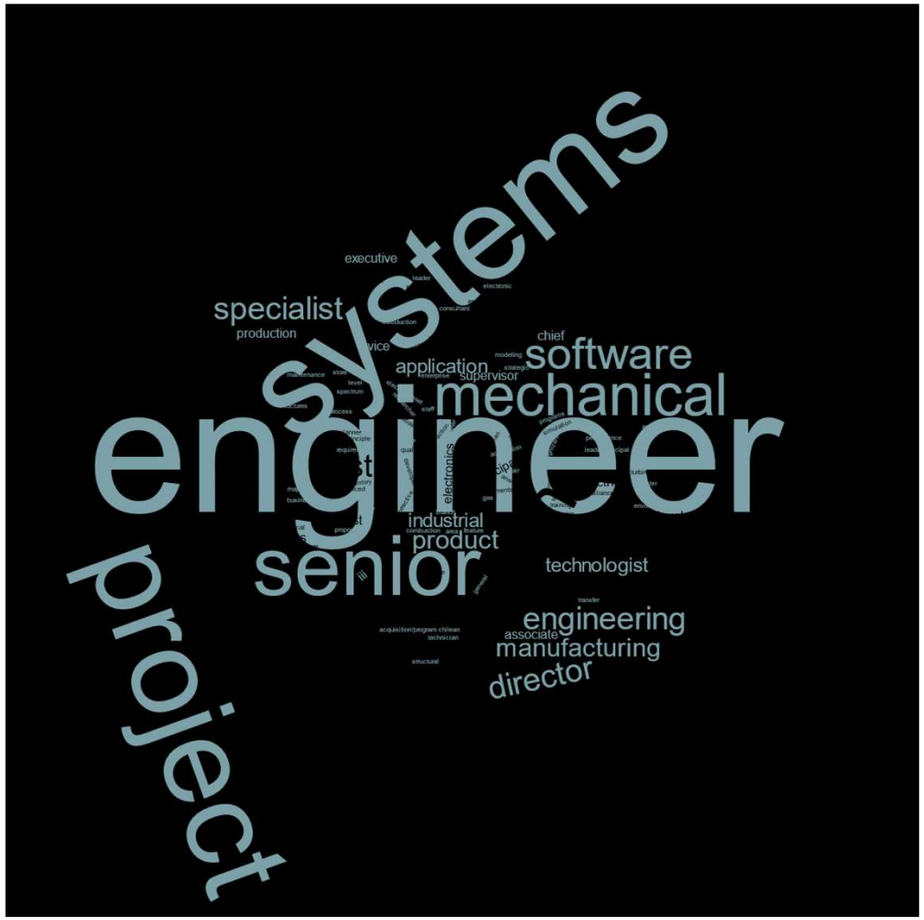


Diversity of Gender



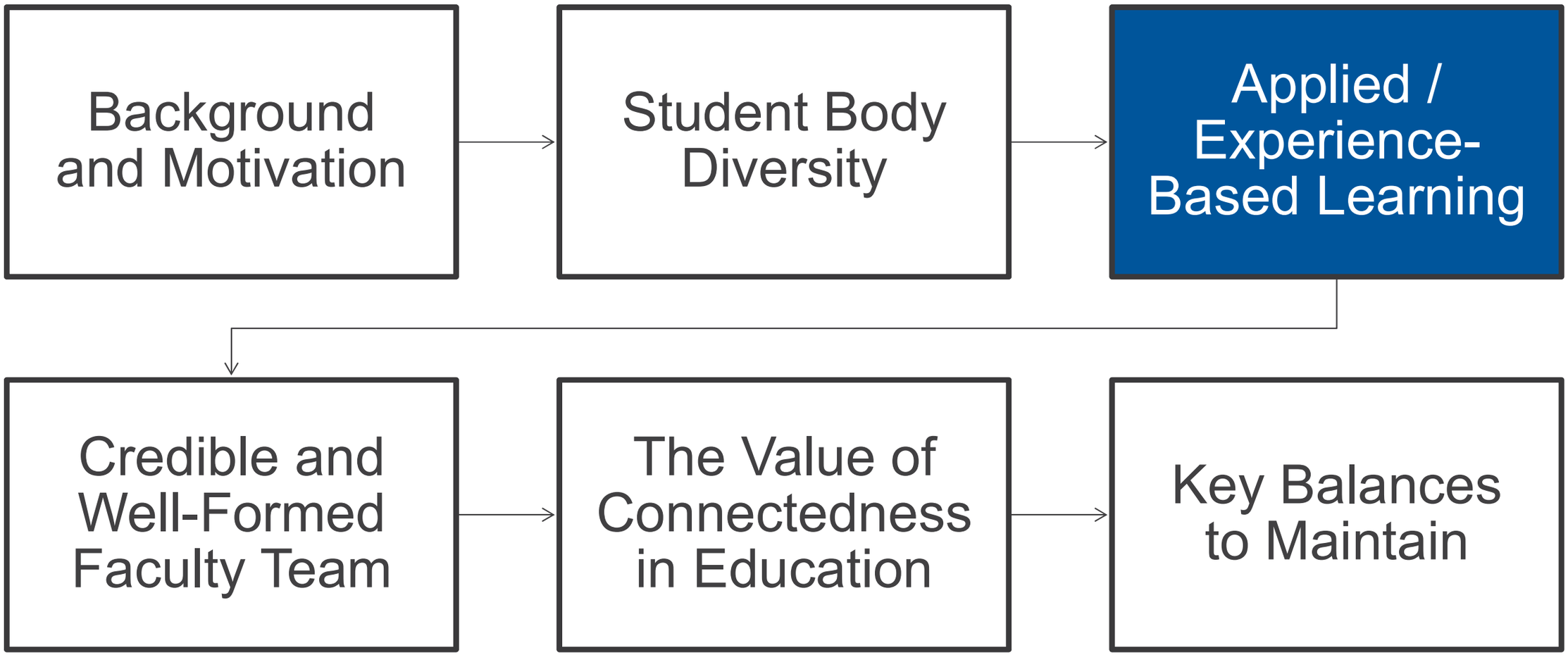


Diversity of Career Background



Job Category	Search Terms	Count
Technical	engineer, scientist, specialist, analyst, technologist, tester	120
Managerial	manager, director, supervisor, commander, chief, president, lead, program, project	61
Teaching	teach	3
Research	research	24

Agenda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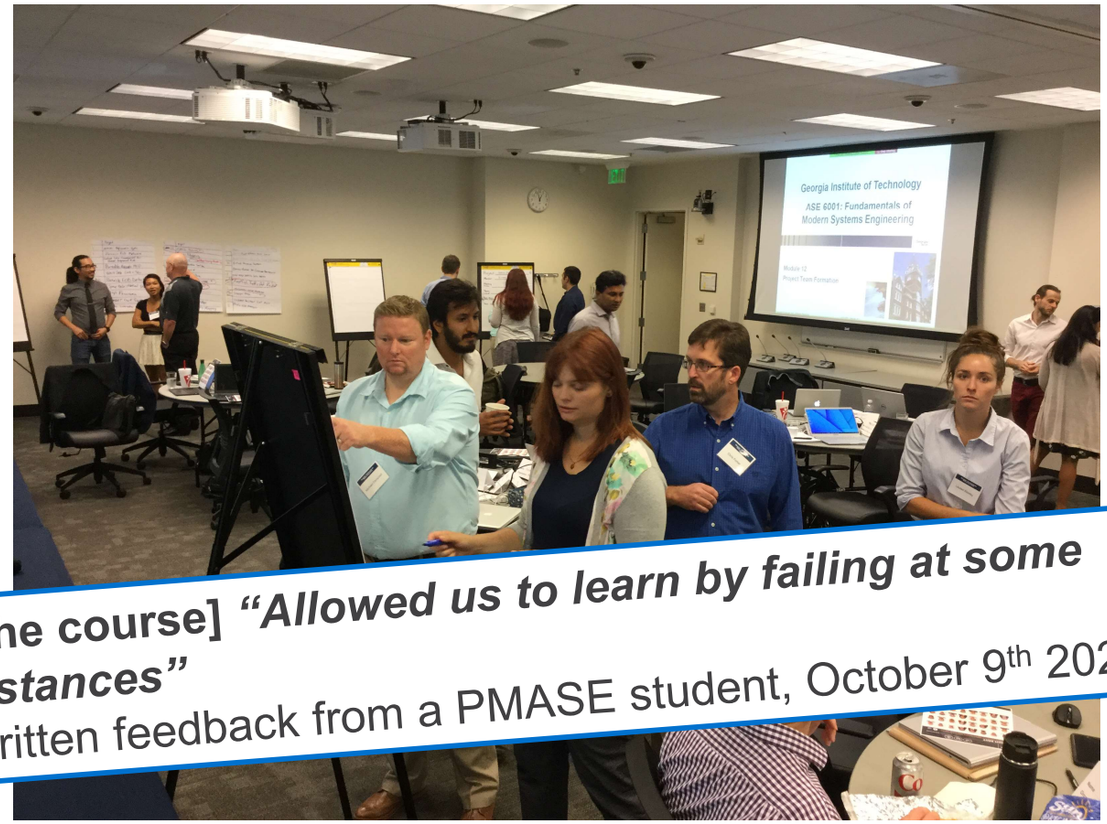
Learning by Practical Application

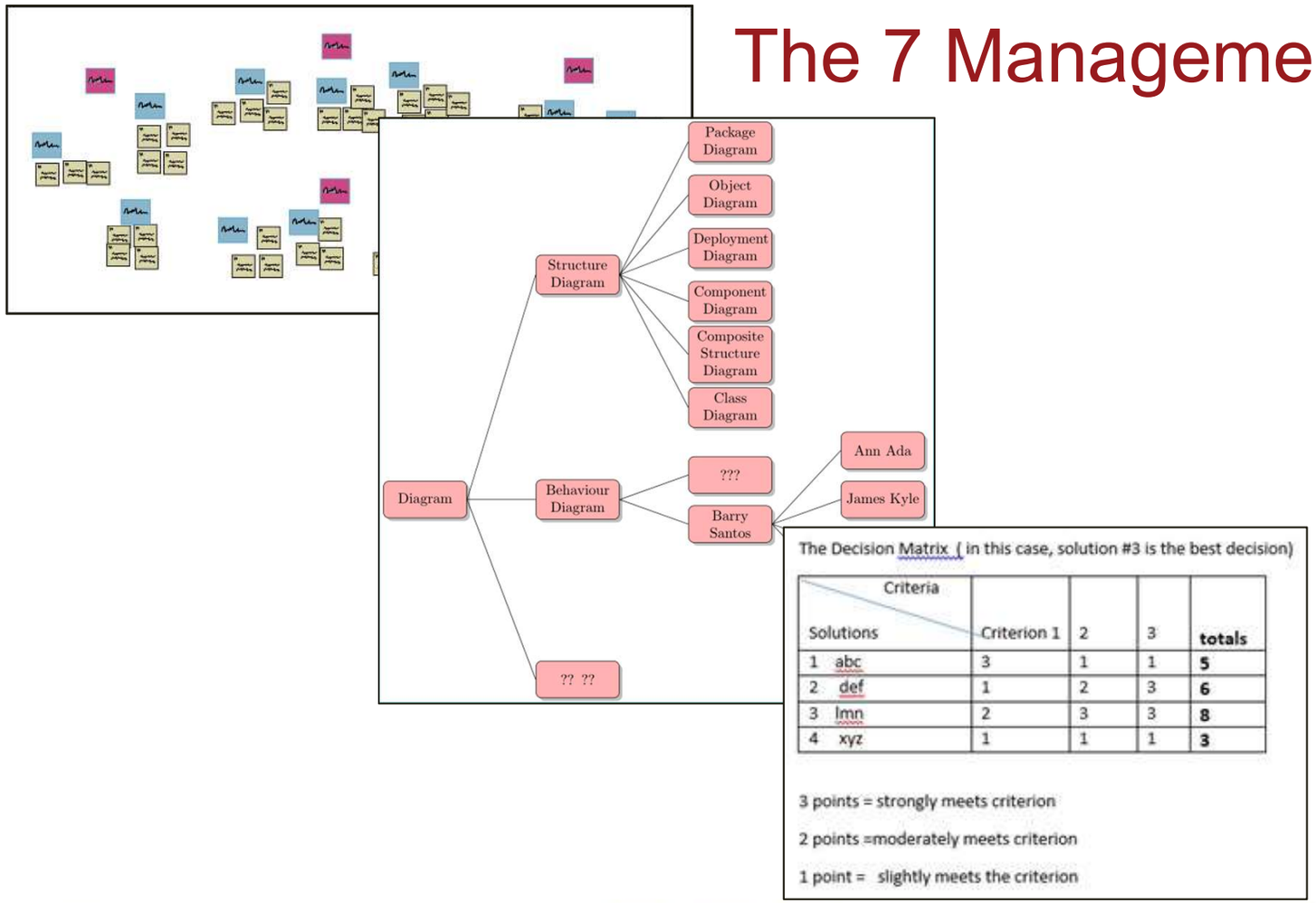
- Live and virtual sessions
- Case studies and projects
  - Individual learning and projects
  - Team learning and projects
    - Self-organizing teams



[The course] ***"Allowed us to learn by failing at some instances"***
Written feedback from a PMASE student, October 9th 2021

Kickoff Week Applied Learning

The 7 Management and Planning Tools



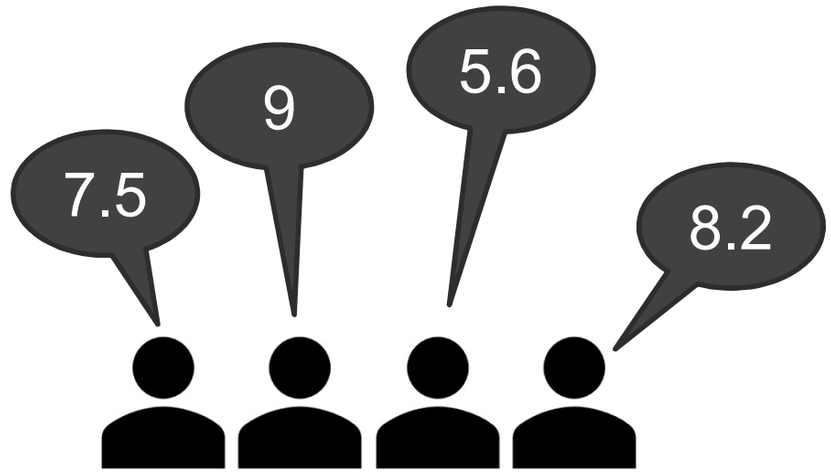
The Decision Matrix (in this case, solution #3 is the best decision)

Criteria / Solutions	Criterion 1	2	3	totals
1 abc	3	1	1	**5**
2 def	1	2	3	**6**
3 lmn	2	3	3	**8**
4 xyz	1	1	1	**3**

3 points = strongly meets criterion

2 points =moderately meets criterion

1 point = slightly meets the criterion



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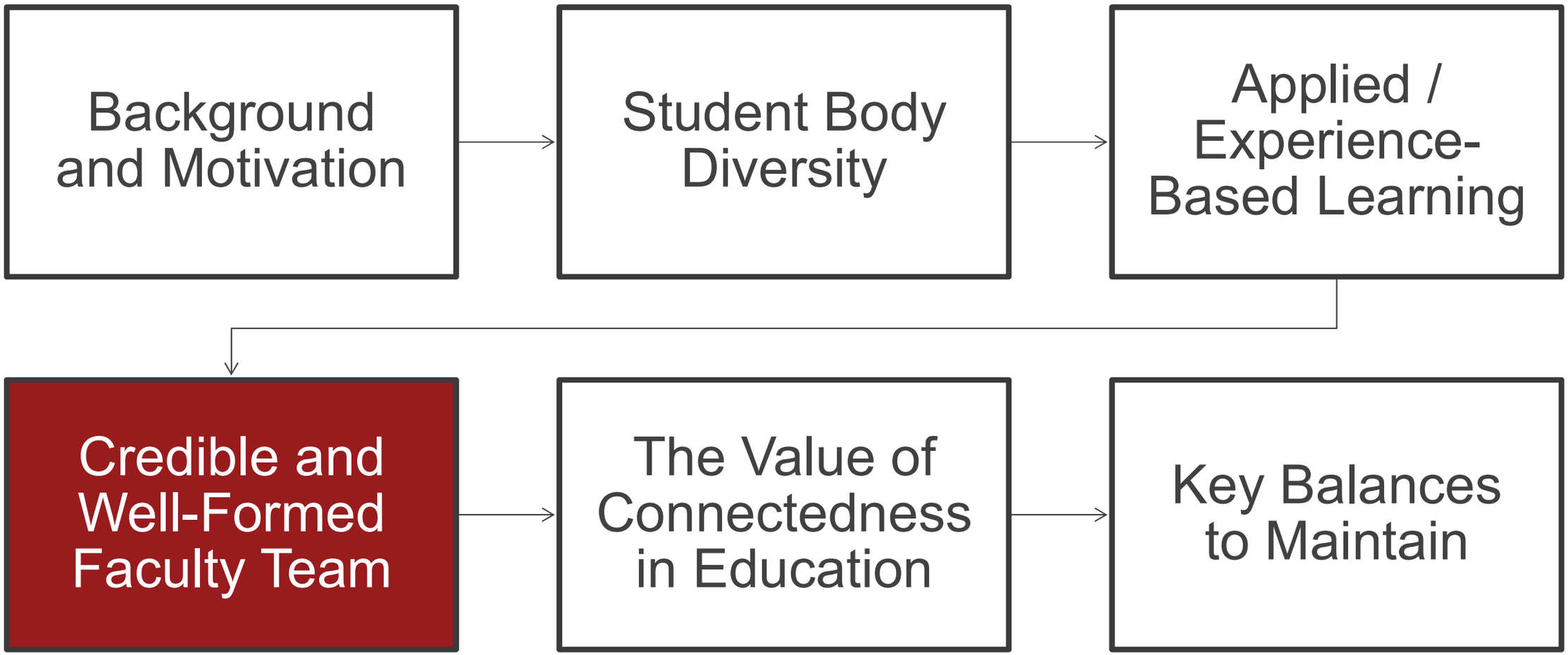
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Credible and Well-Formed Faculty Team

- Mentoring “plays a significant role in graduate students’ professional development”
- Mentors
  - Are “living case studies”
  - Contribute to course development
  - Relate the concepts to the real world
  - Shepherd 8-10 students

- Key ASE 6001 mentor requirements:
  - Practical systems engineering multi-domain experience
  - Ability to interact with and motivate graduate students
  - A graduate degree in a related science or engineering field
  - Passionate about systems engineering

Mentor Expertise

Systems Engineering Experience

Mentor	1	2	3
Requirements Engineering	X	X	X
Risk Management		X	X
Baseline Control			X
Technical Planning	X	X	X
Cost Estimation		X	X
Architecture/Design	X	X	X
QA, V&V	X	X	X
Process Definition	X	X	X
Tooling/Tool chains	X		X
Integration	X	X	X

Domain Expertise

Mentor	1	2	3
Healthcare			X
IT	X	X	X
Transportation	X	X	X
Manufacturing	X	X	
Energy			X

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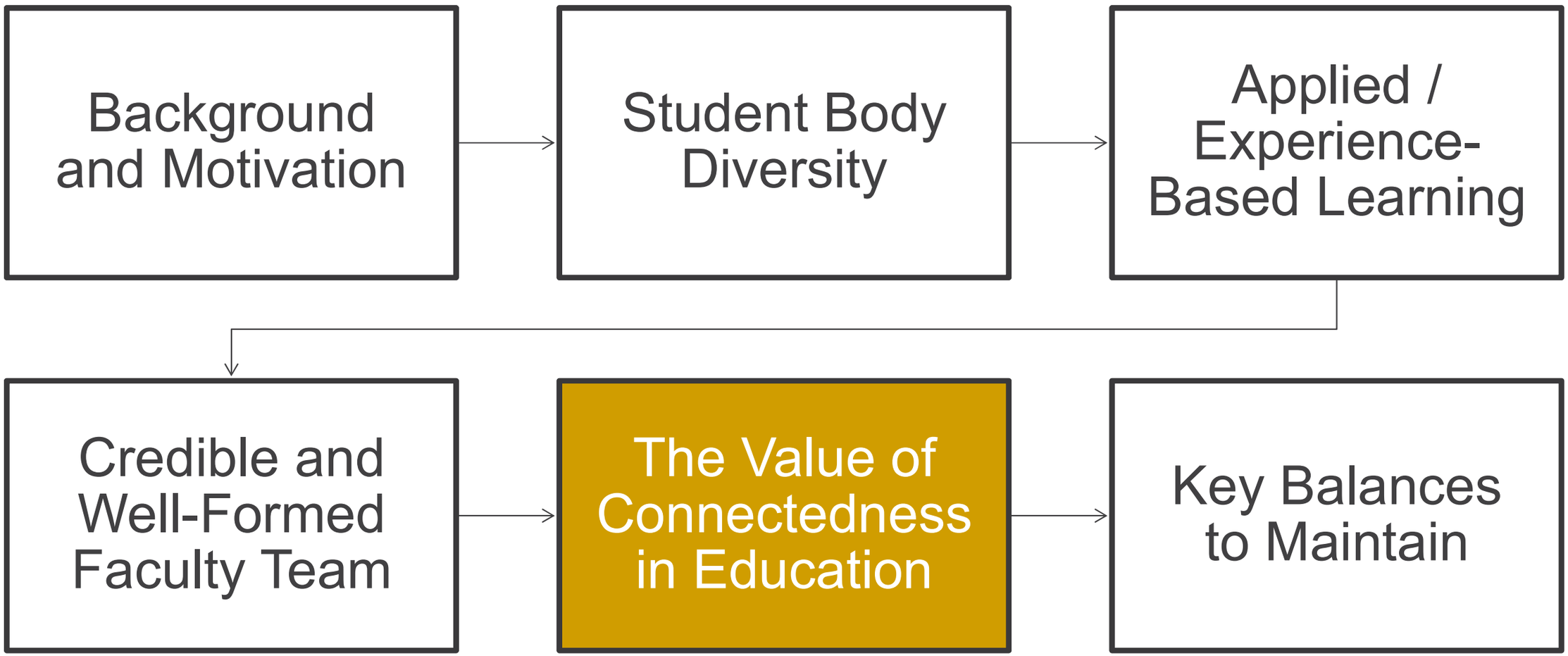
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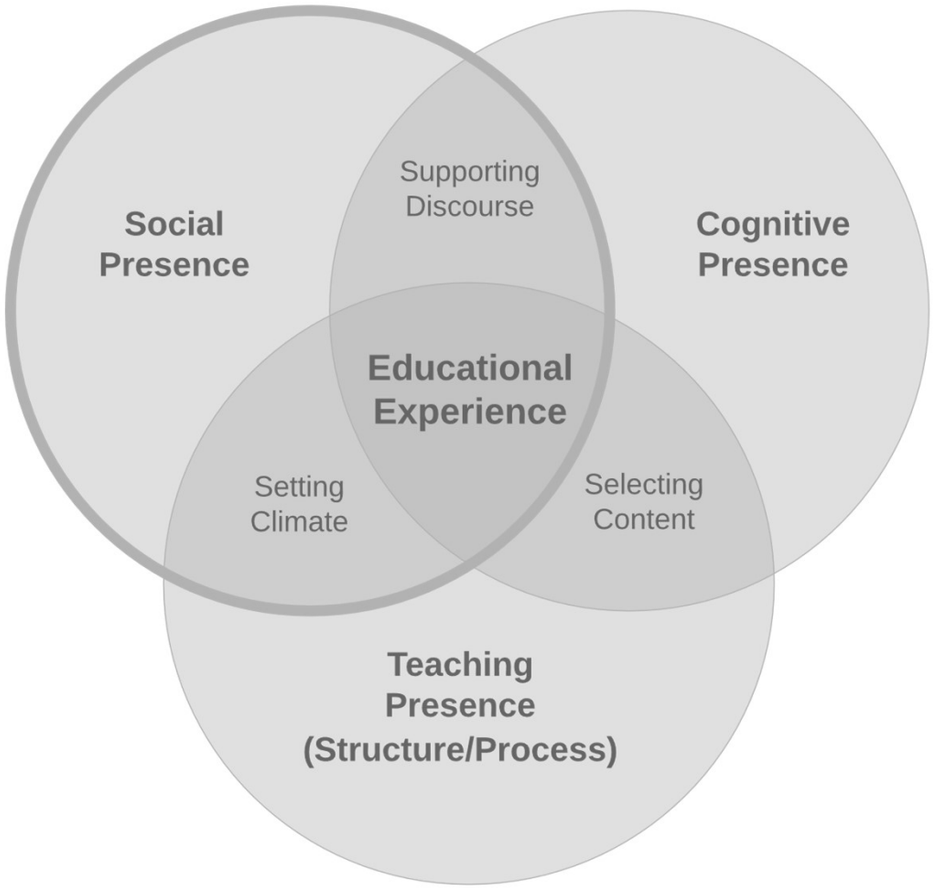

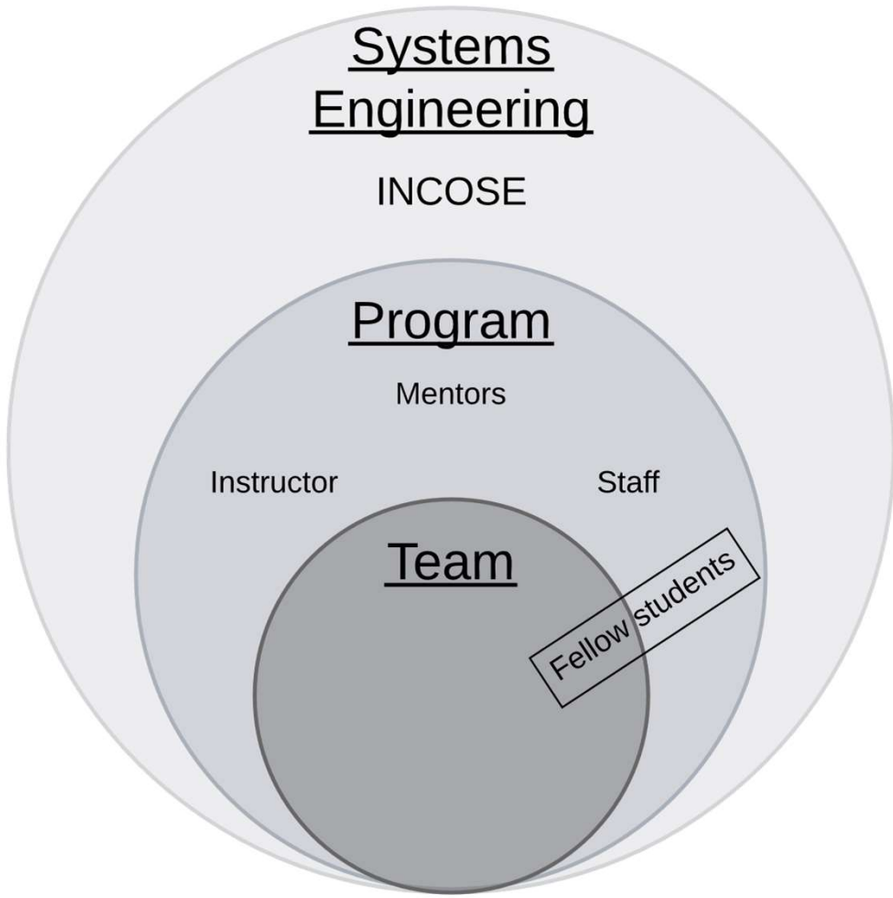

Kickoff Week Example

Faculty Role Facilitating Students' Social Presence

		Learner-Learner		Learner-Instructor	
Faculty Role	**Facilitation Element**	**Team**	**Cohort**	**Faculty**	**Industry**
Informal Communication	Social events	x	x	x	x
	Address students by name	x	x	x	
	Share personal stories	x	x	x	
Formal Communication	Contribute to discussion boards		x	x	
	Prompt response to email			x	
	Office hours	x		x	
Course Design	Integrated comment capability into recorded lectures	x	x		
	Student and faculty profiles		x	x	
	Profile photo gallery		x	x	
	Welcome message			x	
	Open discussion boards		x		
	Team-oriented tasks	x			

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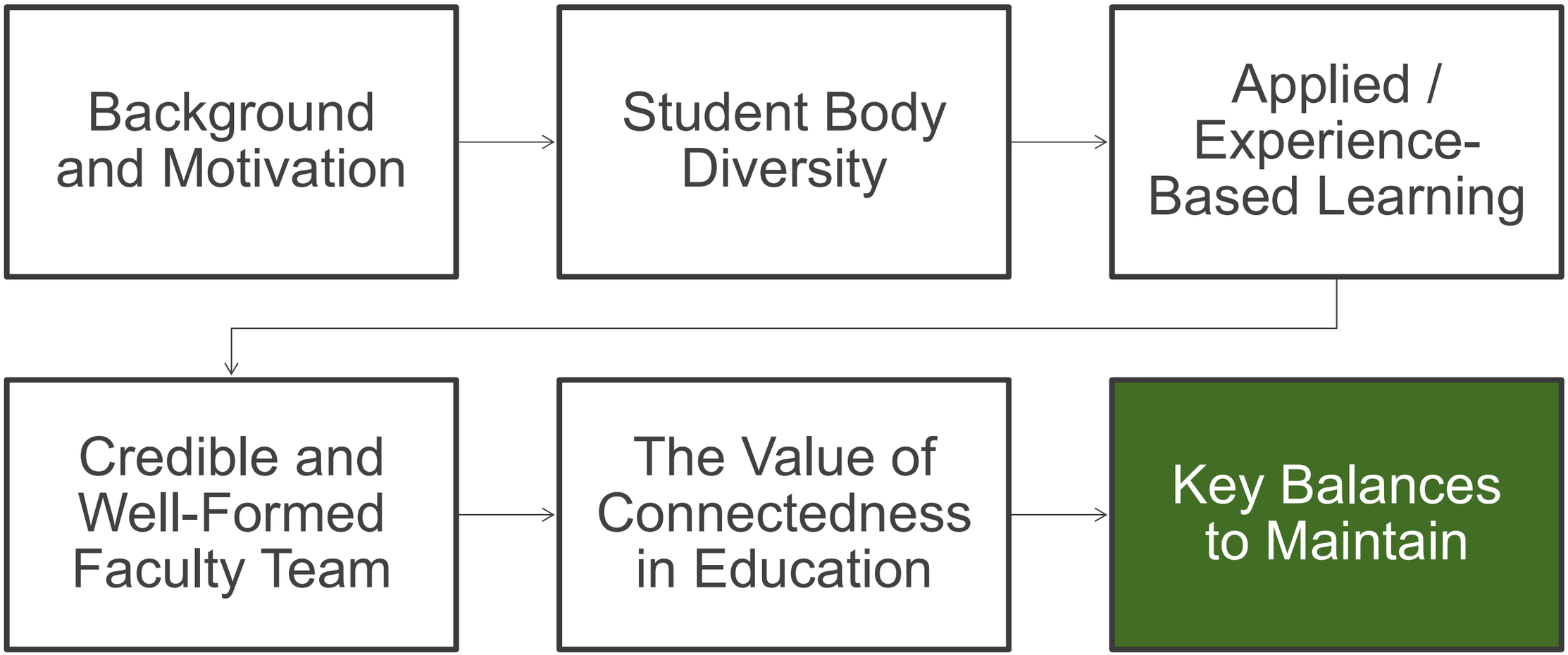
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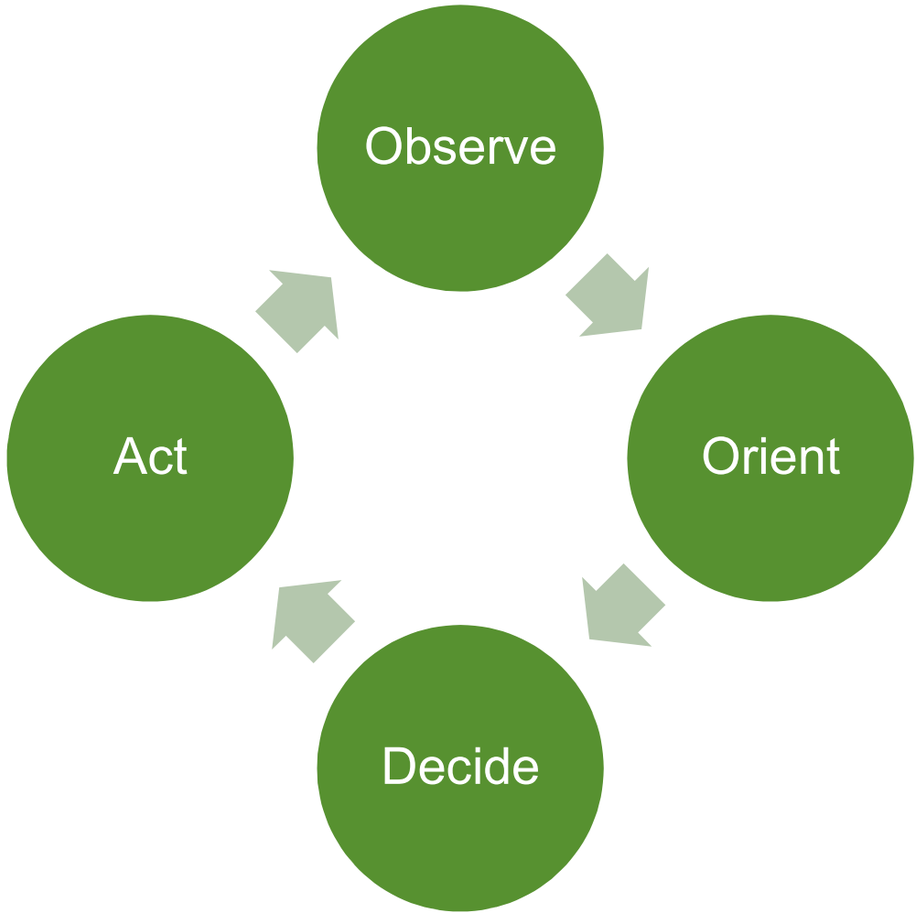
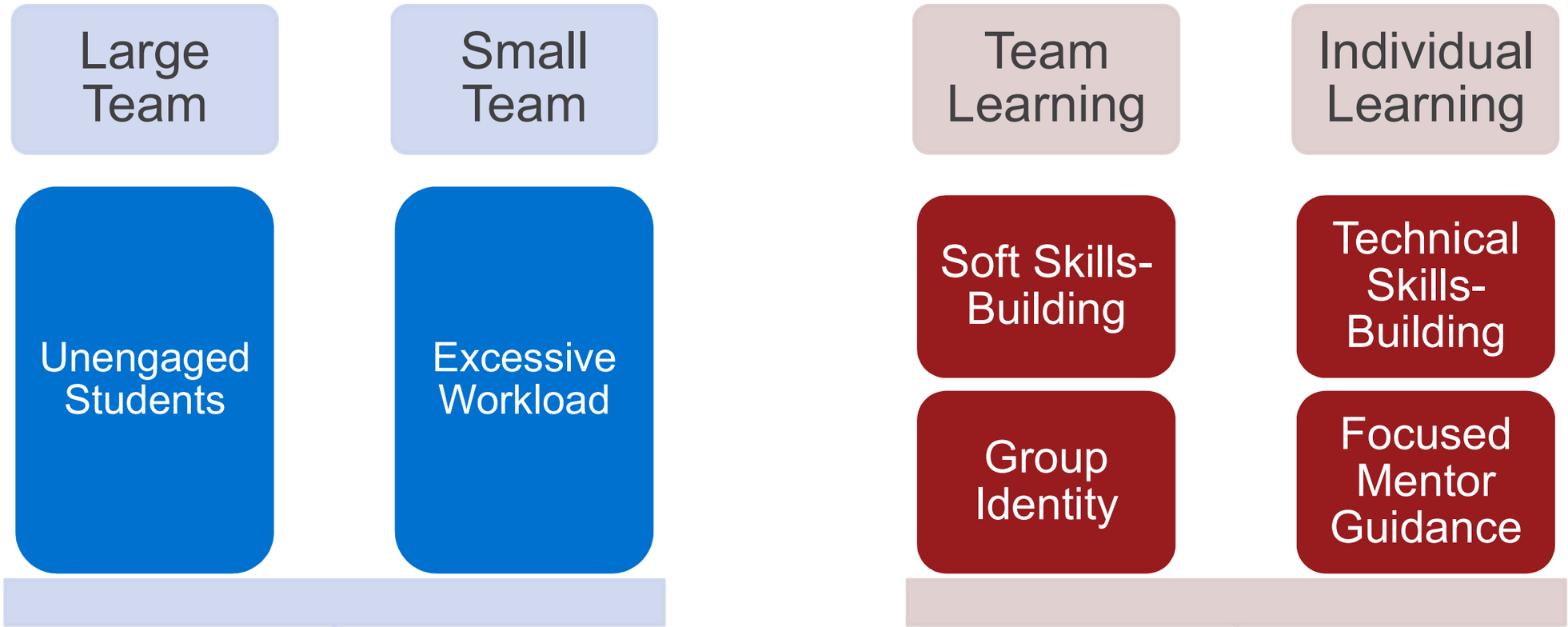


- Team/individual work
- Time use
- Theory vs practice
- Grading and feedback

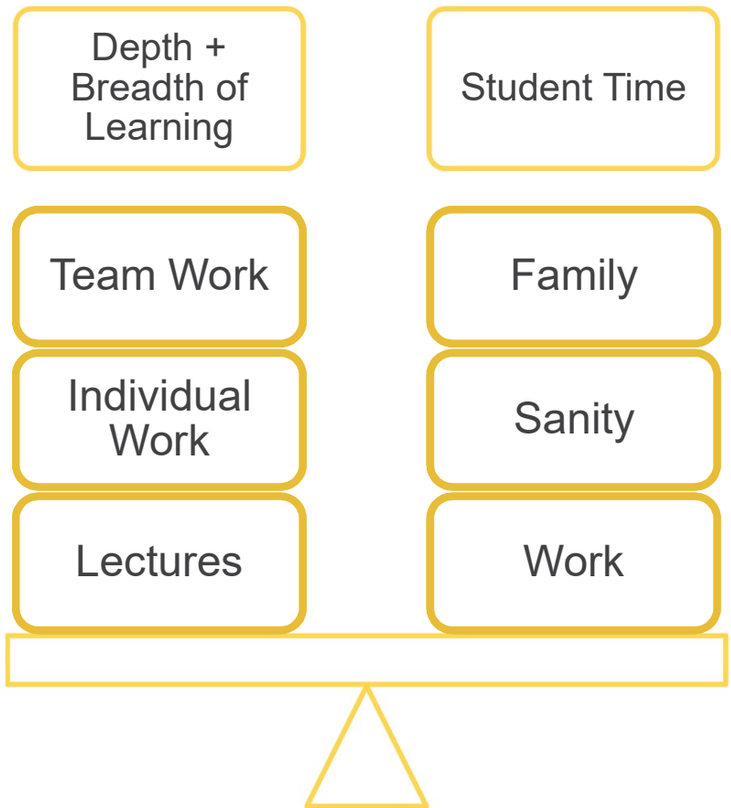
Key Balances - Teams



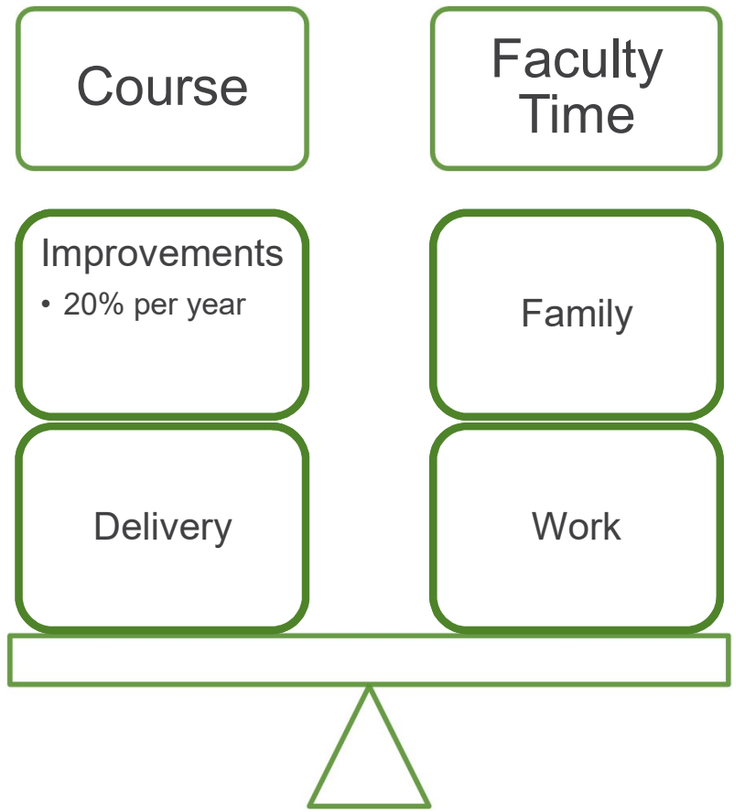
[Best course aspect was] ***"Establishing mutual trust and respect towards team members"***
Written feedback from a PMASE student, October 9th 2021

Key Balances – Time

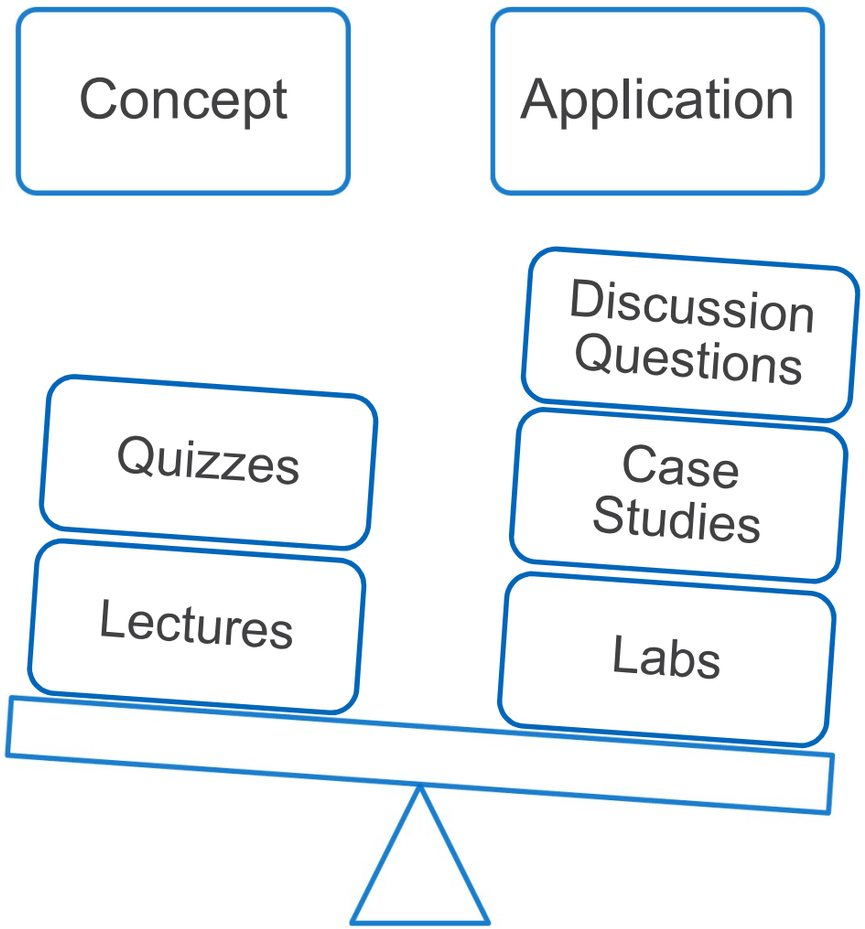
Students



Faculty



Key Balances - Application



TOPSIS Analysis

Quantitative metrics	Simplest	Most Luxurious	Newest Technology
Detection Range	3	3	9
HSI Ease of Use	3	9	9
Physical Size	3	3	9
Data Availability	9	3	9
Vulnerability	9	1	9
Anticipated Maintenance Hours per Month	3	1	9
Cost	1	9	3

- Alternative methods were paired down to 3 from a Pugh matrix
- TOPSIS used to compare against Pugh matrix findings
- Simplest architecture won

Direction of Improvement	Weight	Weighted Metrics	Simplest	Most Luxurious	Newest Technology
min	0.050	Detection Range	0.0151	0.0151	0.0452
max	0.275	HSI Ease of Use	0.0631	0.1893	0.1893
min	0.050	Physical Size	0.0151	0.0151	0.0452
max	0.100	Data Availability	0.0688	0.0229	0.0688
min	0.150	Vulnerability	0.1057	0.0117	0.1057
min	0.150	Anticipated Maintenance Hours per Month	0.0472	0.0157	0.1415
min	0.225	Cost	0.0236	0.2123	0.0708

	Simplest	Most Luxurious	Newest Technology
Closeness to Ideal	0.578	0.515	0.535
	1	3	2

33

Key Balances – Grading and Feedback

Grading

- Breadth and depth vs. time
- Weekly turnaround on assignments
  - Improves quality of future submissions

"Feedback provided on labs ... was informative and constructive and helped a lot with the final project and the other succeeding labs"
Written feedback from a PMASE student, October 9th 2021

Feedback

- Breadth and depth vs. impact
- Justification of grade
- Suggestions for improvement

Mentor-student trust and credibility is key

Summary

- INCOSE and others identify loss of SE experience as critical
- SE is a heuristics-based discipline and relies on the apprenticeship model
- Success factors to increase the 3 kinds of presence in education:
  - Cohort concept
  - Team-based training
  - Highly experienced mentors

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References

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Sheard's 12 Systems Engineering Roles

Number	Abbreviation	Name
1	RO	Requirements Owner
2	SD	System Designer
3	SA	System Analyst
4	VV	Validation/Verification Engr.
5	LO	Logistics/Ops Engineer
6	G	Glue Among Subsystems
7	CI	Customer Interface
8	TM	Technical Manager
9	IM	Information Manager
10	PE	Process Engineer
11	CO	Coordinator
12	CA	Classified Ads