Shooting for a better, fast, and more efficient system: a study on students' timely progress to graduation

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PI Info

Dr. **Ming Chen** specializes in optimization, simulation, and scheduling. His research applies to a variety of service settings where capacity management plays a critical role in a firm's success. His recent teaching assignments involve operations management, service management, managerial decision-making processes, and business analytics.

Dr. **Sherry Su** specializes in optimization, process/systems analysis, performance evaluation, and capacity management. She regularly teaches Operations Planning & Control at undergraduate level and Operations Analysis at graduate level. As the faculty director for the MS Supply Chain Management program, her responsibility involves curriculum design, catalog updates as well as course scheduling.

Dr. **Hongyu Chen** specializes in predictive analytics, business intelligence, stochastic modeling and numerical simulation. His research focuses on applying information technology in business analytics settings (e.g. utilizing customers' purchase history and reviews to predict customers' future purchase).

Outline

- Introduction

- Capacity Analysis

- Degree Road Map

- Predictive Analytics

- Acknowledgements

Data Sources

- IRA
  - Spring 2009 to Spring 2017
  - Over 2,000,000 student course records
  - 93,000 class sessions
  - 8,400 classes total and 5,600 undergraduate
  - Including both course level data such as capacity, enrollments, grades, location and timing, as well as student level data such as grades and demographic info.

- Enrollment Service
  - Classroom capacity
  - Degree planner setup report

- CBA Center for Student Success
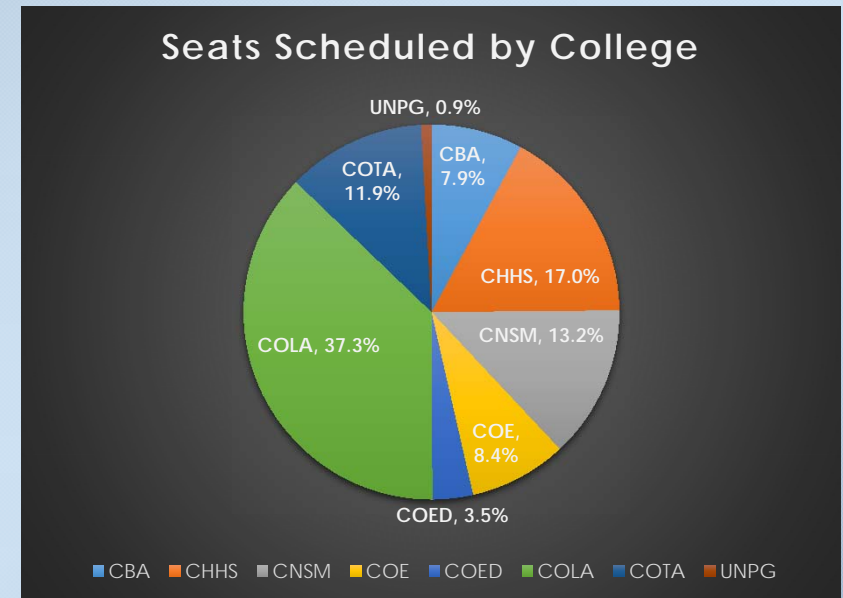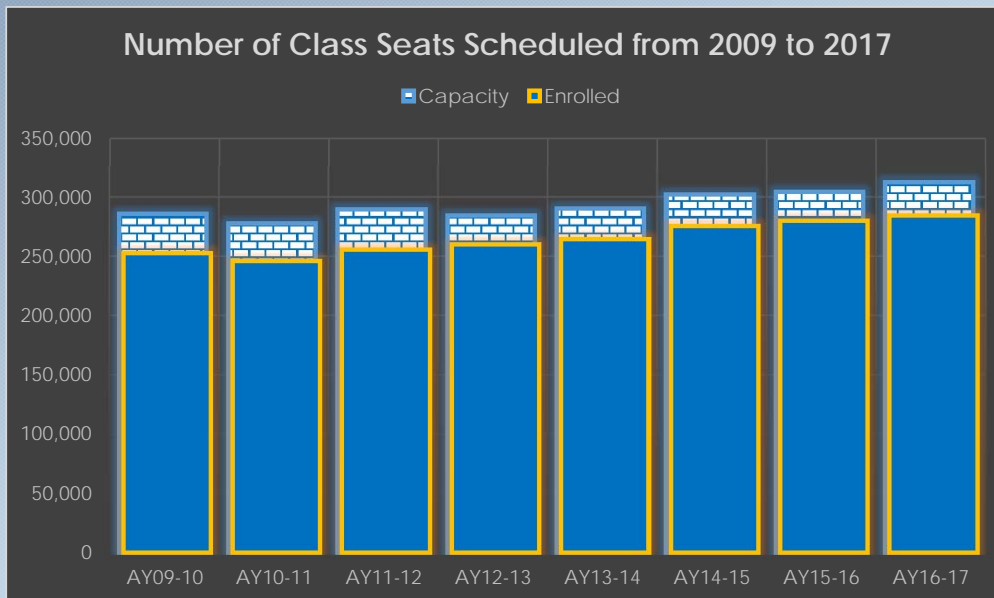
- University Center for Undergraduate Advising

Capacity Dimension
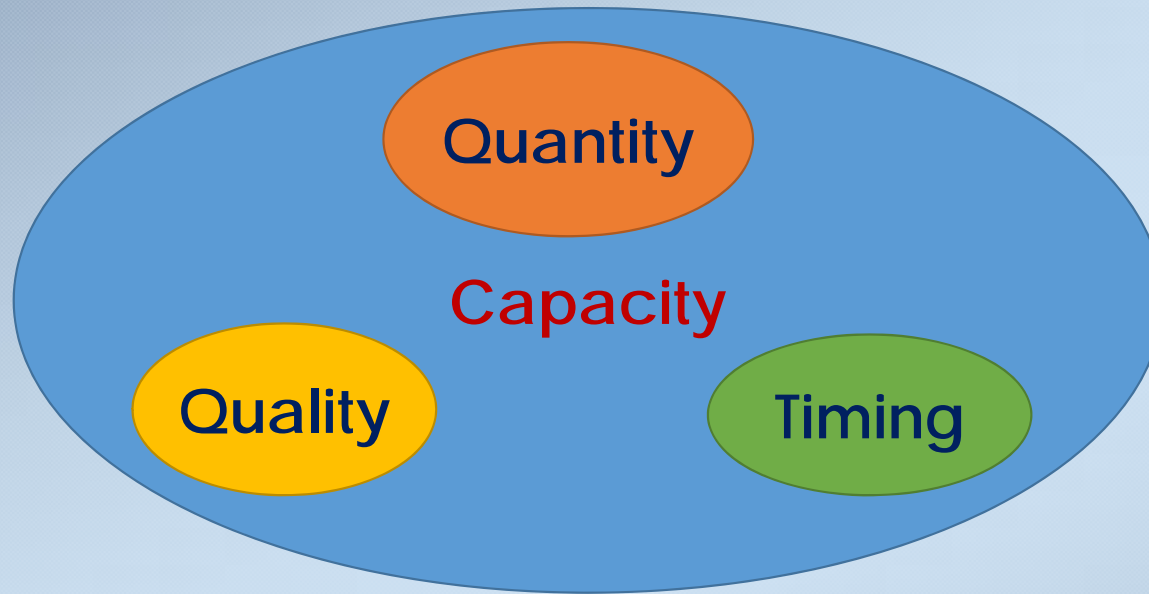
Capacity Management:

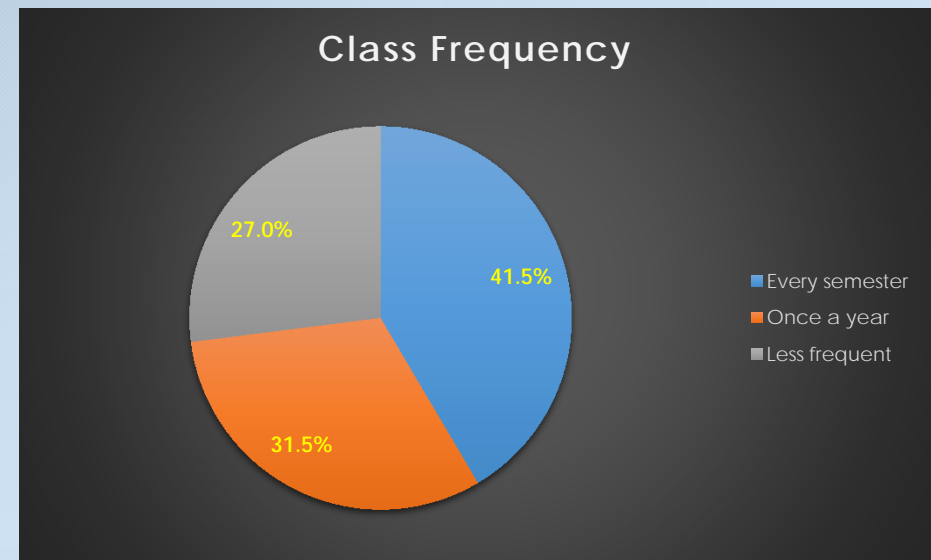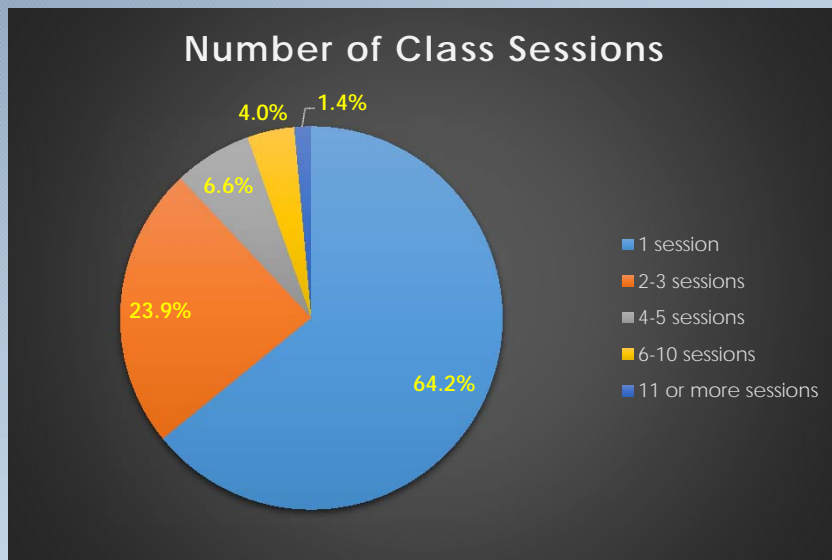offer the right class to the right student at the right time.

Scheduled Capacity 2009-2017

Number of Class Seats Scheduled from 2009 to 2017

Seats Scheduled by College

- From 2009 to 2017, the scheduled capacity across campus increased by 9.2% while enrollments increased by 12.5%, leading to more limited access to desired class for students.
- COLA, the largest college, offers 37.3% of the class seats, followed by CHHS (17.0%).
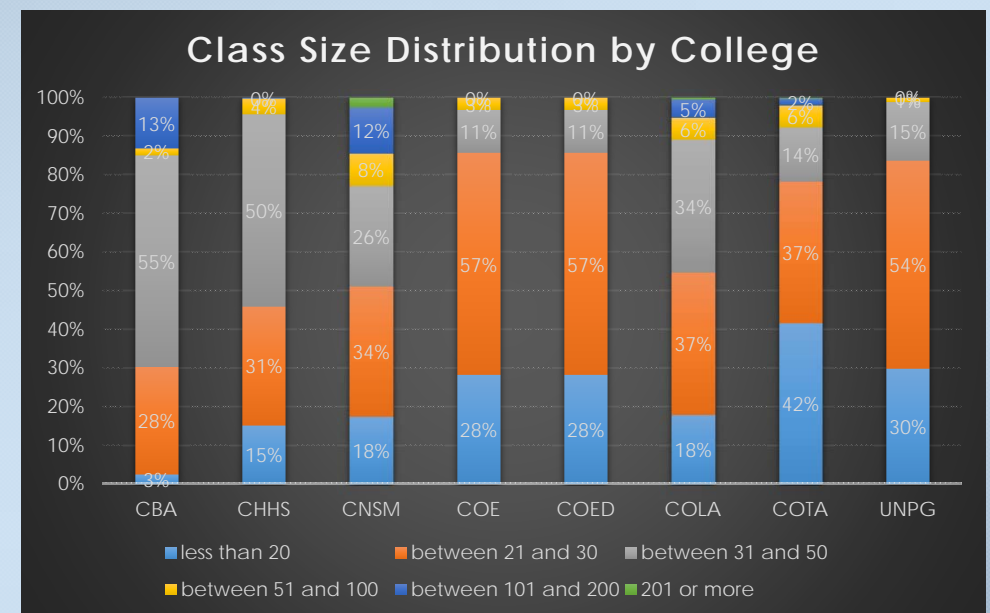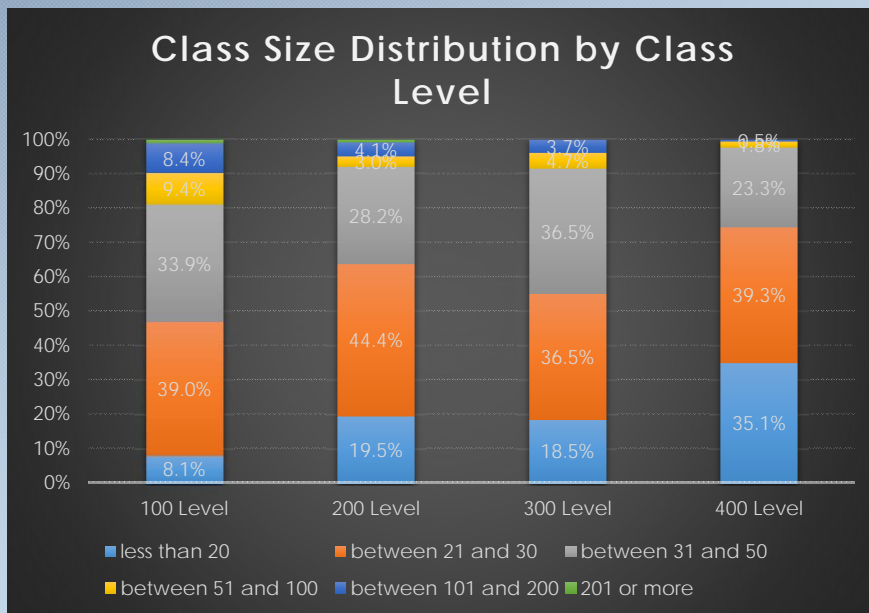
Number of Sessions and Frequency

Number of Class Sessions

- 1 session
- 2-3 sessions
- 4-5 sessions
- 6-10 sessions
- 11 or more sessions

4.0% 1.4%
6.6%
23.9%
64.2%

Class Frequency

- Every semester
- Once a year
- Less frequent

27.0%
41.5%
31.5%

- The vast majority of the classes have a single session and close to 90% of the classes have no more than three sessions.
- About 41% of the classes are offered every semester while 27% of the classes are offered less than once a year.
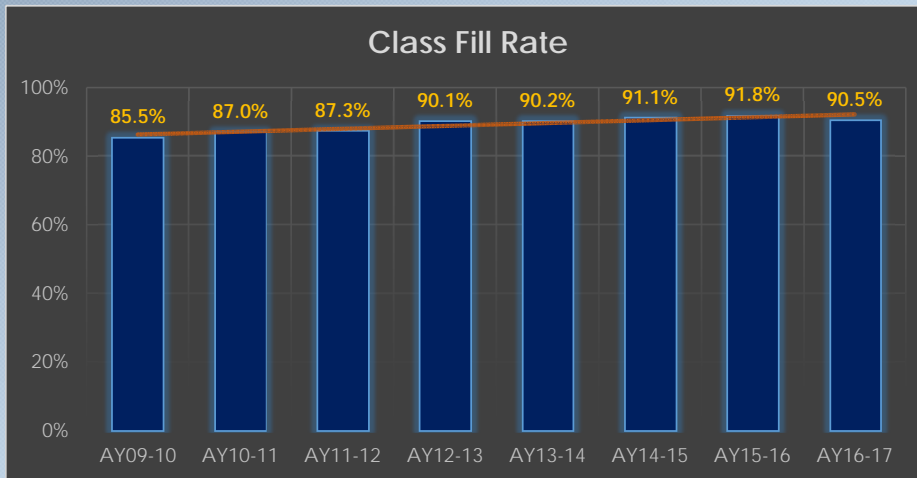
Class Size Distribution

Class Size Distribution by Class Level

	100 Level	200 Level	300 Level	400 Level
between 101 and 200	8.4%	4.1%	3.7%	0.8%
between 51 and 100	9.4%	3.0%	4.7%	0.5%
between 31 and 50	33.9%	28.2%	36.5%	23.3%
between 21 and 30	39.0%	44.4%	36.5%	39.3%
less than 20	8.1%	19.5%	18.5%	35.1%

Legend: less than 20, between 21 and 30, between 31 and 50, between 51 and 100, between 101 and 200, 201 or more

Class Size Distribution by College

	CBA	CHHS	CNSM	COE	COED	COLA	COTA	UNPG
between 101 and 200	13%	0%		0%	0%	5%	2%	0%
201 or more / other	2%	4%	12%				6%	
between 51 and 100			8%	3%	3%	6%	14%	15%
between 31 and 50	55%	50%	26%	11%	11%	34%	37%	54%
between 21 and 30	28%	31%	34%	57%	57%	37%	42%	30%
less than 20	3%	15%	18%	28%	28%	18%		

Legend: less than 20, between 21 and 30, between 31 and 50, between 51 and 100, between 101 and 200, 201 or more

- The class size for the vast majority of the class sessions is under 50. Upper division classes tend to have smaller class size.
- Class size distribution varies across college. CBA and CHHS have relatively larger class sessions while COE and COED have relatively smaller class sessions.

Class Fill Rates

Class Fill Rate

	AY09-10	AY10-11	AY11-12	AY12-13	AY13-14	AY14-15	AY15-16	AY16-17
Fill Rate	85.5%	87.0%	87.3%	90.1%	90.2%	91.1%	91.8%	90.5%

College	Average Class Size	Fill_Rate
CBA	47.2	96.2%
CHHS	33.6	92.7%
CNSM	51.3	88.1%
COE	28.5	92.1%
COED	25.8	75.3%
COLA	38.5	88.4%
COTA	28.5	87.3%
UNPG	27.3	48.7%

- The class fill rate has increased steadily over the past eight years.
- CNSM has the largest average class size.
- CBA has the highest class fill rate.

Where Do We Stand?
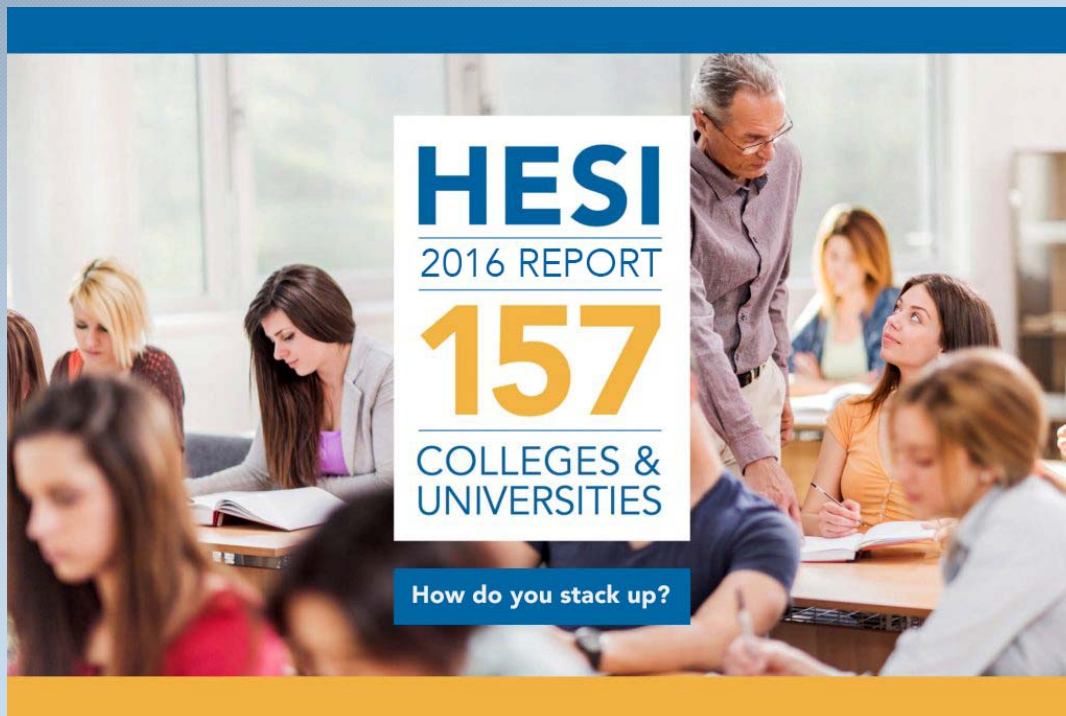
- Published by Ad Astra Information Systems

- The database includes metrics from a cross section of 82 four-year public, 23 four-year private, and 52 two-year public higher education institutions

- Various metrics measuring capacity utilization versus student access

Where Do We Stand?

- **Average Enrollment**: average value of the enrollment per class section
- **Average Enrollment Capacity**: average value of the maximum enrollment per class section
- **Enrollment Ratio**: Overall average fill rate across all class sections
- **Balanced Course Ratio**: the percentage of courses with enrollment ratio between 70% and 95%
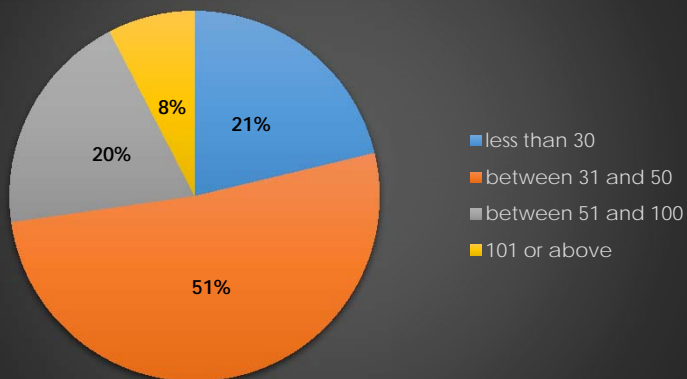- **Under-Utilized Course Ratio**: the percentage of courses with enrollment ratio below 70%
- **Overloaded Course Ratio**: the percentage of courses with enrollment ratio above 95%

Our capacity is much tighter than our peers!
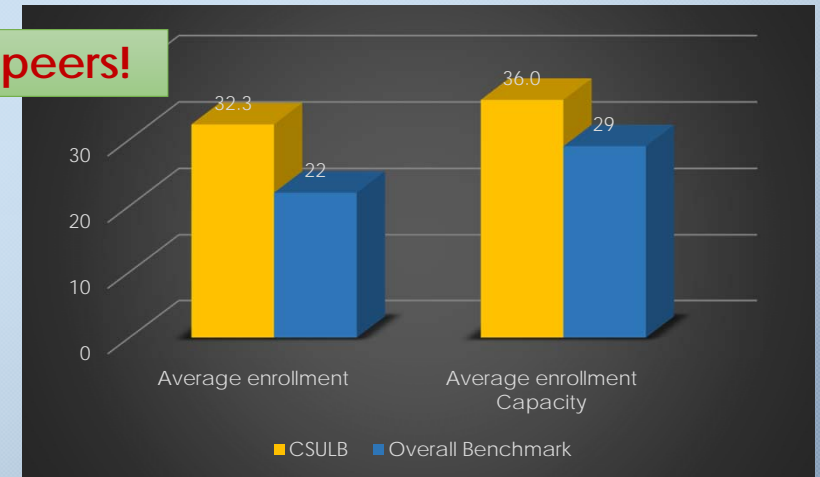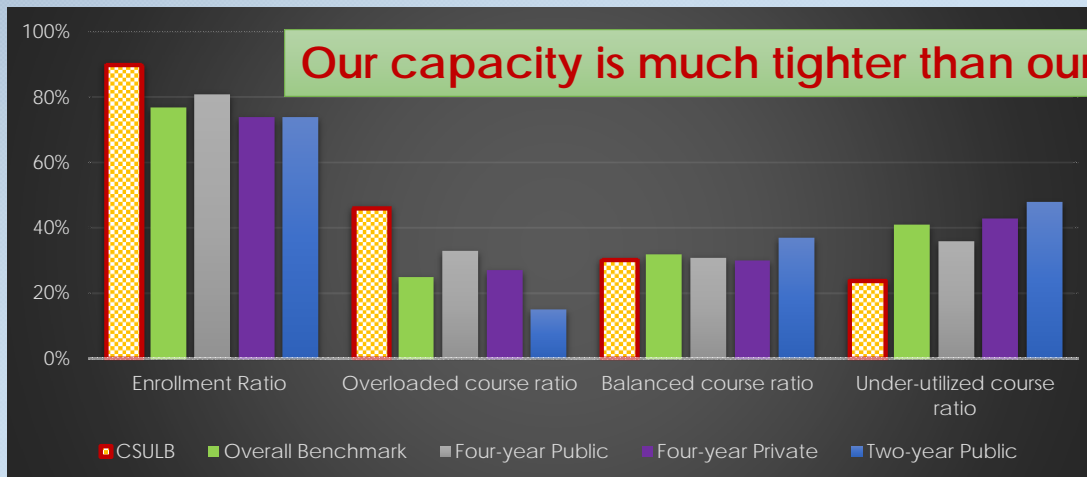
Classroom Utilization

Class Sessions by Room Capacity

- 21% — less than 30
- 51% — between 31 and 50
- 20% — between 51 and 100
- 8% — 101 or above

	Enrollment/Room Capacity	Enrollment Cap/Room Capacity
Benchmark	62.0%	81.0%
CSULB Overall	69.2%	75.8%
less than 30	82.8%	91.4%
between 31 and 50	68.8%	75.2%
between 51 and 100	57.4%	62.4%
101 or above	63.9%	71.2%

There is a potential to capture additional classroom capacity by more careful planning, e.g., matching class session with the right classroom.

Mismatch between Capacity and Demand

Fall 2011			
CLASS_CATALOG_NBR	CLASS_SECTION	CLASS_ENRL_TOT	CLASS_ENRL_CAP
MGMT 426	1	26	40
MGMT 426	2	19	40
MGMT 426	3	22	40
	Total	67	120

one session or 40 seats can be potentially removed by consolidating sessions

Fall 2009			
CLASS_CATALOG_NBR	CLASS_SECTION	CLASS_ENRL_TOT	CLASS_ENRL_CAP
MGMT 410	1	38	35
MGMT 410	2	39	35
MGMT 410	3	48	35
	Total	125	105

one more session or 35 seats can be potentially added due to sufficient demand

Mismatch between Capacity and Demand

Chart axis: 0% to 35%

Categories: CSULB, CBA, CHHS, CNSM, COE, COED, COLA, COTA, UNPG

CSULB: 4.4%, 2.8%, 12.8%, 10.9%
CBA: 1.3%, 0.9%, 11.6%, 9.4%
CHHS: 1.9%, 1.8%, 14.7%, 13.1%
CNSM: 6.1%, 4.1%, 12.0%, 11.3%
COE: 2.9%, 2.6%, 20.4%, 18.6%
COED: 22.0%, 9.0%, 3.7%, 4.2%
COLA: 3.5%, 2.5%, 9.1%, 7.4%
COTA: 2.9%, 2.1%, 18.6%, 16.4%
UNPG: 29.2%, 19.5%, 2.6%, 2.3%

Legend: ■ Percentage of Sessions Removed ▤ Percentage of Seats Removed ■ Percentage of Sessions Added ▤ Percentage of Seats Added
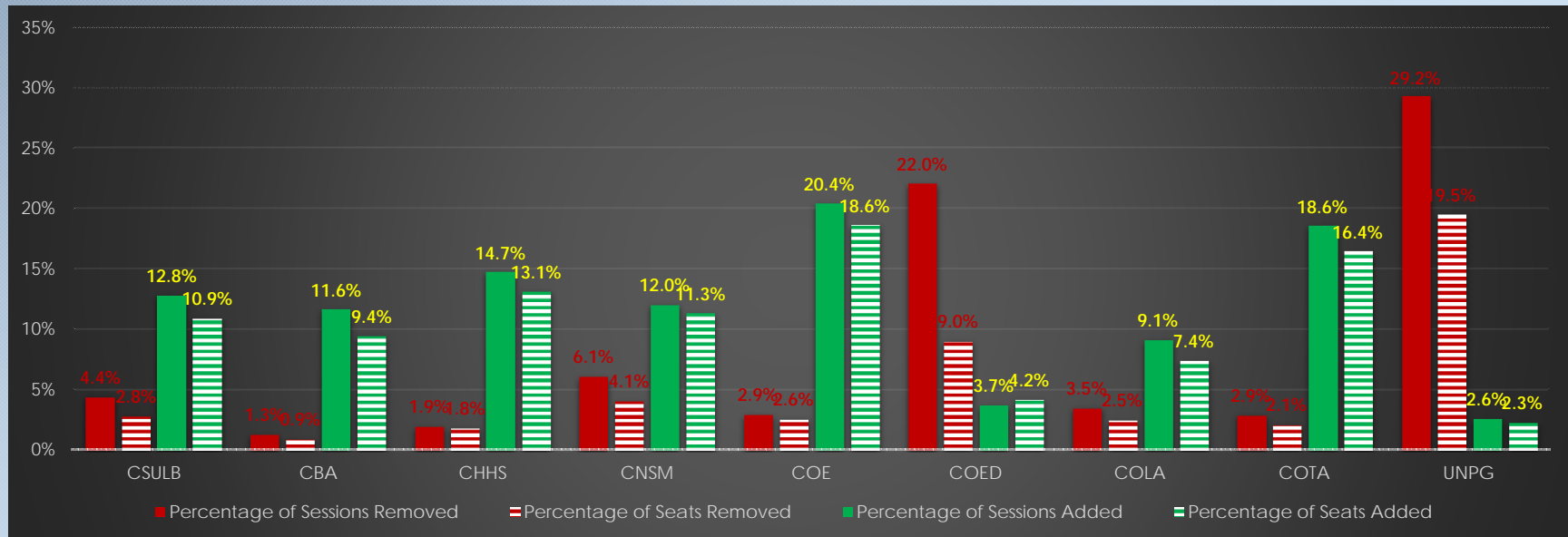
- Across campus, 4.4% of the class sessions can be removed while 12.8% more sessions can be added due to potential demand.
- COE had more potential to add class sessions while COED had more potential to reduce class sessions. CNSM had more potential to better match capacity with demand.
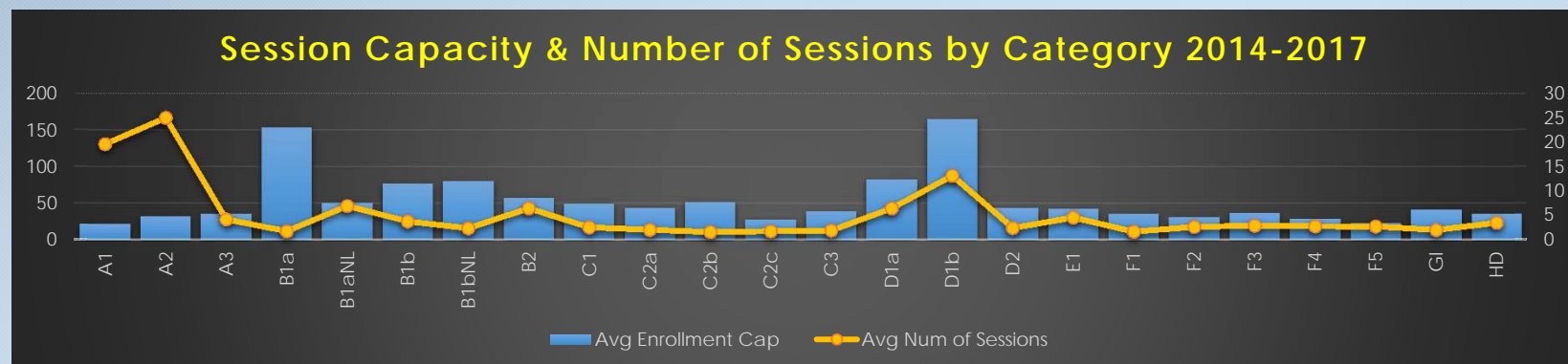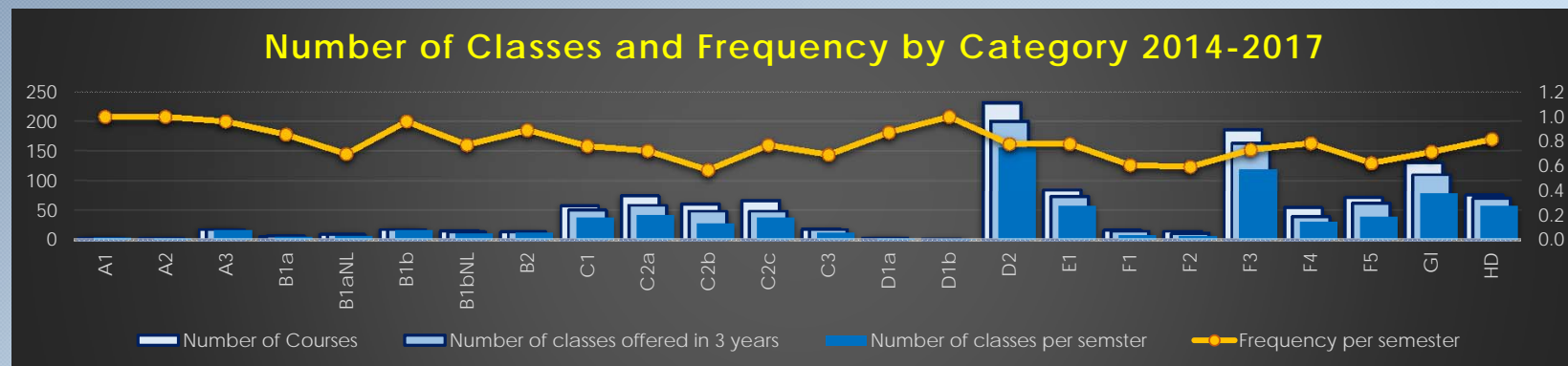
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General Education Capacity Analysis

Units Required, GE Requirement 2012

**GE Capacity/Enrollment by Category 2014-2017**
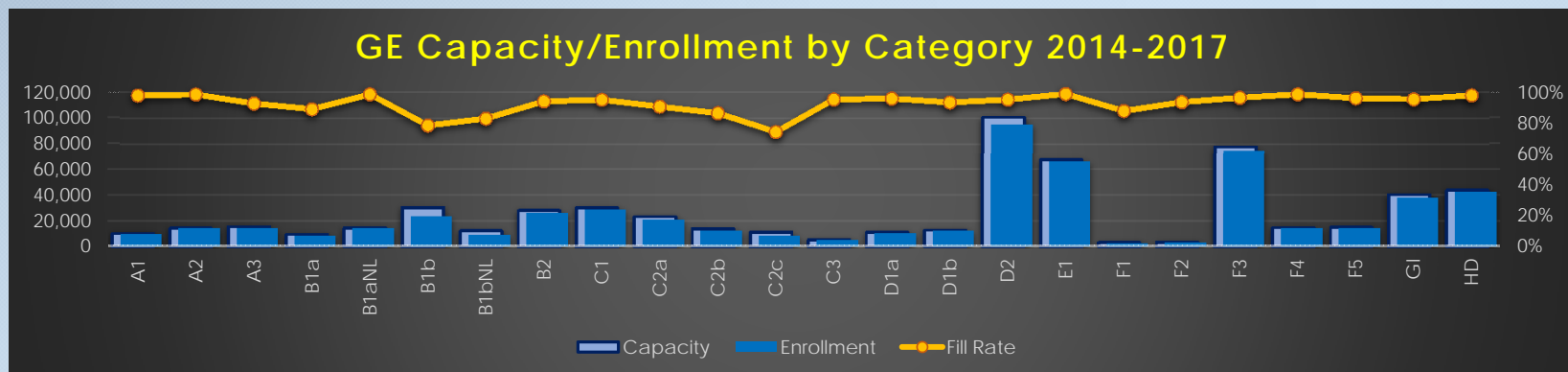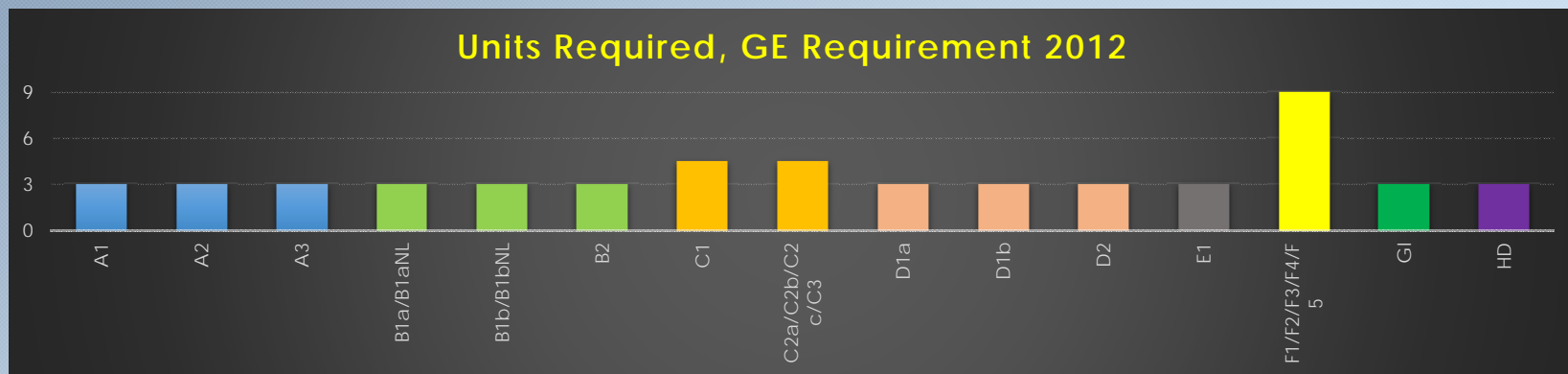
- D2 (Social Sciences and Citizenship), E (Lifelong Learning and Self Development), and F3 (Interdisciplinary Capstone) had the most seats, indicating sufficient capacity in both quantity and variety.

- B1b/B1bNL (Physical Science), C2b (Philosophy), C2c (Foreign Language) had relatively low fill rate.

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General Education Capacity Analysis

Number of Classes and Frequency by Category 2014-2017

Legend: Number of Courses — Number of classes offered in 3 years — Number of classes per semster — Frequency per semester

Session Capacity & Number of Sessions by Category 2014-2017

Legend: Avg Enrollment Cap — Avg Num of Sessions

- Categories D2 (Social Sciences and Citizenship) and F3 (Interdisciplinary Capstone) had the most variety of courses, followed by Categories C1, C2a, C2b, C2c, and E.
- B1a (Life Science) and D1b (Constitution and American Ideals) had larger class capacity.
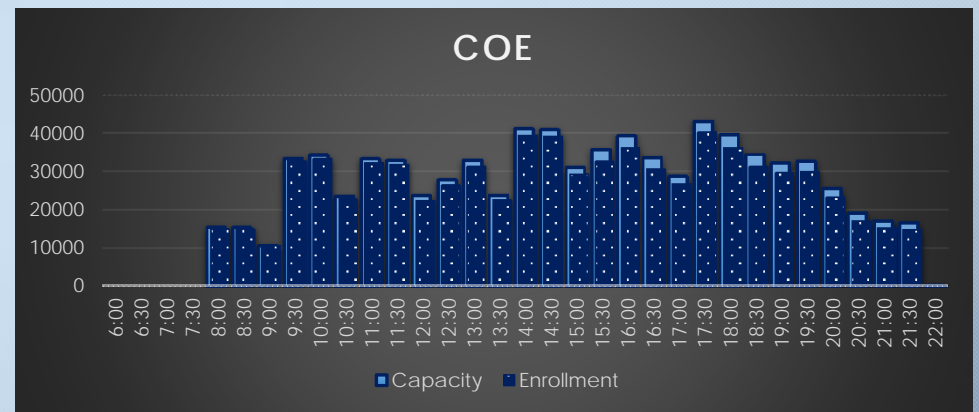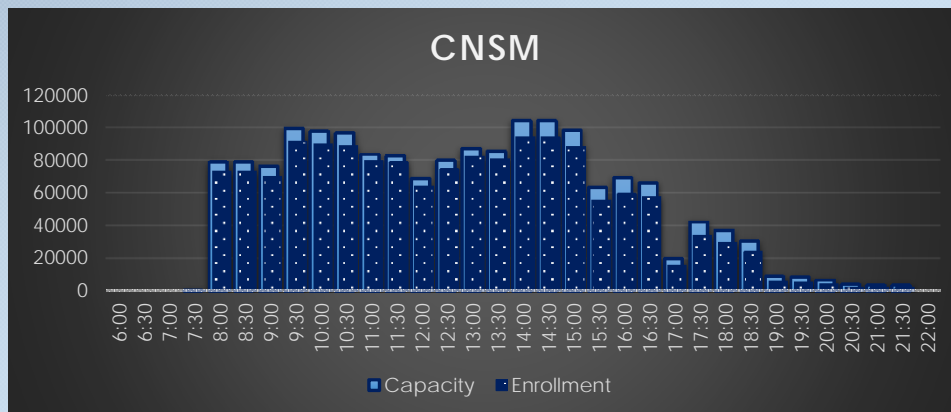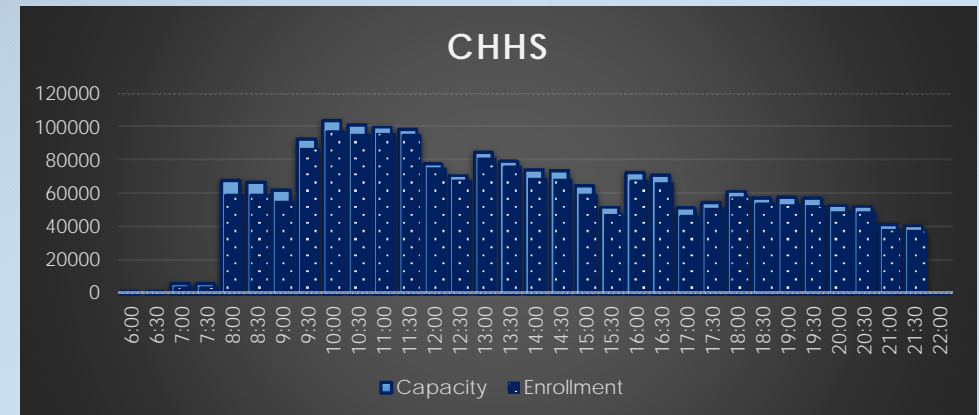
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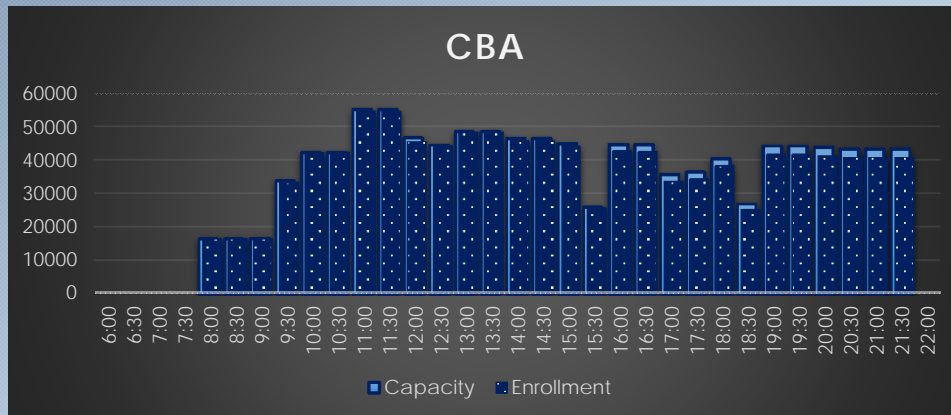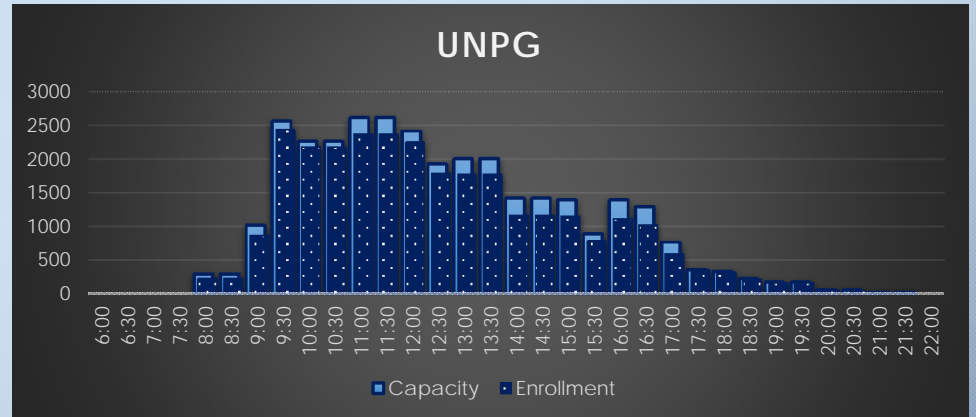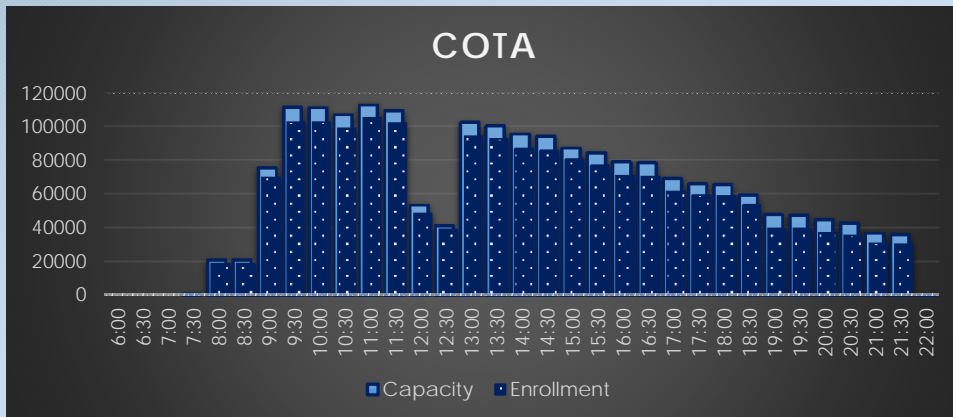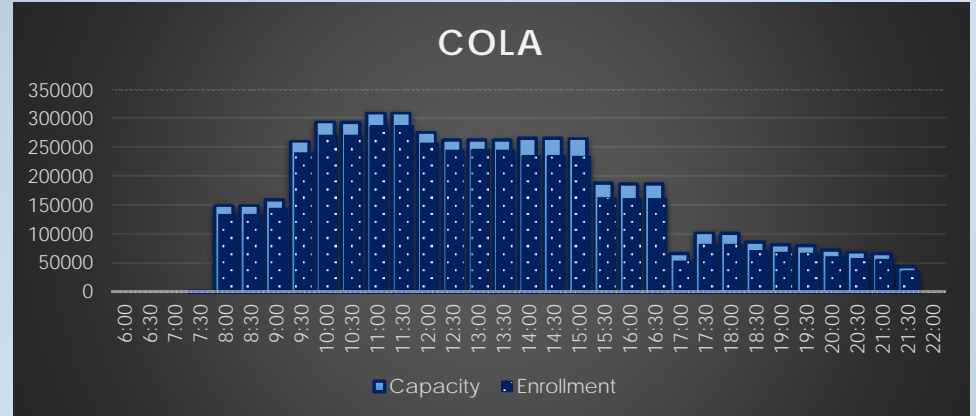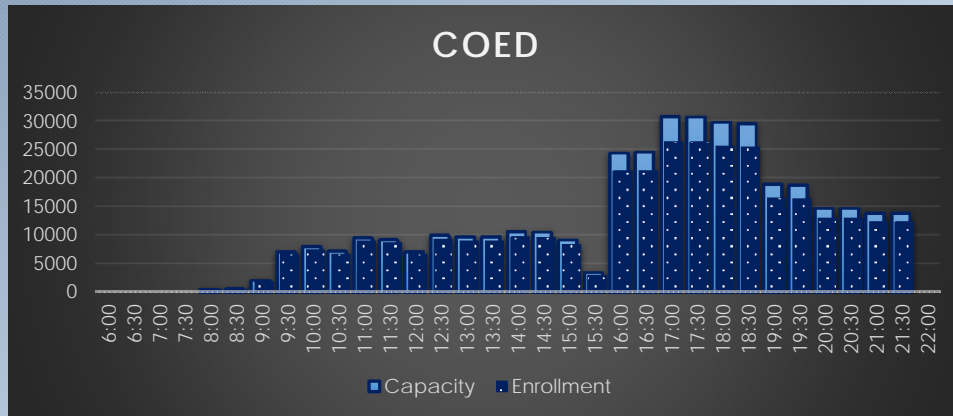# Time Pattern By Hour: Campus-wide
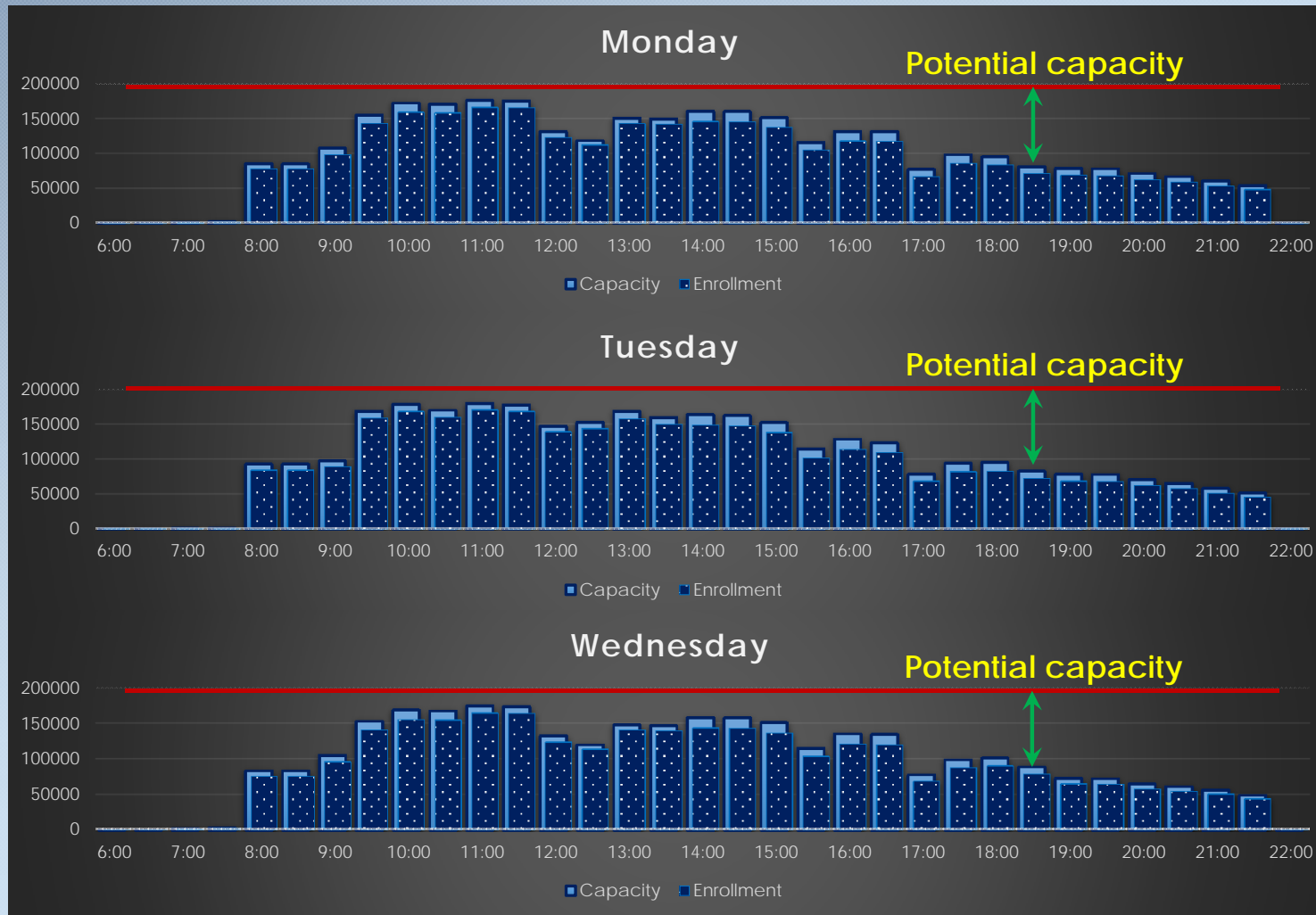
Time Pattern By Hour: Campus-wide
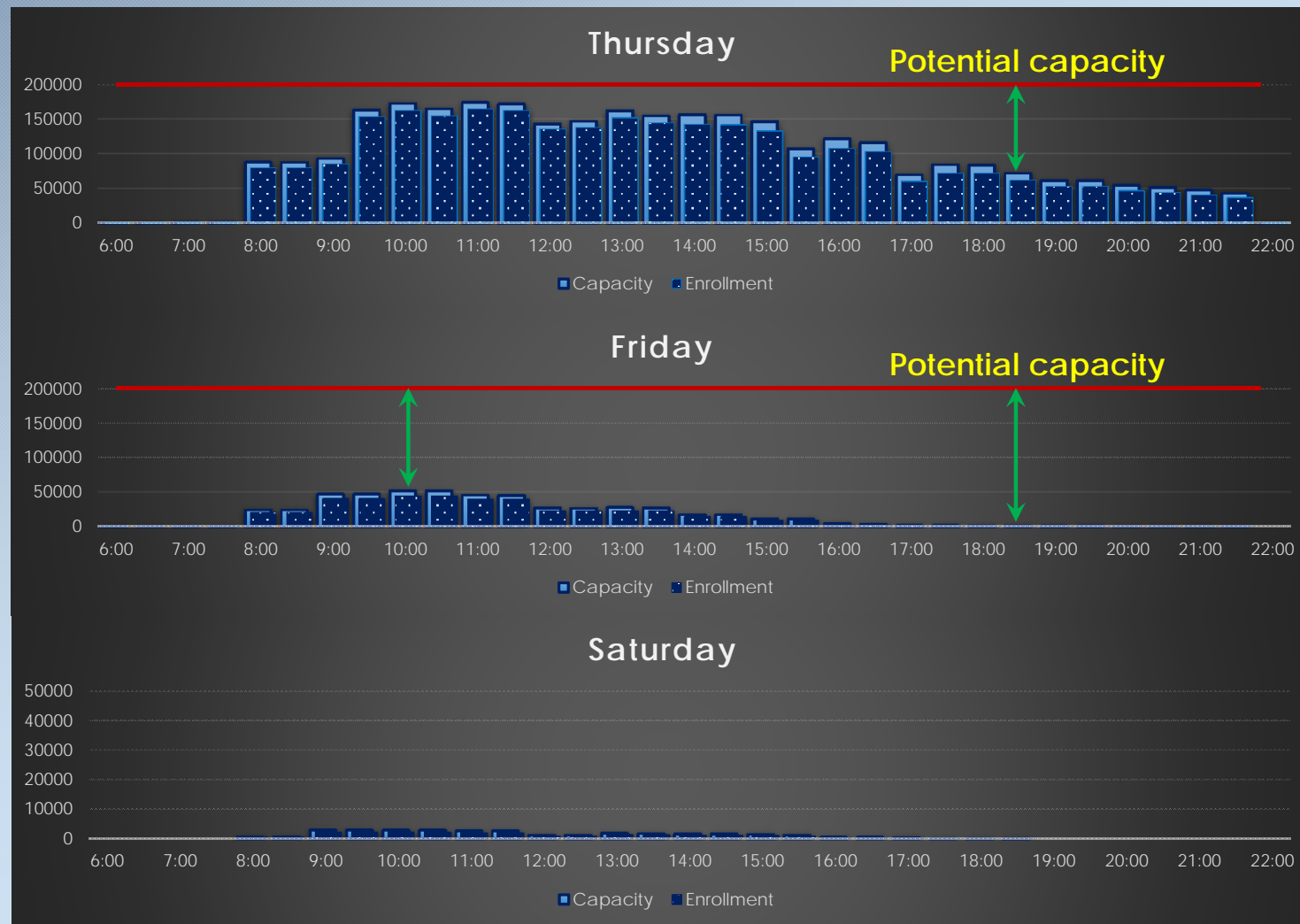
Time Pattern By Hour: by College
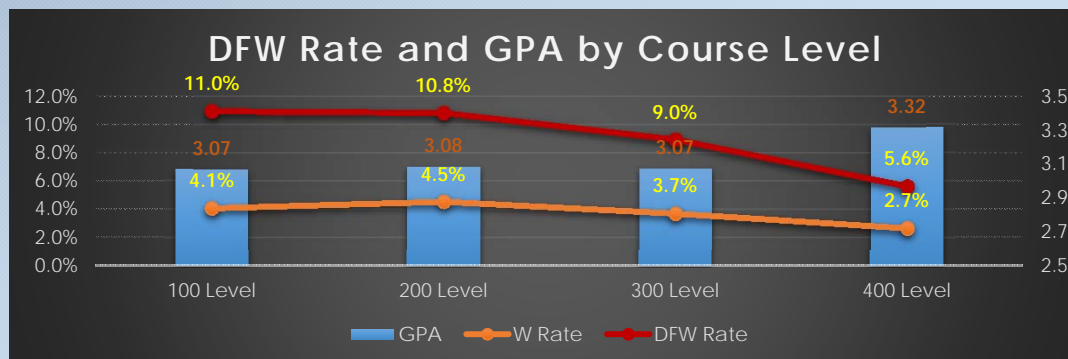
Time Pattern By Hour: by College

Time Pattern

- The prime time for course scheduling is from 9:30 am to 5:00 pm Monday through Thursday.

- There is a potential to expand current capacity without adding new facilities by offering more evening classes and Friday classes.

- Time pattern exhibits distinct features across different colleges. CBA, CHHS and COE in general had offered more balanced capacity during day time/night time; COED offered more classes during night time; while for all other colleges, the majority of the classes were offered during day time.

Survival/Failure Rates

DFW Rate and GPA by Academic Year

|	AY09-10	AY10-11	AY11-12	AY12-13	AY13-14	AY14-15	AY15-16	AY16-17
DFW Rate	9.2%	8.7%	9.1%	8.8%	8.6%	8.8%	8.2%	8.1%
GPA	3.13	3.16	3.14	3.12	3.14	3.13	3.16	3.17
W Rate	4.0%	3.8%	3.9%	3.5%	3.5%	3.5%	3.2%	3.2%

Legend: GPA, W Rate, DFW Rate

DFW Rate and GPA by Course Level

	100 Level	200 Level	300 Level	400 Level
DFW Rate	11.0%	10.8%	9.0%	5.6%
GPA	3.07	3.08	3.07	3.32
W Rate	4.1%	4.5%	3.7%	2.7%

Legend: GPA, W Rate, DFW Rate
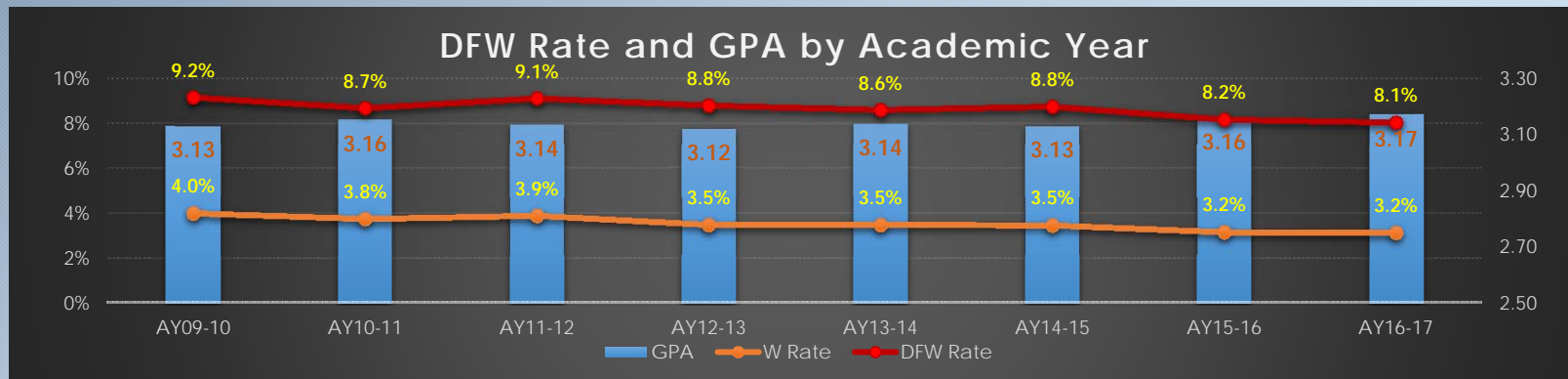
College	GPA	W Rate	DFW Rate
CBA	2.76	3.1%	9.5%
CHHS	3.39	2.2%	5.2%
CNSM	2.81	6.7%	16.4%
COE	3.00	4.8%	10.6%
COED	3.66	2.8%	4.6%
COLA	3.02	4.0%	10.0%
COTA	3.47	2.2%	4.7%
UNPG	3.74	1.6%	2.8%

- With recent campus initiatives, the student success rates have improved in recent years.
- Lower division classes had much lower success rates.
- CNSM had the highest DFW rates while CBA had the lowest class GPA.

Survival/Failure Rates

Class Size	100 Level				200 Level				300 Level				400 Level			
	# Sessions	GPA	W Rate	DFW Rate	# Sessions	GPA	W Rate	DFW Rate	# Sessions	GPA	W Rate	DFW Rate	# Sessions	GPA	W Rate	DFW Rate
20	1448	3.13	3.6%	9.6%	1589	3.45	3.0%	5.9%	4173	3.29	3.0%	6.0%	7431	3.49	2.6%	4.7%
30	6975	3.12	3.6%	9.1%	3626	3.08	4.6%	10.9%	8215	3.09	4.0%	8.8%	8323	3.30	2.8%	6.0%
50	6058	3.14	4.7%	11.6%	2301	3.00	4.8%	11.7%	8205	3.01	3.6%	9.6%	4943	3.15	2.5%	6.0%
100	1678	2.99	3.5%	11.2%	241	2.82	5.6%	15.6%	1050	2.88	4.7%	12.9%	376	3.08	3.2%	8.6%
200	1508	2.62	4.7%	17.1%	336	2.52	7.6%	20.0%	842	2.68	3.6%	13.0%	96	3.19	1.3%	4.5%
201 or more	223	2.60	5.1%	18.8%	75	2.34	5.3%	20.4%	16	2.93	2.7%	9.4%	21	3.49	1.5%	2.9%

DFW Rates and GPA by Category 2014-2017
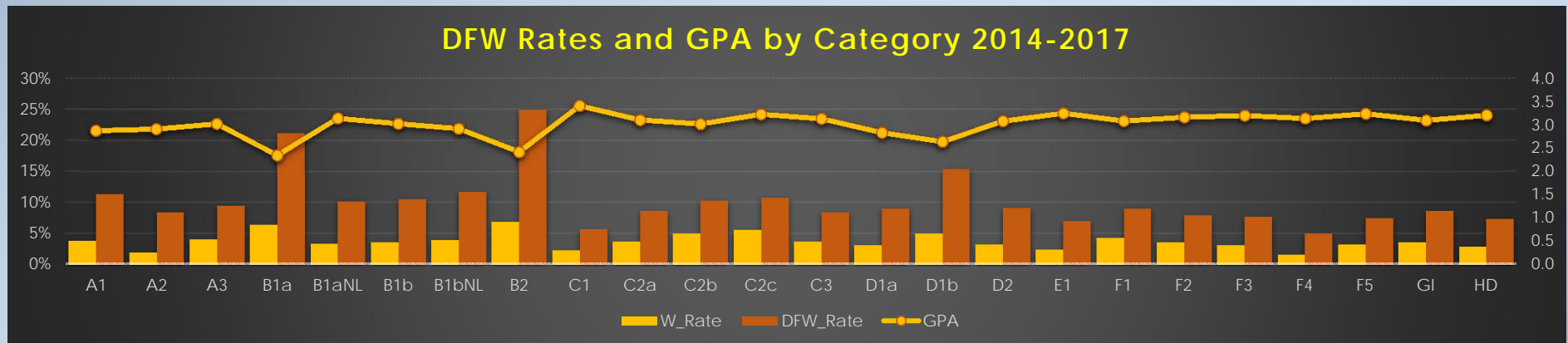
- Class size does affect student success rates for all class levels. Students success rates are lower in larger classes.
- Categories B1a, B2 and D1b had the lowest student success rates compared to other GE categories

Inconsistent Grading Criterion

ABC 100, Fall 2014
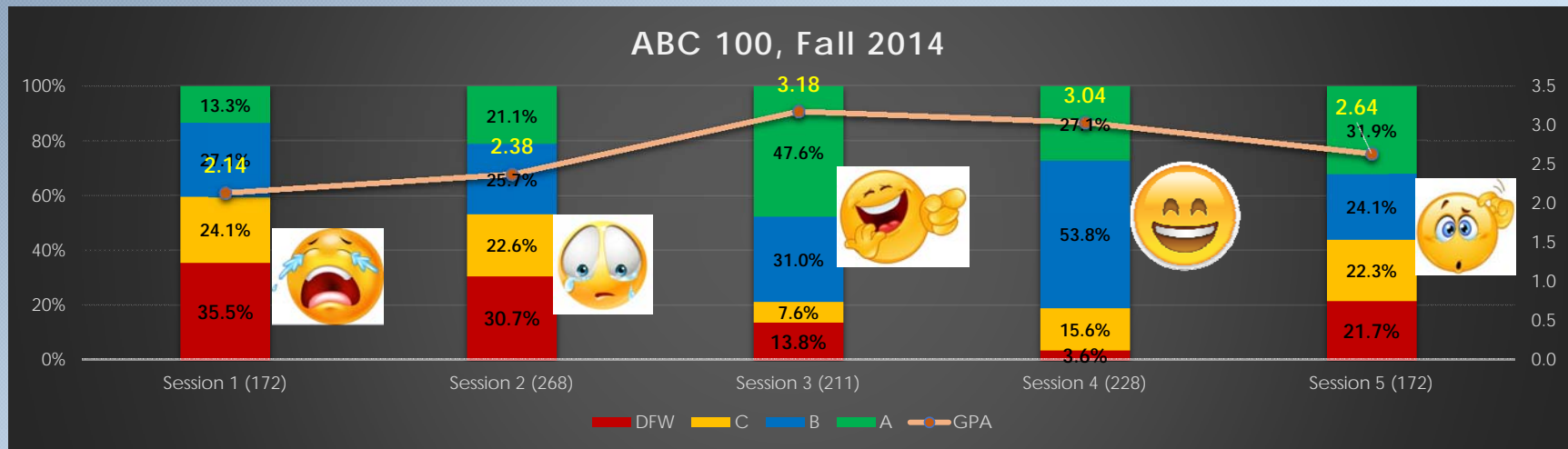
Number of Sections	Class Size<=20		Class Size<=30		Class Size<=50		Class Size<=100		Class Size<=200		Class Size>=201	
	Stdev	Range	Stdev	Range	Stdev	Range	Stdev	Range	Stdev	Range	Stdev	Range
2 and 3	0.22	0.34	0.23	0.36	0.23	0.36	0.22	0.35	0.22	0.36	0.26	0.47
4 and 5	0.28	0.65	0.29	0.66	0.27	0.63	0.27	0.62	0.26	0.60	0.26	0.62
6 to 10	0.30	0.82	0.33	0.91	0.30	0.85	0.31	0.89	0.27	0.76		
11 or more	0.34	1.21	0.32	1.20	0.30	1.04	0.34	1.17	0.36	1.27		

- Inconsistent grading criterion presents a big issue across campus particularly for classes with a large number of sessions.

Student Course Schedule

Monday	Tuesday	Wednesday	Thursday
8:00 am – 9:15 am MKTG 300	8:00 am – 9:15 am MGMT 300	8:00 am – 9:15 am MKTG 300	8:00 am – 9:15 am MGMT 300
Break	9:30 am – 10:45 am FIN 300	Break	9:30 am – 10:45 am FIN 300
10:00 am – 11:50 am ACCT 300A	11:00 am – 12:15 am IS 301	10:00 am – 11:50 am ACCT 300A	11:00 am – 12:15 am IS 301

- Student A, Spring 2017
- Take 16 units
- Come to school four days a week
- Total in-class time 16 hours
- Total At-school time 17 hours
- In-class/at-school ratio = 0.94

Monday	Tuesday	Wednesday	Thursday
	15:30 pm – 16:45 pm HRM 360		15:30 pm – 16:45 pm HRM 360
			Break
19:00 pm – 21:45 pm IS 300		19:00 pm – 21:45 pm FIN 300	19:00 pm – 21:45 pm IS 340

- Student B, Spring 2017
- Take 12 units
- Come to school four days a week
- Total in-class time 12 hours
- Total At-school time 14 hours
- In-class/at-school ratio = 0.86

Student Course Schedule

Monday	Tuesday	Wednesday	Thursday
	9:30 am – 10:45 am MGMT 425		9:30 am – 10:45 am MGMT 425
	11:00 am – 12:15 am IS 310		11:00 am – 12:15 am IS 310
	12:30 pm – 13:45 pm MUS 468		12:30 pm – 13:45 pm MUS 468

Monday	Tuesday	Wednesday	Thursday
	11:00 am – 11:50 am MATH 115		11:00 am – 11:50 am MATH 115
	12:00 pm – 13:50 pm ACCT 300A		12:00 pm – 13:50 pm ACCT 300A
	Break		Break
	15:30 pm – 16:45 pm HRM 360		15:30 pm – 16:45 pm HRM 360
	Break		Break
17:30 pm – 20:15 pm PHIL 352	17:30 pm – 18:45 pm MGMT 300		17:30 pm – 18:45 pm MGMT 300

- Student C, Spring 2017
- Take 9 units
- Come to school two days a week
- Total in-class time 9 hours
- Total At-school time 9 hours
- In-class/at-school ratio = 1.00

- Student D, Spring 2017
- Take 16 units
- Come to school three days a week
- Total in-class time 15 hours
- Total At-school time 19 hours
- In-class/at-school ratio = 0.79

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Course Schedule

Units Taken Per Semester, avg=11.29

- 0.2%
- 8.0%
- 15.4%
- 14.2%
- 30.8%
- 31.3%

Legend:
- 1-6 units
- 7-9 units
- 10-12 units
- 13-15 units
- 16-18 units
- 19 units or above
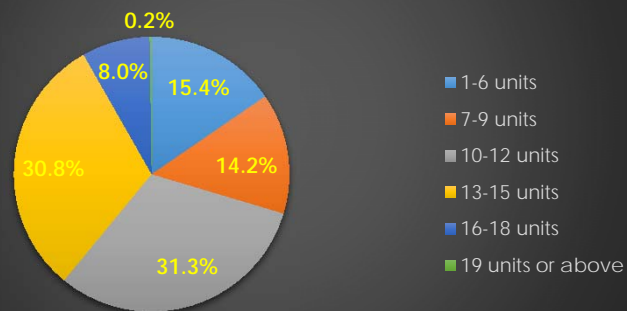
Number of Days to School, avg=3.32

- 0.0%
- 5.6%
- 12.8%
- 24.0%
- 41.7%
- 15.8%

Legend:
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days
- 6 days
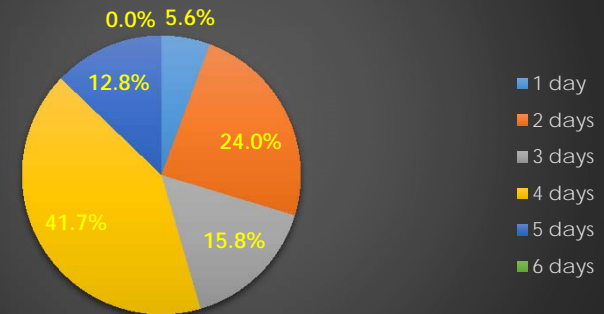
In-class/at-school Ratio, avg=80.2%

- 7.1%
- 10.4%
- 14.4%
- 18.4%
- 12.0%
- 37.8%

Legend:
- <=0.5
- between 0.5 and 0.6
- between 0.6 and 0.7
- between 0.7 and 0.8
- between 0.8 and 0.9
- >0.9
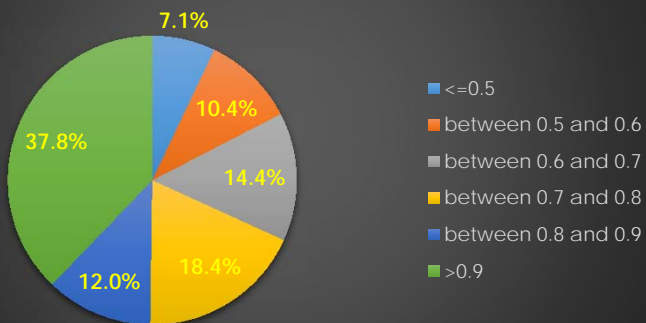
Units Taken Per Semester	Days at School	In-Class Time	At-School Time	In-class/at-school Ratio
1-6 units	1.91	5.10	5.62	95.7%
7-9 units	2.92	8.99	11.35	84.1%
10-12 units	3.51	12.05	16.24	77.9%
13-15 units	3.83	13.87	19.48	74.7%
16-18 units	4.02	16.38	23.19	73.6%
19 units or above	3.97	20.37	26.43	83.2%

Course Schedule

- On average, students take 11.29 units per semester. Over 60% of the students take 12 units or less, which prohibits them from graduating within four years even if classes are available.

- Over 40% of the students come to school less than three days a week.

- Most students prefer back-to-back class scheduling possibly due to other commitments, which suggests the important of coordinated course scheduling.

Timely Graduation—
From Process Analysis Perspective

Outline

- Understanding the process—roadmaps
- Craft the roadmap (4-year academic plan)—arrange the sequence based on analytics
- Process analysis:
  - ➤ Calculating 4-year graduation rate
  - ➤ Sensitivity analysis—direct effort and resources to the critical issues and critical links
- Process monitoring—success markers and alerts

Current Roadmap— on Department's Website

Four Year Plan - 120

Course	Units	Course	Units
Semester 1		**Semester 2**	
ENGR 101, Intro to Engineering (Part of GE E)	1	ENGR 102, Academic Success (Part of GE E)	1
Written Communication (GE A1)	3	MAE 101B, Intro to ME (Part of GE E)	1
MAE 172, Engineering Design Graphics	2	PHYS 151, Mech/Heat (GE B1b)	4
MATH 122 Calculus (GE B2)	4	MATH 123, Calculus II (GE B2)	4
Oral Communication (GE A2)	3	CHEM 111A, Gen Chemistry	5
Total Units	**13**	**Total Units**	**15**
Semester 3		**Semester 4**	
CE 205, Analyt Mech I (Statics)	3	MATH 370A, Applied Math I	3
PHYS 152 Elec & Magnetism or EE 210 & EE 210L	4	MAE 371, Analyt Mech II (Dynamics)	3
MATH 224, Calculus III (GE B2)	4	MAE 373, Mech Deformable Bodies	3
MAE 205, Computer Methods in MAE	2	MAE 322, Engr Matls & Matls Processes	3
MAE 272, Intro to Manufacturing Proc	2	GE Course (C1)†	3
Total Units	**15**	**Total Units**	**15**
Semester 5		**Semester 6**	

Current Roadmap—Degree Planner

[01] 1st Semester (Units: 14, Lines: 5)

01.01 GE Written Communication (Area A1) 0320, General Education & Foundation (GE Written Comm (Area A1)), Units: 3 CRITICAL ⏰ Min Grade Points/Unit: 2 Notes: Major Declaration Requirement Course	Degree 1 Only: Y Major 1 Only: Y Pre-Major Requirement: Y Display Note: Y

Pre-Requirement • Composition I (10014/0050)

01.02 CECS 100 Critical Thinking Digital Information Age (GE Area: A3) 0010, Major Requirement (Major Requirement) Units: 3,CRITICAL ⏰ Min Grade Points/Unit: 2 Notes: Major Declaration Requirement Course Pre-Major Requirement: Y Display Note: Y Typically Offered: Fall, Spring, Summer	⟷ Co-Req	**GE Written Communication (Area A1) (1 of 1)** 0320, General Education & Foundation (GE Written Comm (Area A1)), Units: 3
01.03 ENGR 101 Introduction to Engineering (GE Area: E) 0020, Major Requirement (Major Requirement) Units: 1 Min Grade Points/Unit: 2 Typically Offered: Fall, Spring	⟷ Co-Req	**MATH 122 Calculus I (GE Area: B2) - Note: Major Declaration Requirement Course. (1 of 1)** 0030, Major Requirement (Major Requirement), Units: 4

Pre-Requirement • MATH 111 Precalculus Trigonometry (10039/0030)
     • see above
     and

     • MATH 113 Precalculus Algebra (10039/0040)

Inconsistency--Degree Planner VS Catalog

Computer Engineering

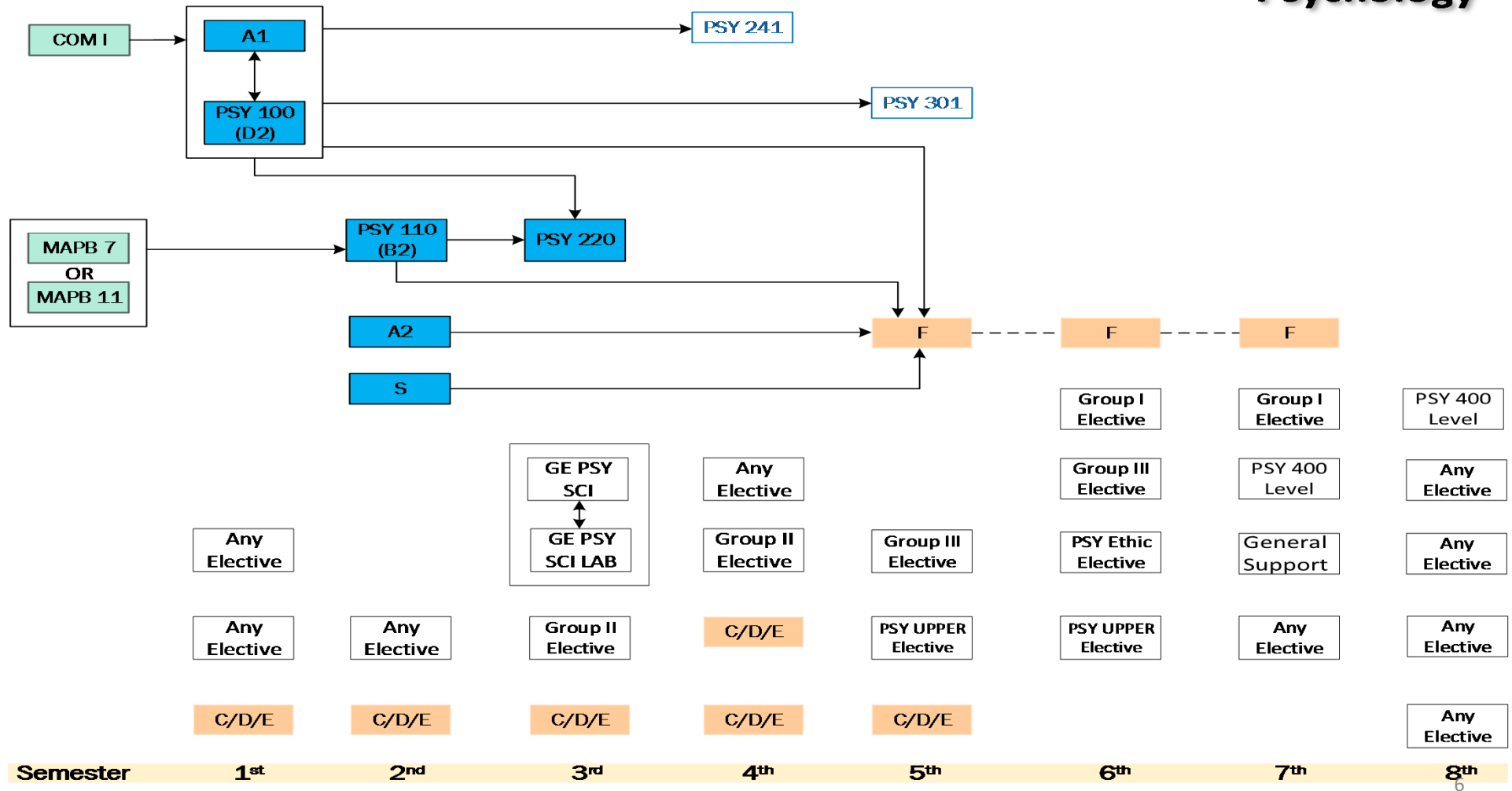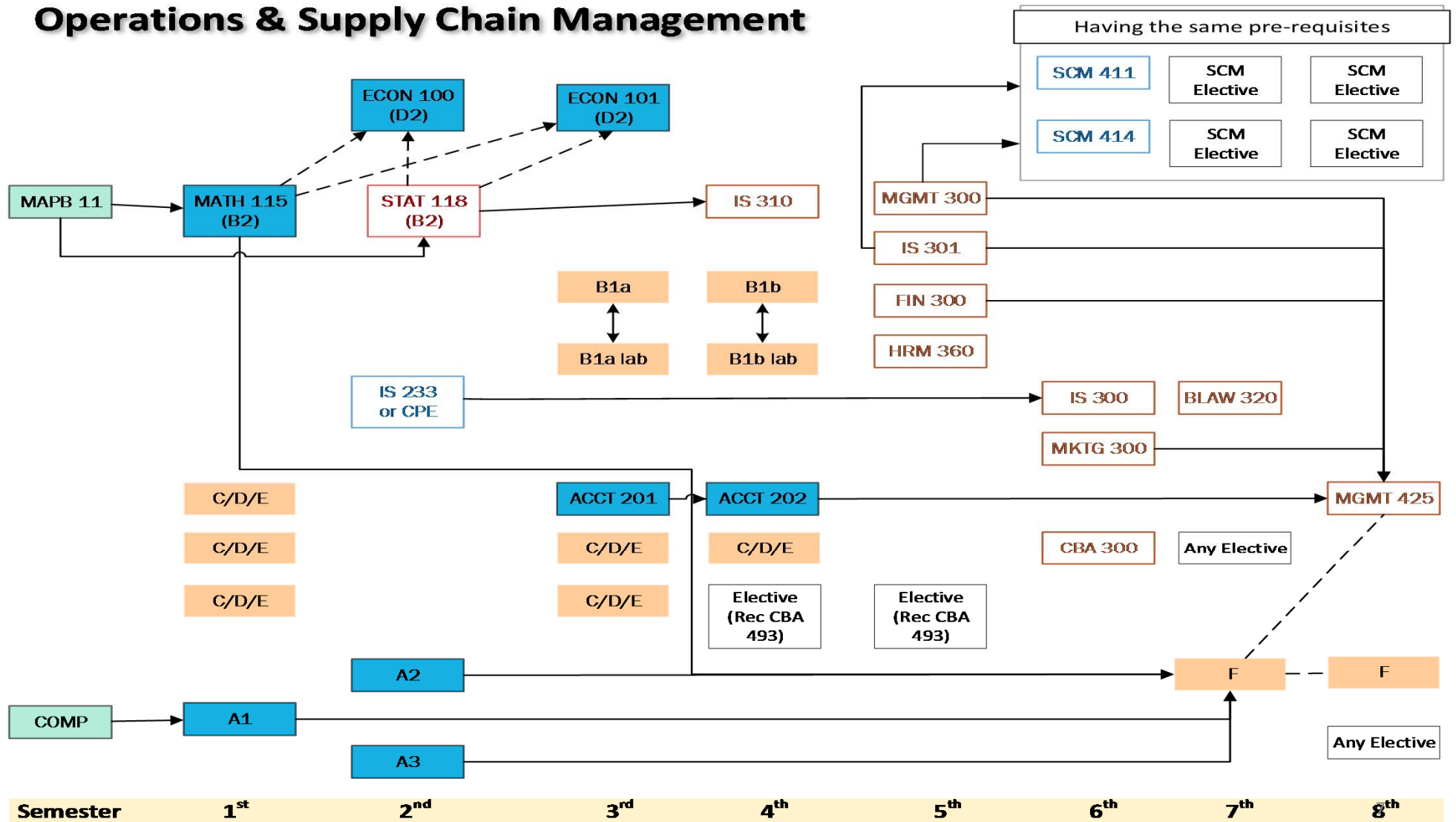|	Degree planner	Catalog
CECS 174	CECS 100	CECS 100 & MATH 113 or equivalent
CECS 201		MATH 113 or equivalent
CECS 271	CECS 174 & MATH 123	CECS 229 or Math 247 all with a grade "C" or better
ENGR 101		Prerequisite/corequisit: Math 111 or Math 113 or Math 122
CECS 326	CECS 346	CECS 275 or 282 and CECS 341 or CECS 346
CECS 347	CECS 346, CECS 311 and CECS 301	CECS 346, CECS 311
CECS 360	CECS 301, 346 and Math 123	CECS 301 and CECS 311
EE 380	Math 123 and CECS 100	MATH 123; (EE 202 or CECS 271 or CECE 274)

Mechanical Engineering

	Degree planner	Catalog
CHEM 111A	ENGR 101	pre-req: Chem place. Co-requisit MATH 109 or higher
MAE101B	NONE	Freshman standing or consent of instructor and MATH 111 or MATH 113 or MATH 122 with a grade of "C" or better.
CE 205	PHYS 151 and MATH 123	Prerequisite: PHYS 151 all with a grade of "C" or better.
		Prerequisite/Corequisite: MATH 123.
MAE 322	CHEM 111A, MATH 123 and MAE 172	Prerequisites: CHEM 111A, MATH 123 all with a grade of "C" or better.
MAE 471	373 and 375 plus A1, A2, Math 122	MAE 322, MAE 373 and MAE 375
MAE 336	None	MAE 300

Proposed Roadmap—A Visual Complement to Degree Planner

Psychology

| Semester | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |

Operations & Supply Chain Management

Having the same pre-requisites

SCM 411	SCM Elective	SCM Elective
SCM 414	SCM Elective	SCM Elective

ECON 100 (D2)

ECON 101 (D2)

MAPB 11 → MATH 115 (B2)

STAT 118 (B2)

IS 310

MGMT 300

IS 301

FIN 300

HRM 360

B1a ↔ B1a lab

B1b ↔ B1b lab

IS 233 or CPE

IS 300   BLAW 320

MKTG 300

MGMT 425

C/D/E

ACCT 201 → ACCT 202

C/D/E   C/D/E   C/D/E   CBA 300   Any Elective

C/D/E   C/D/E   C/D/E   Elective (Rec CBA 493)   Elective (Rec CBA 493)

A2

COMP → A1

A3

F — F

Any Elective

Semester	1st	2nd	3rd	4th	5th	6th	7th	8th

Accountancy

| Semester | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |

Biology

Flowchart of Biology course sequence by semester.

Semester 1 (1st):
- CHPT → CHEM 111A (B1b)
- MAPT OR MATH 113 → MATH 119A (B2) OR MATH 122 (B2)
- MAPT OR MATH 111 & 113
- Com I → A1
- Any Elective
- C/D/E

Semester 2 (2nd):
- BIOL 211
- CHEM 111B
- A2
- A3
- Any Elective

Semester 3 (3rd):
- BIOL 212
- CHEM 220A → CHEM 220B
- CHEM 223A → CHEM 223B
- BIOL 260
- Any Elective
- C/D/E

Semester 4 (4th):
- BIOL 213
- BIOL 340
- Any Elective
- C/D/E

Semester 5 (5th):
- BIOL 312
- BIOL 342 and 342L OR BIOL 345 and 345L OR BIOL 447
- Any Elective
- C/D/E

Semester 6 (6th):
- BIOL 350
- PHYS 100A (B1b) OR PHYS 151 (B1b)
- BIOL 370 (F)
- C/D/E

Semester 7 (7th):
- BIOL DIVERS
- BIOL SCI Elective
- PHYS 100B (B1b) OR PHYS 152 (B1b)
- MATH 123
- BIOL SCI 400 Elective
- GE Cap (F)
- GE Cap (F)

Semester 8 (8th):
- BIOL DIVERS
- BIOL 480
- BIOL SCI 400 Elective
- Any Elective
- C/D/E

Notes on flowchart:
- MATH 109 or higher (dashed arrow to CHEM 111A)
- Or CHEM 350 (BIOL 260 → BIOL 370)

Computer Engineering

COM 1 → A1

A2

Science Elective

CECS 105 (E)

ENGR 101 (E) → ENGR 102 (E)

PHYS 151 (B1b) → EE210 & EE 210L OR PHYS 152 (B1b)

F

C/D/E

CECS 490A (F) → CECS 490B (F)

MATH 123 (B2)

CECS 229

MDPT OR MATH 111& 113 → MATH 122 (B2)

CECS 211 → CECS 311

CECS 347 → CECS 447

CN Elective

CECS 346 → CECS 326

CECS 440

CECS 201 → CECS 301

CECS 360 → CECS 460

CECS 262

PHYS 255

CECS 463

CECS 228

CECS 174 → CECS 275

C/D/E

CECS 271

BLOL 200 (B1a) OR PHYS 254 OR CHEM 11A (B1b)

C/D/E

C/D/E

CECS 100 (A3) → EE 380

C/D/E

C/D/E

C/D/E

Semester	1st	2nd	3rd	4th	5th	6th	7th	8th

Mechanical Engineering

A Visual Roadmap Helps Students Stay Track Academically

❖[Self-efficacy] is the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations (Albert Bandura)

❖A visual map helps to develop students self-efficacy because

✓It only takes 1-page to show the whole picture—a clearly charted courses of action for students.

✓If students clearly understand their status or position in their academic journal, they have a better chance to succeed.

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Success stories: University of Hawaii at Manoa

Trends in 4, 5, 6, and 8 year Graduation Rates
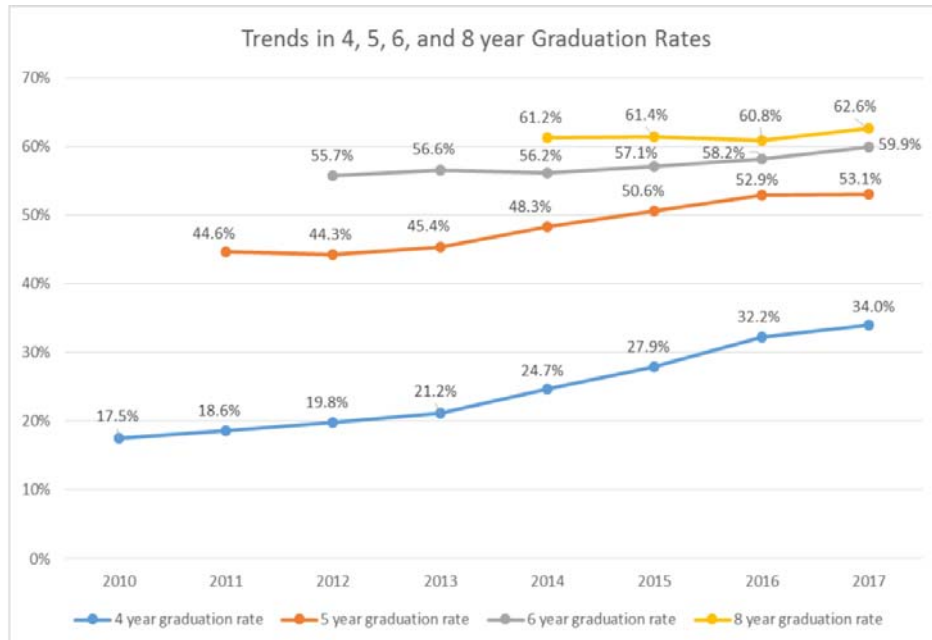
The 4-year plan, along with the STAR degree audit system has had more impact on the perception of students about the university's commitment to their success than anything else.

For the last five years, UHM has enjoyed record numbers of students graduating and <u>academic advisers identify the 4-year academic plans as the most important factor in that success.</u>
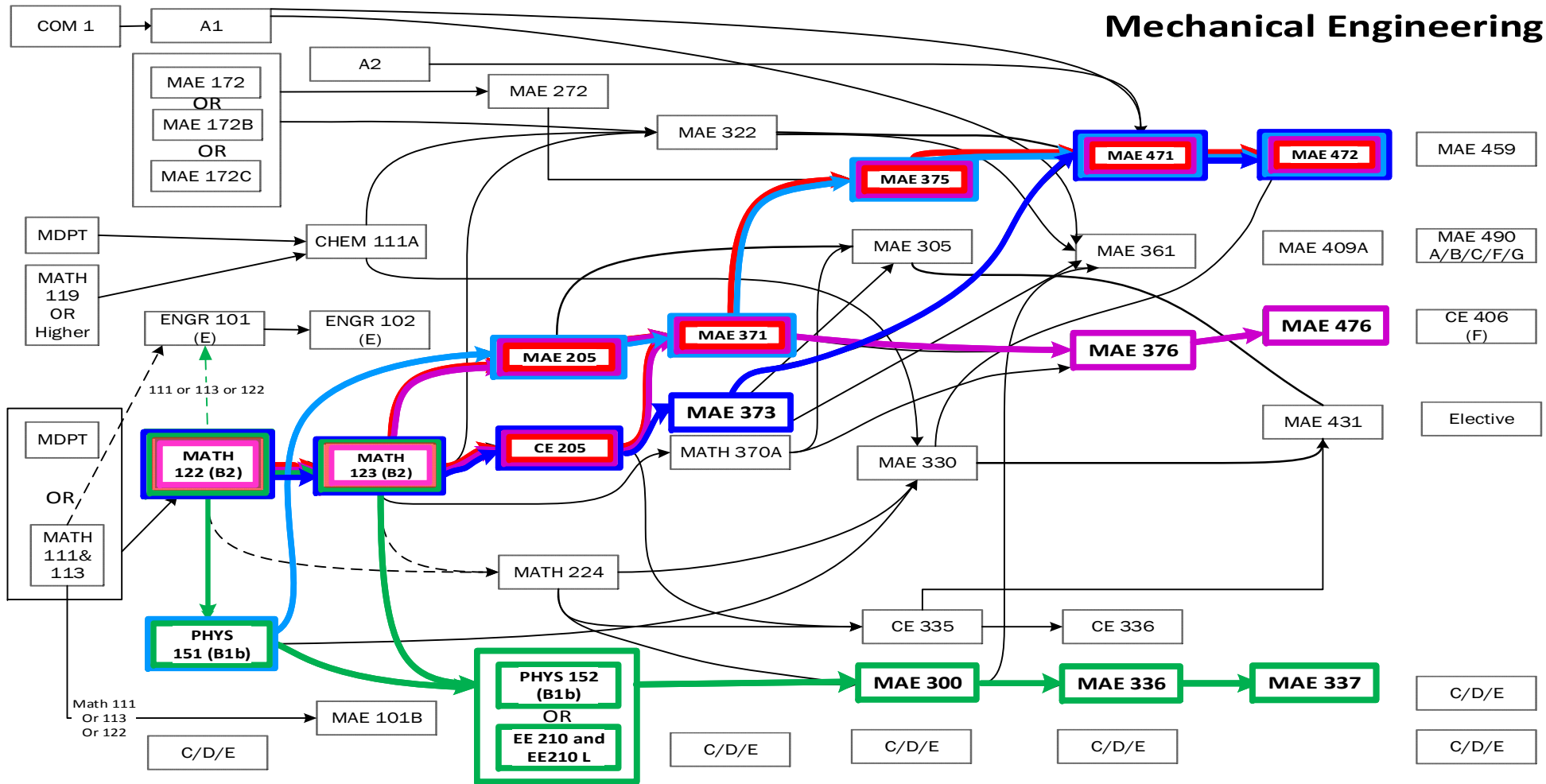
Actionable Items:

1. One set of 4-year roadmap for each of the undergraduate degrees.

2. Integrated into the university catalog and degree planner, along with the other information that was shared with students by advisers, faculty advisers, and departmental handouts.

3. The appointment of the "University Catalog" Committee responsible for maintaining dependable and accurate roadmaps for students.

4. Make the 4-year roadmap (academic plan) an integral part of students' mandatory advising and their registration meetings with advisers.

Mechanical Engineering

COM 1 → A1

A2

MAE 172 OR MAE 172B OR MAE 172C → MAE 272

MDPT → CHEM 111A

MATH 119 OR Higher

ENGR 101 (E) → ENGR 102 (E)

111 or 113 or 122

MDPT OR MATH 111 & 113

MATH 122, (B2) → MATH 123 (B2)

PHYS 151 (B1b)

Math 111 Or 113 Or 122

MAE 101B

C/D/E

PHYS 152 (B1b) OR EE 210 and EE210 L

MAE 322

MAE 375

MAE 305

MAE 205

MAE 371

MAE 373

MATH 370A

CE 205

MATH 224

CE 335 → CE 336

MAE 300 → MAE 336 → MAE 337

MAE 471 (F) → MAE 472 (F)

MAE 459

MAE 361

MAE 409A

MAE 490 A/B/C/F/G

MAE 376

MAE 476

CE 406 (F)

MAE 330

MAE 431

Elective

C/D/E

C/D/E

C/D/E

C/D/E

C/D/E

C/D/E

Semester	1st	2nd	3rd	4th	5th	6th	7th	8th

15

Mechanical Engineering

COM 1 → A1

A2 → MAE 272

MAE 172 OR MAE 172B OR MAE 172C

MAE 322

MAE 375

MAE 471 → MAE 472

MAE 459

MDPT → CHEM 111A

MAE 305

MAE 361

MAE 409A

MAE 490 A/B/C/F/G

MATH 119 OR Higher

ENGR 101 (E) → ENGR 102 (E)

MAE 371

MAE 376 → MAE 476

CE 406 (F)

111 or 113 or 122

MAE 205

MAE 373

MDPT OR MATH 111& 113

MATH 122 (B2) → MATH 123 (B2)

CE 205

MATH 370A

MAE 330

MAE 431

Elective

MATH 224

PHYS 151 (B1b)

CE 335 → CE 336

Math 111 Or 113 Or 122

MAE 101B

PHYS 152 (B1b) OR EE 210 and EE210 L

MAE 300 → MAE 336 → MAE 337

C/D/E

C/D/E

C/D/E

C/D/E

C/D/E

C/D/E

C/D/E

Craft the Best 4-Year Academic Plan

A – <u>the longest path</u> branching out from this course

B – <u>the number of followers</u>

C – <u>number of paths</u> branching out from this course

D – <u>the average of length</u> of following paths branching out from this course

$$\begin{bmatrix} A & B \\ D & C \end{bmatrix}$$

$$\begin{bmatrix} 7 & 24 \\ 5 & 28 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 9 \\ 3.2 & 6 \end{bmatrix}$$

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Craft the Best 4-Year Academic Plan Cont.

Semester 1st	2nd	3rd	4th	5th	6th	7th	8th
A1	A2	$\begin{bmatrix} 4 & 3 \\ 4 & 1 \end{bmatrix}$ MAE 272	$\begin{bmatrix} 3 & 3 \\ 2.5 & 2 \end{bmatrix}$ MAE 322	$\begin{bmatrix} 3 & 2 \\ 3 & 1 \end{bmatrix}$ MAE 375	$\begin{bmatrix} 2 & 1 \\ 2 & 1 \end{bmatrix}$ MAE 471 (F)	MAE 472 (F)	MAE 459
$\begin{bmatrix} 7 & 24 \\ 5 & 28 \end{bmatrix}$ MATH 122 (B2)	$\begin{bmatrix} 4 & 6 \\ 3.3 & 4 \end{bmatrix}$ CHAM 111A	$\begin{bmatrix} 5 & 11 \\ 3.7 & 6 \end{bmatrix}$ CE 205	$\begin{bmatrix} 4 & 5 \\ 3.5 & 2 \end{bmatrix}$ MAE 371	$\begin{bmatrix} 2 & 1 \\ 2 & 1 \end{bmatrix}$ MAE 305	MAE 361	MAE 409A	MAE 490 A/B/C/F/G
$\begin{bmatrix} 6 & 15 \\ 4.3 & 7 \end{bmatrix}$ PHYS 151 (B1b)	$\begin{bmatrix} 6 & 19 \\ 4.5 & 15 \end{bmatrix}$ MATH 123 (B2)	$\begin{bmatrix} 4 & 4 \\ 3.5 & 2 \end{bmatrix}$ PHYS 152 (B1b) OR EE 210 and EE210 L	$\begin{bmatrix} 3 & 3 \\ 2.5 & 2 \end{bmatrix}$ MAE 373	$\begin{bmatrix} 2 & 2 \\ 2 & 2 \end{bmatrix}$ MAE 330	MAE 476	MAE 431	CE 406 (F)
$\begin{bmatrix} 5 & 6 \\ 4 & 3 \end{bmatrix}$ MAE 172 OR MAE 172B OR MAE 172C	$\begin{bmatrix} 5 & 8 \\ 4 & 3 \end{bmatrix}$ MAE 205	MAE 101B	$\begin{bmatrix} 3 & 4 \\ 3 & 2 \end{bmatrix}$ MAE 370A	$\begin{bmatrix} 2 & 1 \\ 2 & 1 \end{bmatrix}$ MAE 376	CE 336	MAE 337	Elective
ENGR 101	$\begin{bmatrix} 4 & 9 \\ 3.2 & 6 \end{bmatrix}$ MATH 224	ENGR 102 (E)	$\begin{bmatrix} 3 & 3 \\ 2.5 & 2 \end{bmatrix}$ MAE 300	$\begin{bmatrix} 2 & 2 \\ 2 & 2 \end{bmatrix}$ CE 335	$\begin{bmatrix} 2 & 1 \\ 2 & 1 \end{bmatrix}$ MAE 336	C/D/E	C/D/E
C/D/E			C/D/E	C/D/E			C/D/E

Mechanical Engineering

Mechanical Engineering

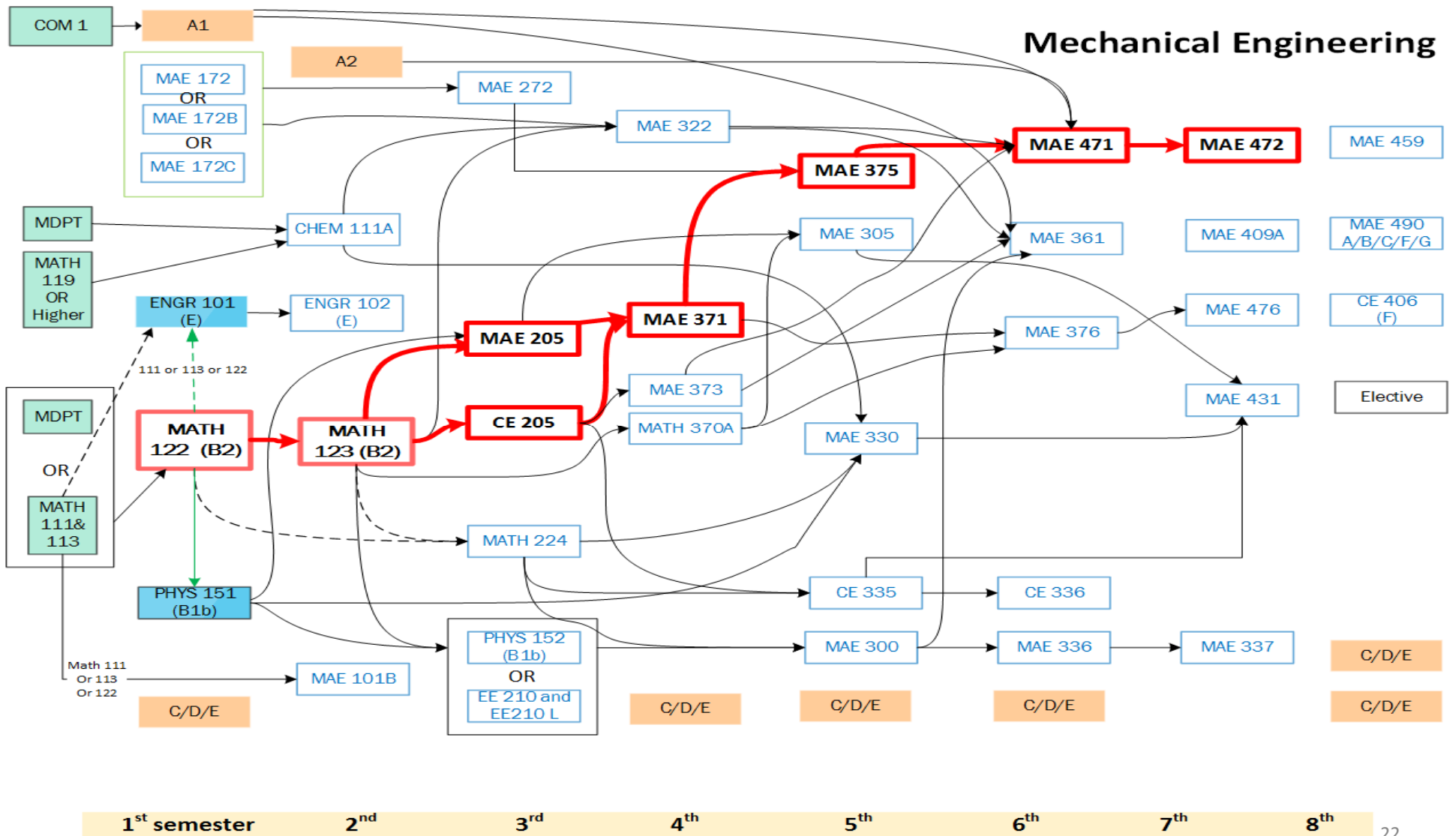| Semester	1st	2nd	3rd	4th	5th	6th	7th	8th

Process Analysis

1. <u>Given the current academic preparation (measured by DFW levels),</u> what is the 4-year graduation rate?

2. <u>Given limited resources,</u> how to prioritize the issues that need to be tackled?

    -Sensitivity analysis

Mechanical Engineering

COM 1 → A1

A2

MAE 172 OR MAE 172B OR MAE 172C

MAE 272

MAE 322

MAE 375

MAE 471 → MAE 472

MAE 459

MDPT

MATH 119 OR Higher

CHEM 111A

MAE 305

MAE 361

MAE 409A

MAE 490 A/B/C/F/G

ENGR 101 (E) → ENGR 102 (E)

MAE 205

MAE 371

MAE 376

MAE 476

CE 406 (F)

111 or 113 or 122

MDPT OR MATH 111& 113

MATH 122 (B2) → MATH 123 (B2)

CE 205

MAE 373

MATH 370A

MAE 330

MAE 431

Elective

MATH 224

PHYS 151 (B1b)

CE 335 → CE 336

PHYS 152 (B1b) OR EE 210 and EE210 L

MAE 300 → MAE 336 → MAE 337

C/D/E

Math 111 Or 113 Or 122

MAE 101B

C/D/E

C/D/E

C/D/E

C/D/E

C/D/E

C/D/E

1st semester   2nd   3rd   4th   5th   6th   7th   8th

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Probability of Successfully Completing a Path

<u>Path A:</u> the top red path

<u>P(A):</u>   the prob. of successfully completing path A in the

4-year window

✓Define P_i as the probability of successfully completing course i on the path

P_i =1-DFW$_i$ i =1, 2, …..7   Let $P=P_1*P_2*P_3*P_4*P_5*P_6*P_7$

Then P(A)= P+ $\sum_{i=1}^{7} DFW_i$ *P

Probability of Timely Graduation—The Model

Prob. of timely graduation
=Prob. (completing all paths in the 4-year window)

Suppose there are only three paths in a roadmap: path A, B and C

P(A) means probability of successfully completing path A

P(B|A) means probability of successfully completing path B **given** successfully completing path A

P(C|A∩B) means probability of successfully completing path C **given** successfully completing path (A and B)

Probability of timely graduation is

P (A∩B∩C)=P((A∩B) ∩C)
    =P(C|(A∩B))*P(A∩B)
    = P(C|(A∩B))* (P(A)*P(B|A))
    = P(A)*P(B|A)* P(C|(A∩B))

Mechanical Engineering has 37 Paths

Writing Simulation with C++

Probability of 4-year graduation=34%

Probability of Timely Graduation--The Reality

✓Many factors: enough seats, right time, right professor

Assume successful enrollment probability for the 8-semester window is as follows

Sem 1	Sem 2	Sem 3	Sem 4	Sem 5	Sem 6	Sem 7	Sem 8
100%	90%	85%	85%	85%	90%	100%	100%

the overall probability of successful enrollment is 57.8%

=>Revised Graduation Rate

= 34%*57.8%=19.6%

Sensitivity Analysis---What ifs?
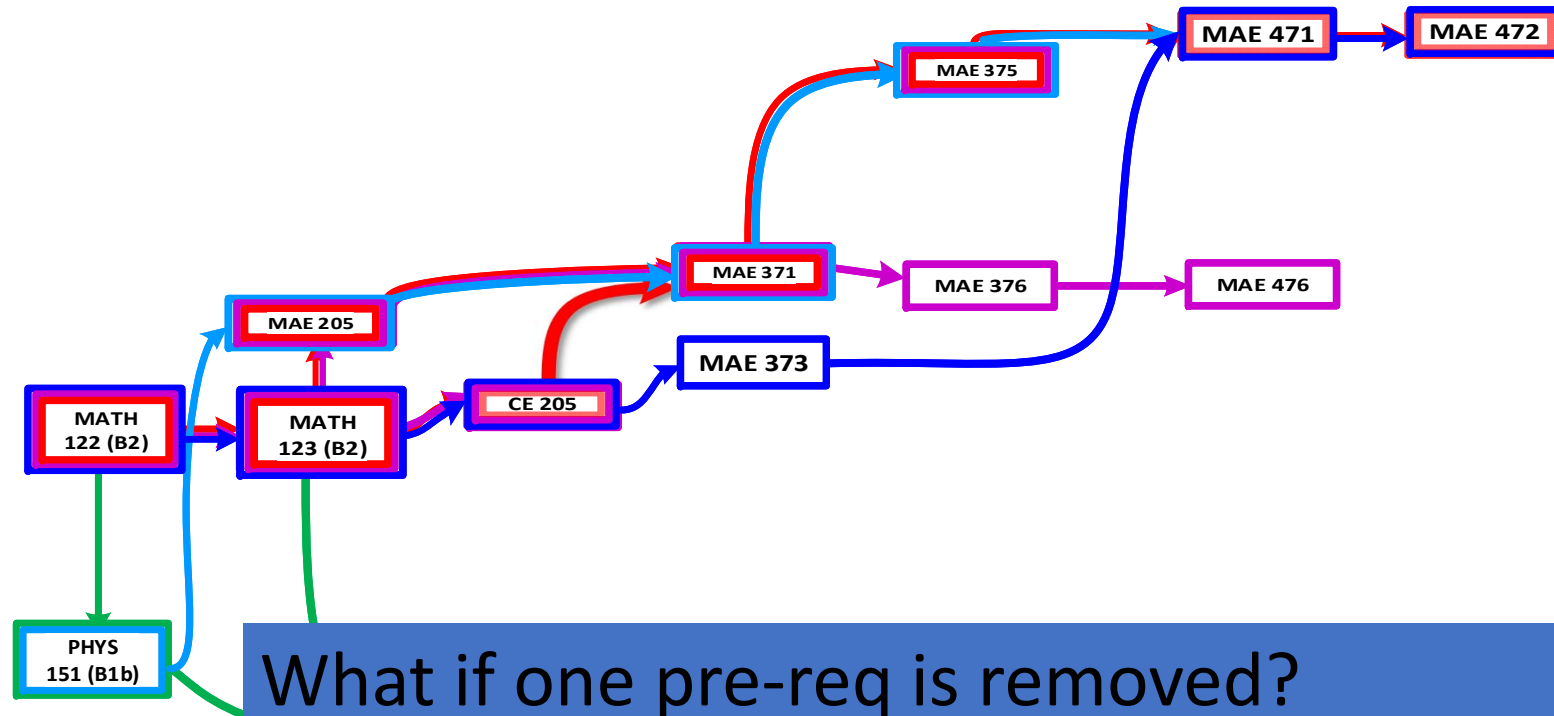
What if one pre-req is removed?

What if DFW ratios are reduced?

What if 5 courses per semester at most?

Sensitivity Analysis

Easy Fix

Targeted Attacks

Up to discussion?

Expose the impact of DFW

Something To be aware of

Mechanical Engineering	4 years	4.5 years	5 years	5.5 years	6 years
Current roadmap	34.0%	33.1%	12.5%	3.4%	0.8%
Improved course sequence	37.2%	30.8%	11.9%	3.1%	0.7%
Improved course sequence (Math 122, 123 , 85%)	48.1%	30.8%	7.8%	1.4%	0.2%
Remove 1 pre-req (remove CE 205 from MAE 371)	56.1%	27.1%	4.4%	0.4%	0.0%
Reduce failure rates by 50% for all courses	44.5%	34.4%	8.7%	1.6%	0.2%
Bring all success rate to at least 0.9 for first year	52.8%	31.7%	5.4%	0.6%	0.0%
Bring all success rate to at least 0.9	63.6%	29.1%	4.4%	0.4%	0.0%
No prerequisite at all	64.7%	17.6%	1.4%	0.0%	0.0%
Allow at most 5 courses per semester	9.5%	44.1%	21.7%	6.9%	1.3%

Performance Monitoring—Success Markers/Alerts

ES: Early Start

 Earliest time student can start a course

LS: Late Start

 latest time student can start a course without delaying graduation

[Slack]=LS-ES

Mechanical Engineering
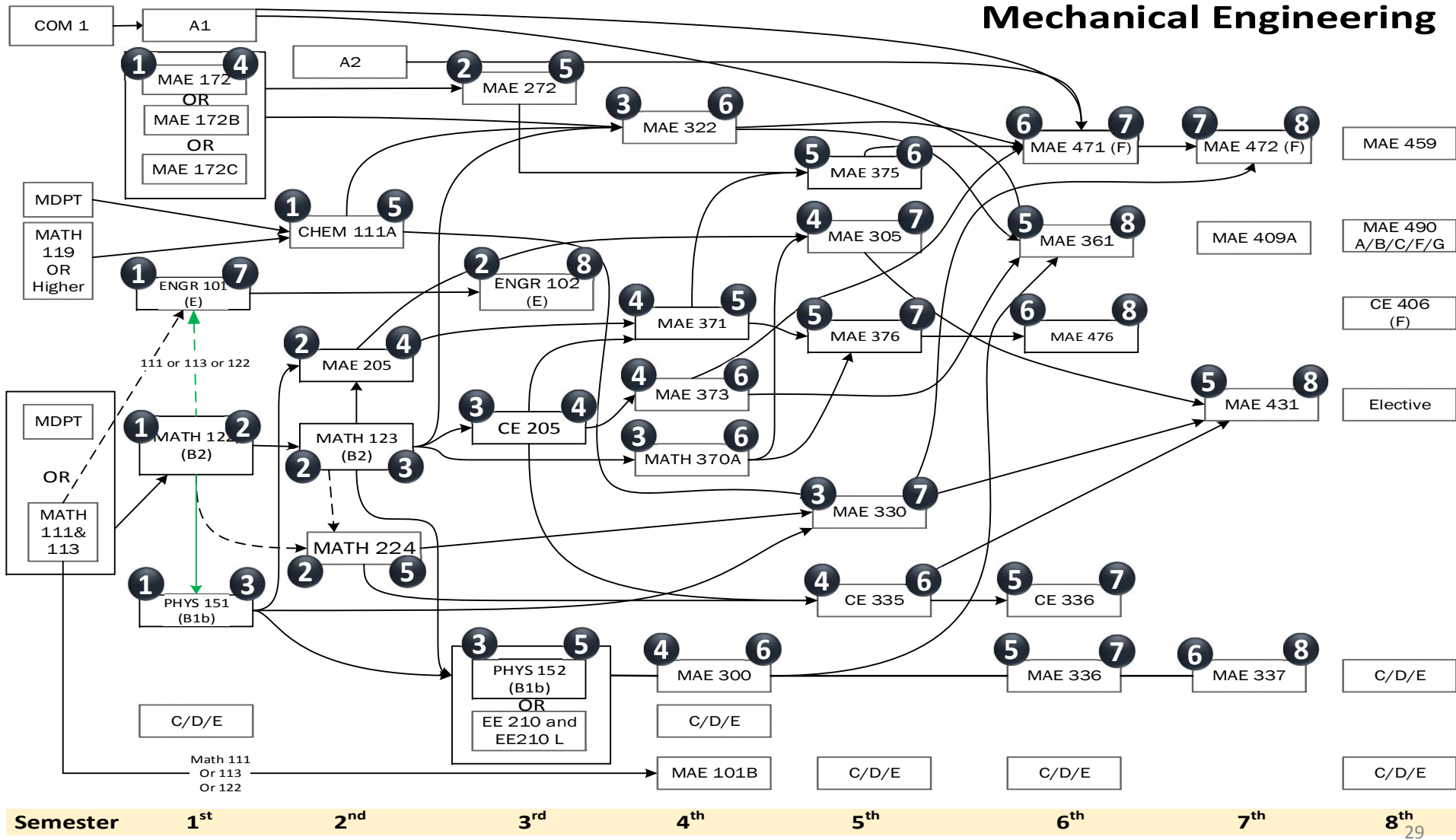
A Predictive Model on Students' Timely Graduation

The Problem

- A model to identify students who will graduate on time (or not)
  - Quantify the probability
  - Identify important factors

- The desired attributes
  - Accurate
  - Understandable
  - Easy to implement
  - Robust

Our Approach

- Data
  - Information we know at the admitting time(Demographic)
    - Gender, age …
    - High school GPA, SAT, ACT…
    - Parents' education, income
    - …
  - Information after joining CSULB(Transcript)
    - Units attempted
    - Points earned
    - PELL
    - The first 3 semesters

- Decision Tree Based Methods
  - A family of methods
  - Use single tree to understand
  - Use ensemble/boosting methods to improve the performance(accuracy)

Working Process

Data cleansing
- Match and merge students' records
- Generate derivative features
- Handling missing data
- Only keep who matriculated from 2009-2012 and had less than 12 transfer units
- ➔ Total 13538 students' records

Splitting the data
- Among the 13538 students
- ~ 10,000 (80%) records were used to build the model (the training set)
- ~ 3,000 (20%) records were used for validation purpose (the validation set)

Model building
- Single tree methods first
- C5.0 algorithm has the best performance

Ensemble/ Boosting
- The purpose is to increase prediction accuracy
- Random Forest
- Gradient Boost (XGBoost)

G5	age	MULTIPLE_MAJOR_DEGREE_FLAG	COLLEGE_PREPARATORY_ENGLISH	COLLEGE_PREPARATORY_MATH	T3P	T3G	PELL1	PELL2	PELL3	GSPAN
0	20.59	0	0	0	29	2.23077	0	1	1	7
0	22.26	0	8	8	54	3.375	0	0	1	6
0	36.88	100	8	10	0	0	0	1	1	100
0	22.99	0	8	6	49	3.76923	0	0	1	6
1	23.35	0	8	10	48	3	0	1	1	3.5

G5

Node 0
MULTIPLE_MAJOR_DEGREE_FLAG

0.000
Node 1
T3P

1.000
Node 28
T2P

2.000; 100.000
Node 33

<= 38.500
Node 2
T2U

> 38.500
Node 3

<= 33.500
Node 29

> 33.500
Node 30
T3P

<= 14.500
Node 4
COLLEGE_PREP_HISTORY

> 14.500
Node 17
T1P

<= 53.500
Node 31

> 53.500
Node 32

<= 4.500
Node 5

> 4.500
Node 6
T1P

<= 39.500
Node 18
PELL2

<= 40.500
Node 7

> 40.500
Node 8
SEX_CODE

1.000
Node 19

0.000
Node 20

5
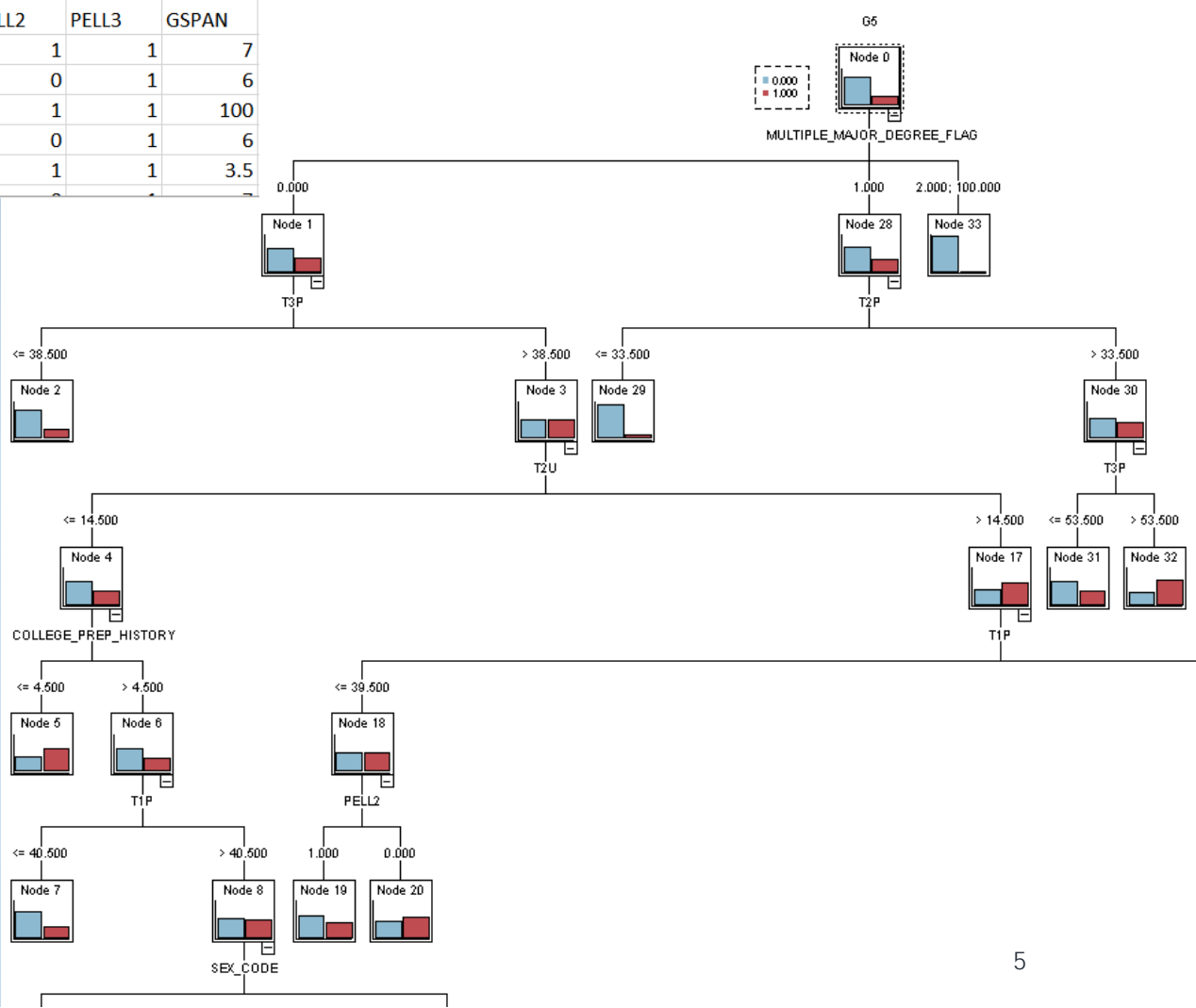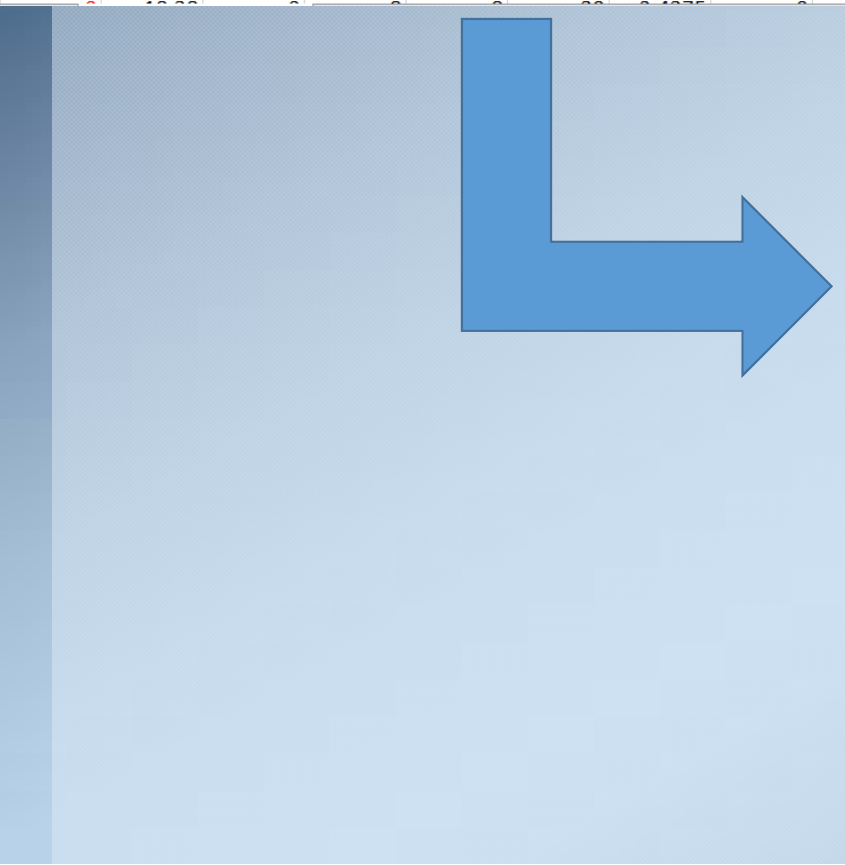
Predictor Importance

Target: G5

Predictor	
MULTIPLE_MAJOR_DEGREE_FLAG	
T3P	
T1P	
T2U	
T2P	
COLLEGE_PREP_VISUAL_PERF_ART	
SEX_CODE	
T3U	
PELL2	
T1U	

0.0   0.2   0.4   0.6   0.8   1.0
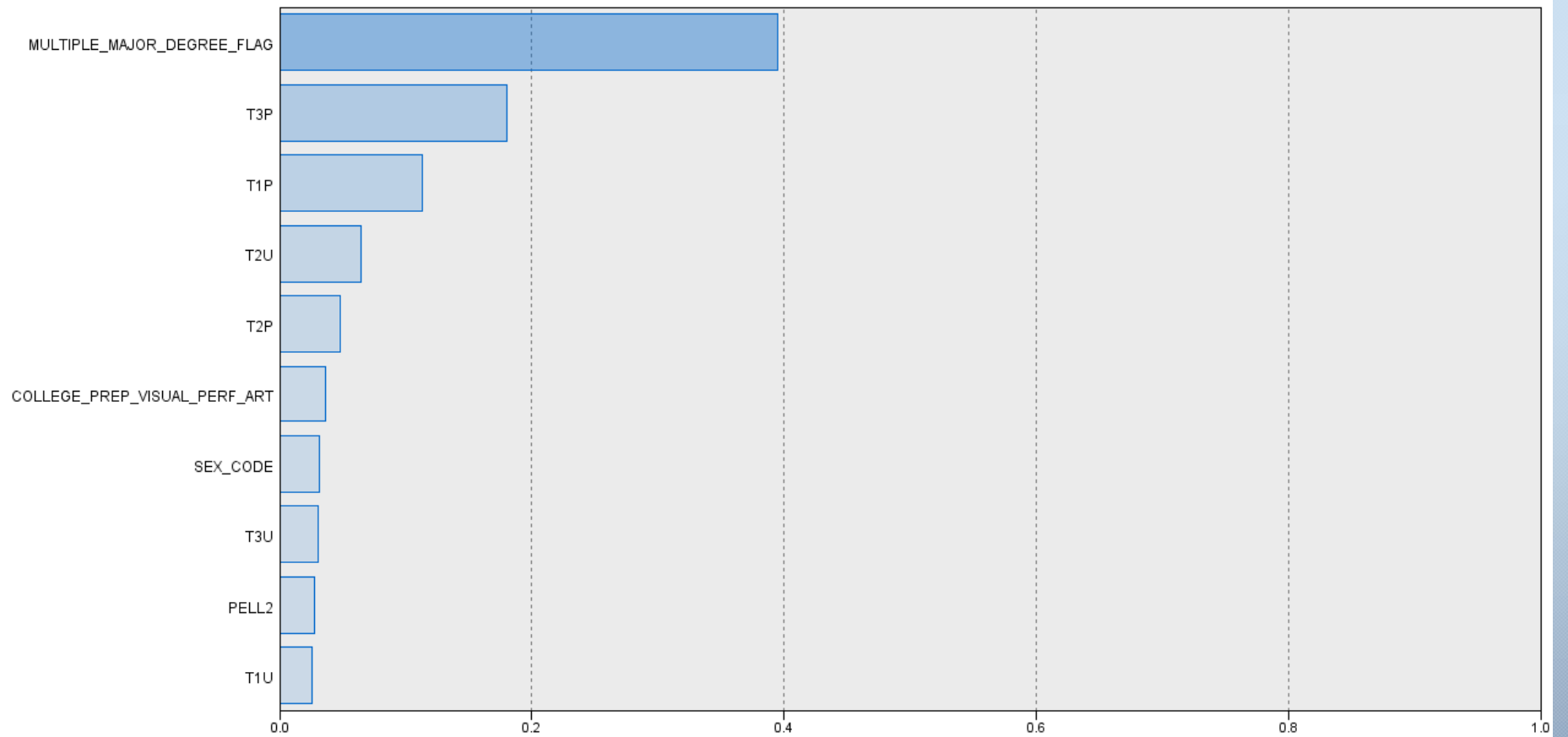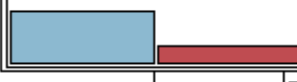
T1U   MULTIPLE_MAJOR_DEGREE_FLAG

Least Important   Most Important

Predictive Performance

- 78.39%

'Partition'	2_Testing	
Correct	2,126	78.39%
Wrong	586	21.61%
Total	2,712	

- How to improve
  - Ensemble/Boosting!
  - using many trees to vote
  - Intuition
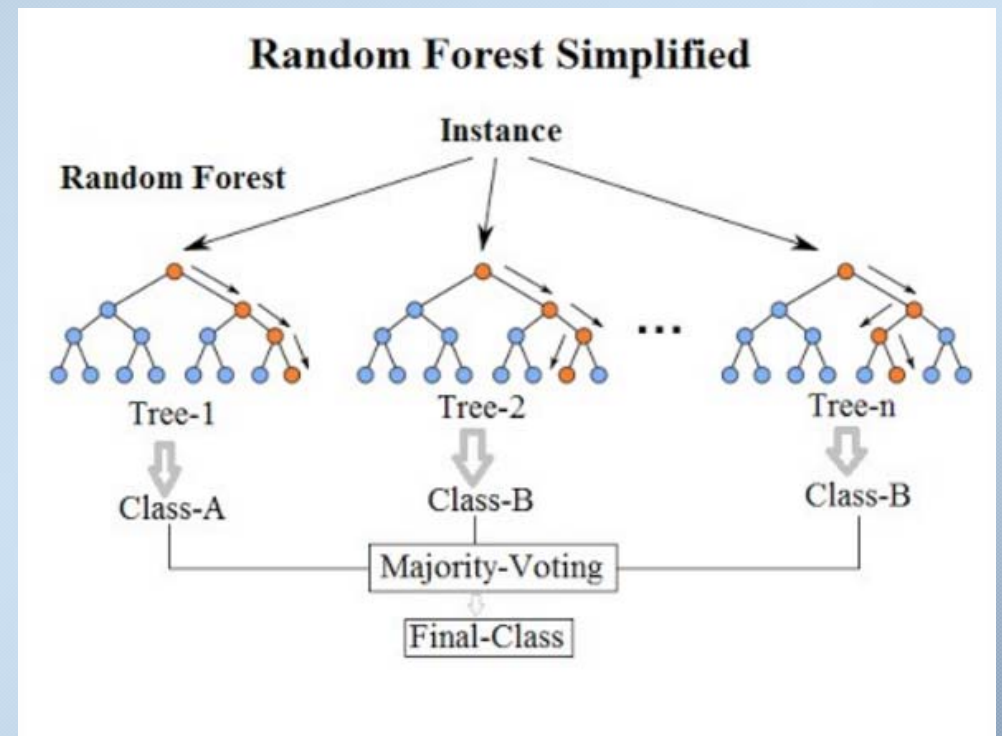
Performance

- Random Forest

  - 79.28%

- Gradient Boost (XGBoost)

  - Half of the Kaggle machine learning competition winners using this method

  - Arguably the best

  - 80.2%

  - It's practical!

- Can we further improve?

  - A similar research in UW*:   66.59% using logistic regression

  - The real challenge – still missing critical information!

  *https://arxiv.org/abs/1606.06364

Other Notes

- Trace students every semester
  - We use 3 semester performance to illustrate the model. It has no difficulty to include more semesters.

- University environment changes
  - The model is based on historical data
  - We need to update the model yearly (adding new graduates)

Acknowledgements

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