



Engineers at Play: Utilization of Games as Teaching Tools for Undergraduate Engineering Students

**Mr. Daniel Anastasio, Dr. Cheryl Bodnar,
Dr. Daniel Burkey and Dr. Josh Enszer**

What is a Game?



What Makes a Good Game?

- Games have the ability to push individuals to work to their edge of their capabilities
- They also have 3 key criteria:
 - They are designed with a set goal
 - They have rules for players to follow while seeking that goal
 - They provide players with immediate feedback



Aren't Games Just for Fun?

- Yes and No....
 - Games allow us to immerse ourselves
 - Learning gains are achieved even when games are played just for fun
 - Games allow us to learn through failure



Why Games for Engineering Education?

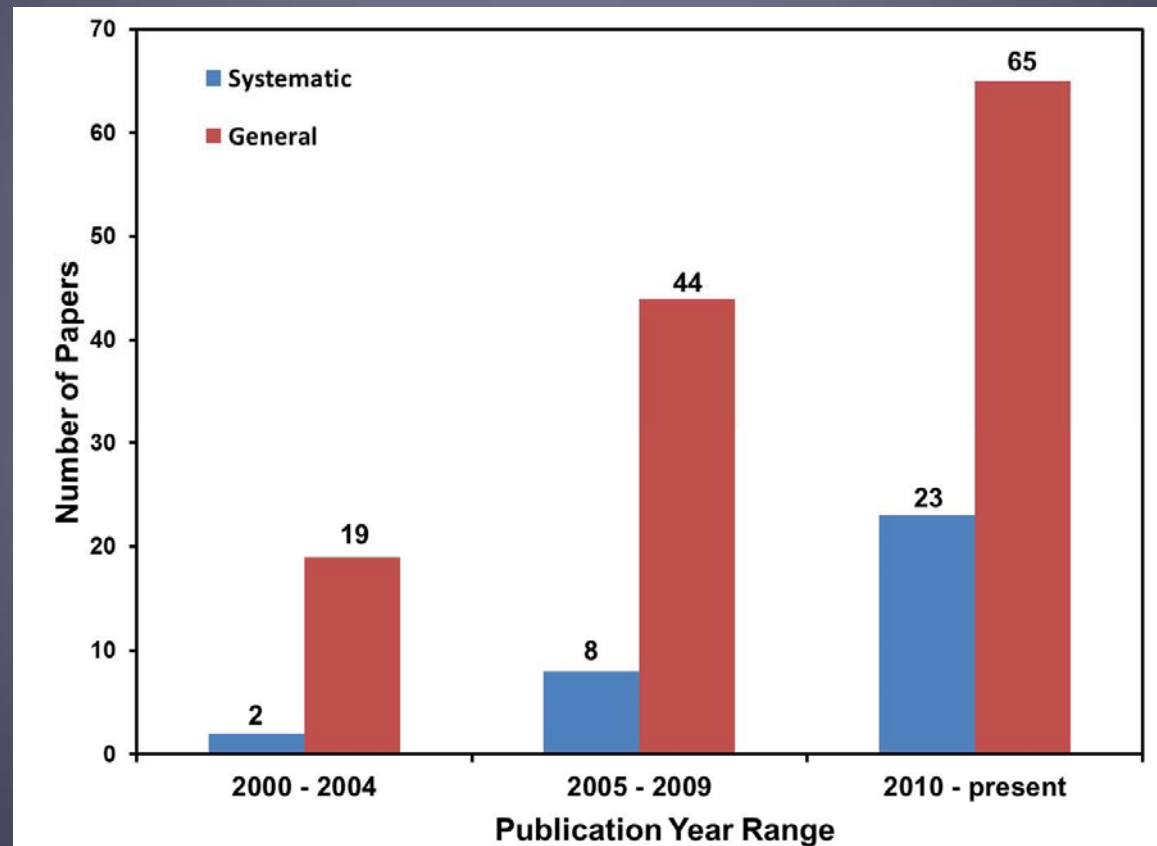
- Goal:
 - Produce innovative and competent engineers
 - Develop key 21st Century skills in graduates
- Pedagogies:
 - Traditional lecture style
 - Collaborative learning
 - Problem based learning
 - Game based learning



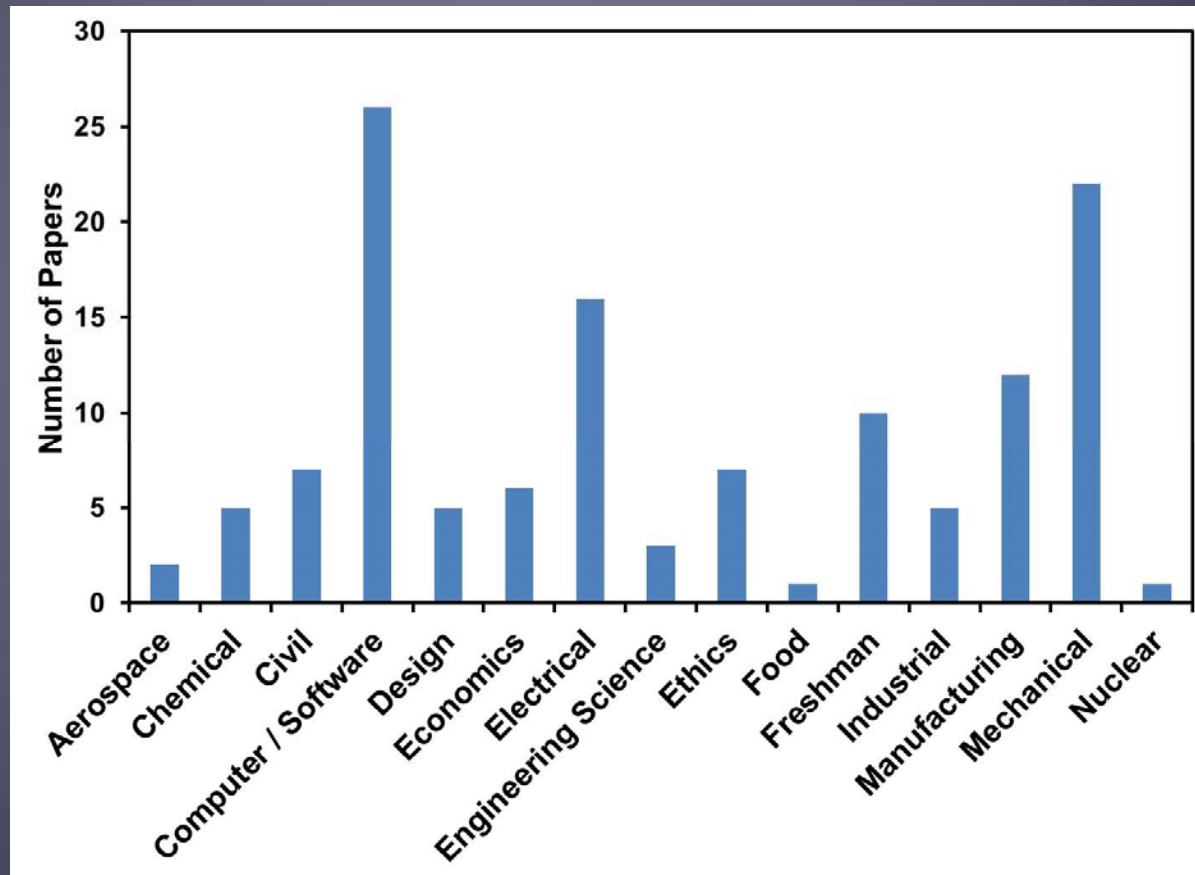
Active
learning



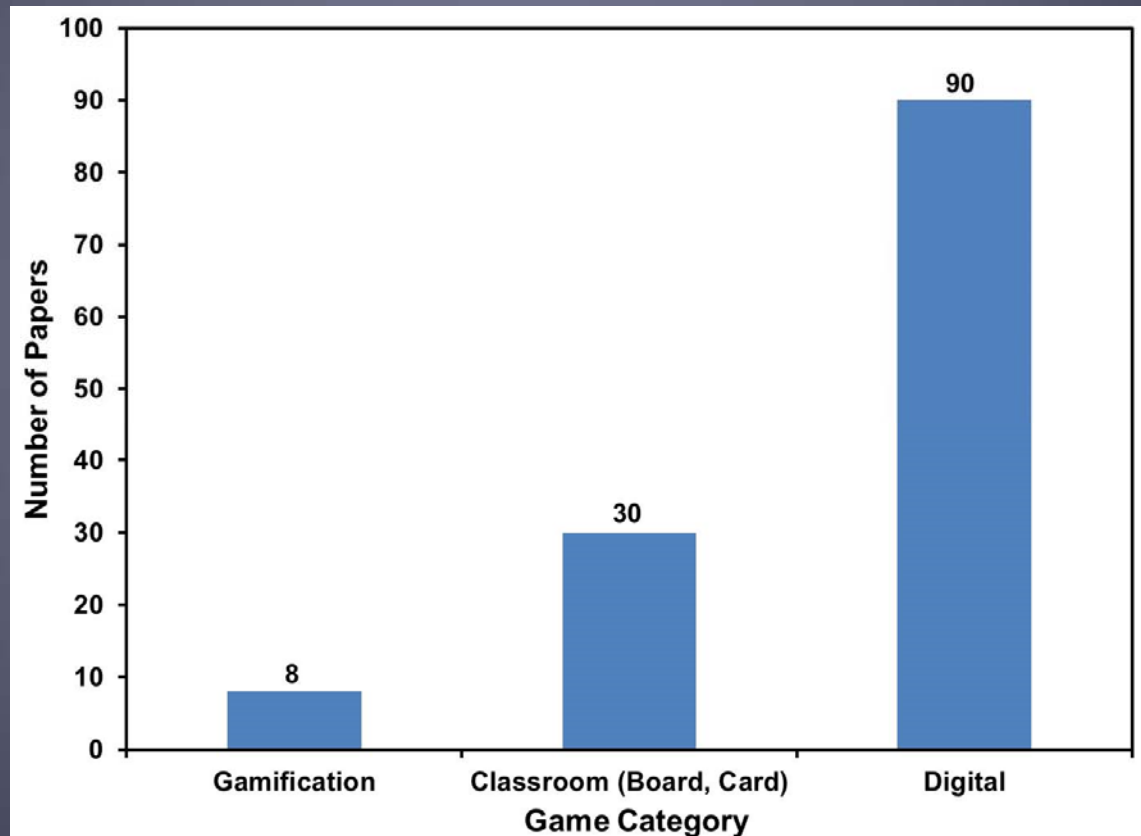
Recent History of Games in Engineering Education



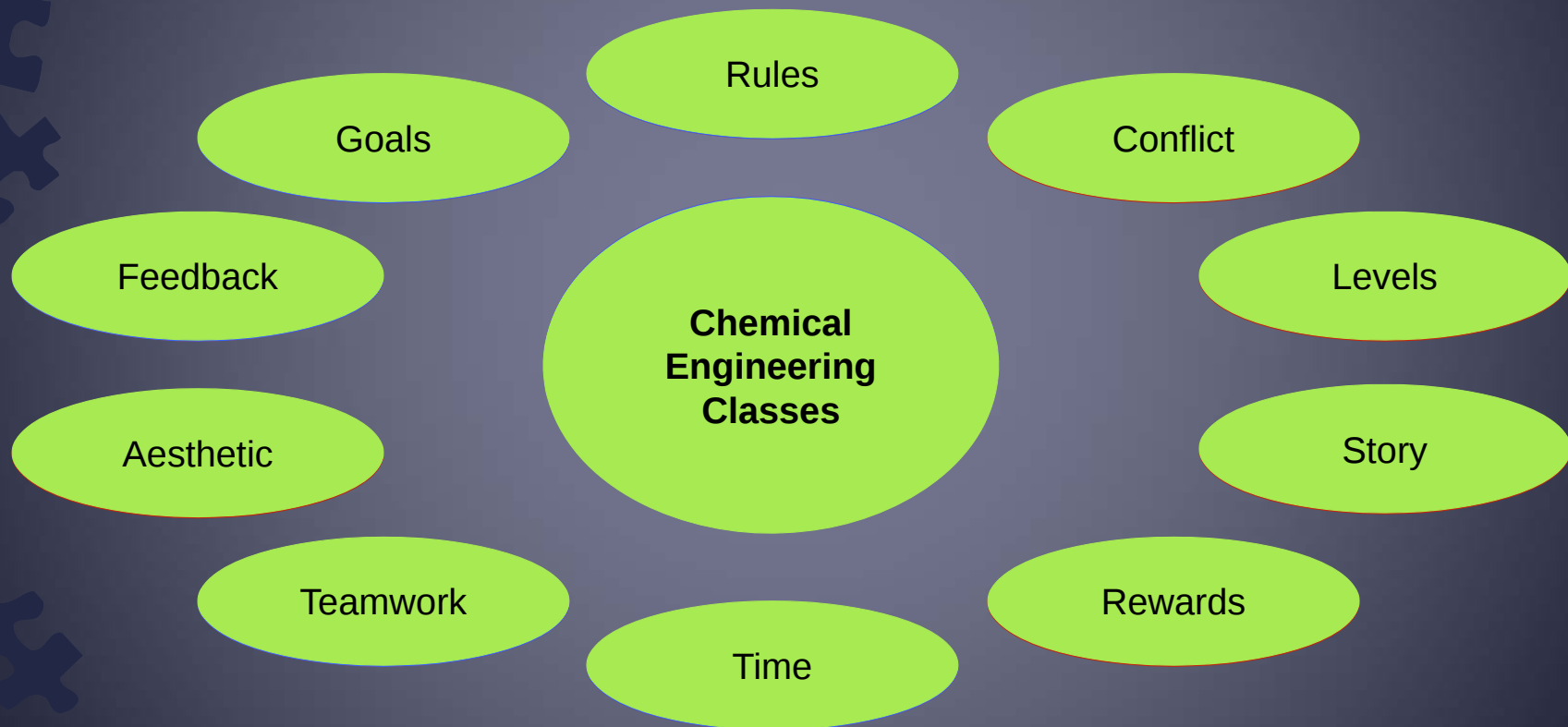
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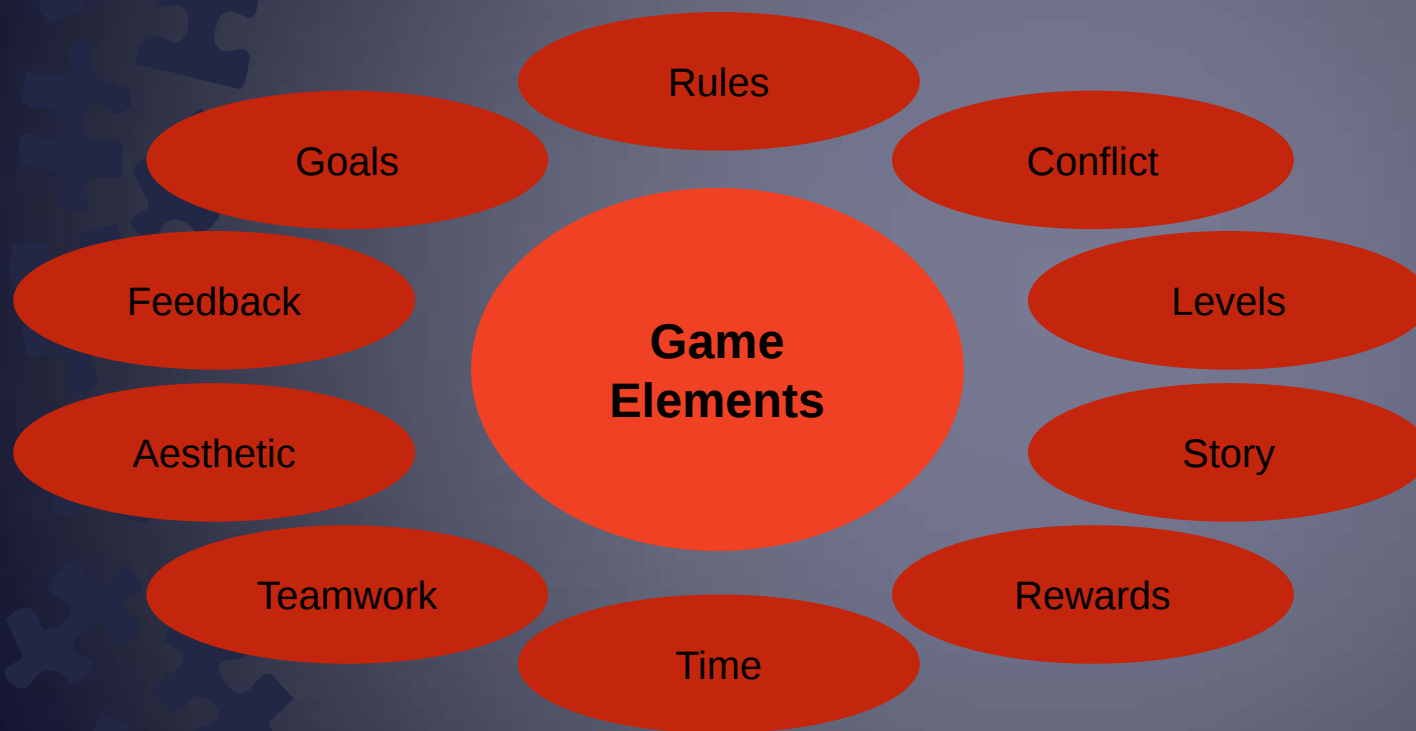
Recent History of Games in Engineering Education



Gamifying Chemical Engineering Classes



Basic Game Elements



Grade Points (XP)

**Class Standing
(Level)**

Student Team

Team Points

University of Pittsburgh

Sophomore Introduction to Chemical Product Design



Game Class Comparison Study – Assessment Methodology

- Student engagement:
 - College and University Classroom Environment Inventory (CUCEI)
 - Subset of the National Survey of Student Engagement (NSSE)
- Analysis of student performance on learning outcomes:
 - Clicker questions
 - Formative: during class lectures
 - Summative: review questions during last day of class
 - Group design project

Classroom Environment Survey Results

Dimension	Definition	Game AVG	Non-Game AVG	Difference <i>p</i>
Student Cohesiveness	Students know, help, and are friendly to one another	3.45	3.21	0.083
Individualization	Students make decisions; treated differentially or individually	2.70	2.57	0.246
Innovation	New or unusual class activities or teaching techniques	3.45	3.32	0.176
Involvement	Students participate actively and attentively in class	3.39	3.17	0.116
Personalization	Students interact with instructor; concern for students' welfare	3.83	3.52	0.039
Satisfaction	Enjoyment of classes	3.11	2.97	0.511
Task Orientation	Class activities clear and well organized	3.68	3.45	0.073
Sample Size (n)		40	41	

* Results obtained in collaboration with Dr. Renee Clark

Student Performance on Learning Outcomes During Course

Topic	# of Questions	Non Game Avg	Game Avg	P-Value
Brainstorming Techniques	4	56.65%	61.36%	0.322
Customer Info	6	82.90%	81.40%	0.677
Market Analysis	11	77.28%	84.04%	0.004
Communication	5	76.69%	75.87%	0.826
Teamwork	4	58.20%	64.05%	0.294
Leadership	4	83.83%	88.34%	0.222
Decision Making	3	61.55%	62.70%	0.873

* Results analyzed by William Bongiorno (Undergrad ChE Student)

Student Performance on Learning Outcomes At End of Course

Topic	# of Questions	Non Game Avg	Game Avg	P-Value
Brainstorming Techniques	4	37.87%	49.15%	0.024
Customer Info	6	74.43%	73.25%	0.749
Market Analysis	11	71.92%	79.82%	0.002
Communication	5	70.99%	71.84%	0.795
Teamwork	4	58.86%	69.74%	0.021
Leadership	4	88.32%	92.02%	0.222
Decision Making	3	67.88%	72.95%	0.303

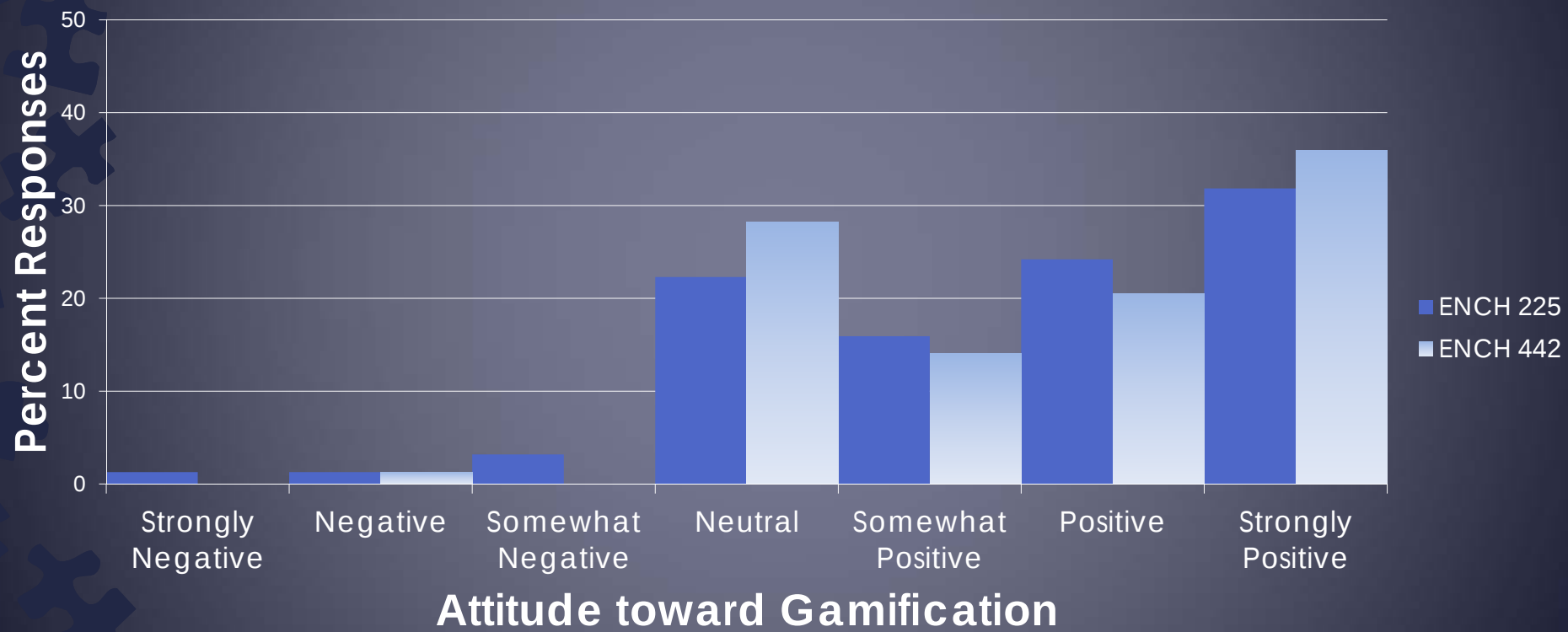
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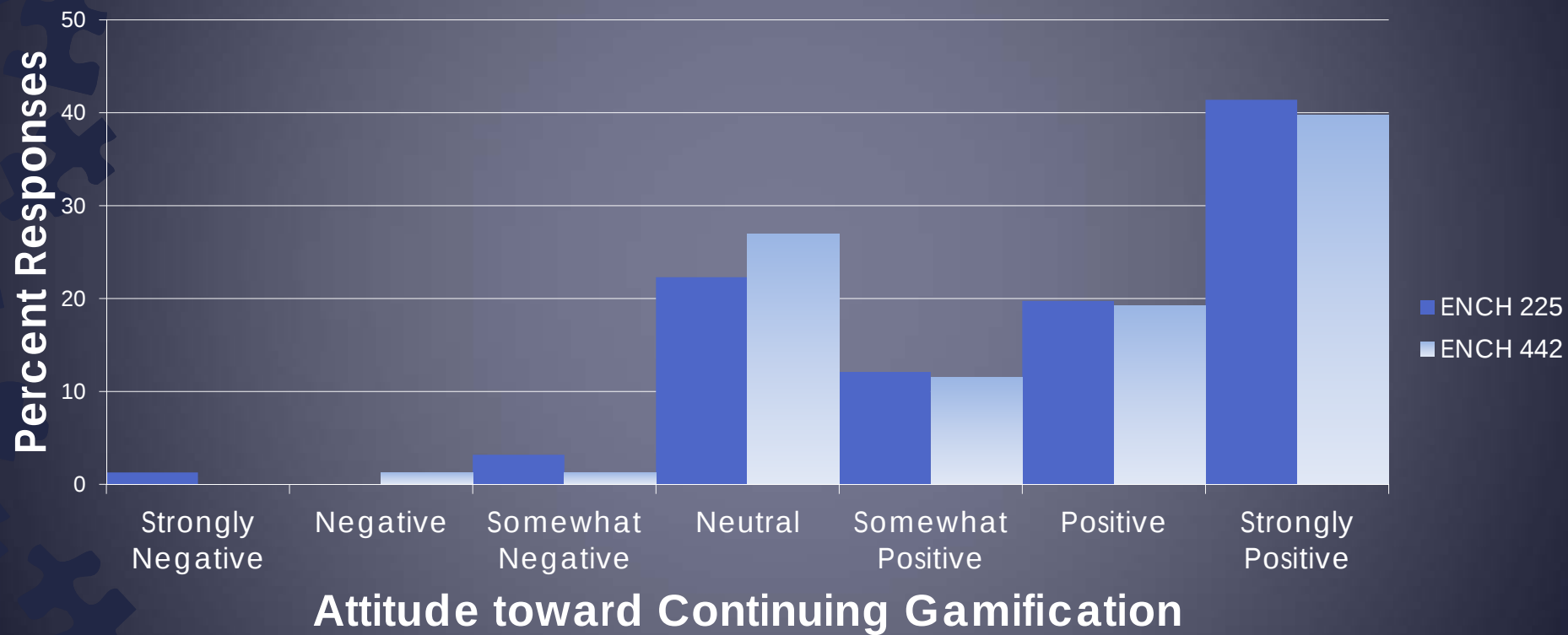
University of Maryland Baltimore County

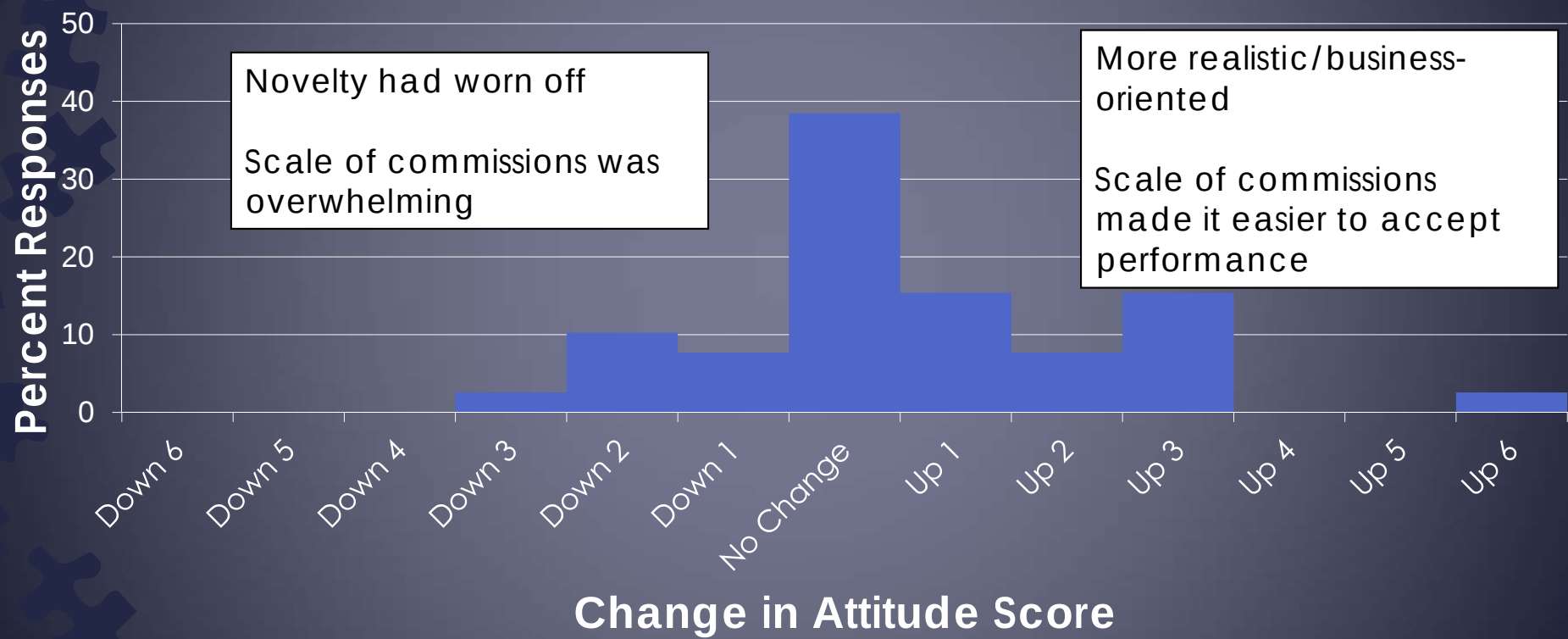
Sophomore Experimental Design Junior Process Control & Safety

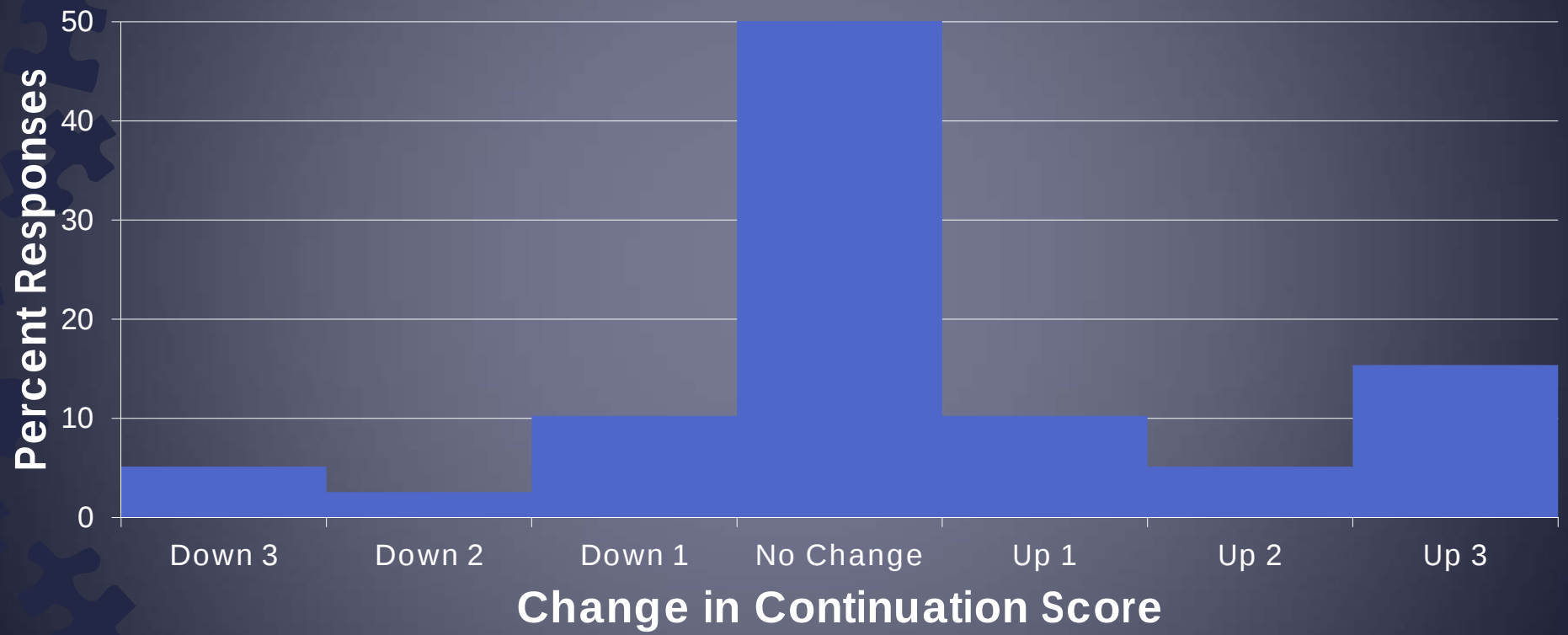


	Problem Solving and Experimental Design	Chemical Process Control and Safety
Year	Sophomore (ENCH 225)	Junior (ENCH 442)
Students Surveyed	157	78
Core Topics	MATLAB, statistics, technical writing	Numerical optimization, control system design, industrial hygiene
Points scheme	Experience points (XP) and a “level-up” system	Commissions (credits) earned based on quality of memos, projects, and exams
Story	None	Internship with pharma company
Other game elements	Achievements	Time extensions





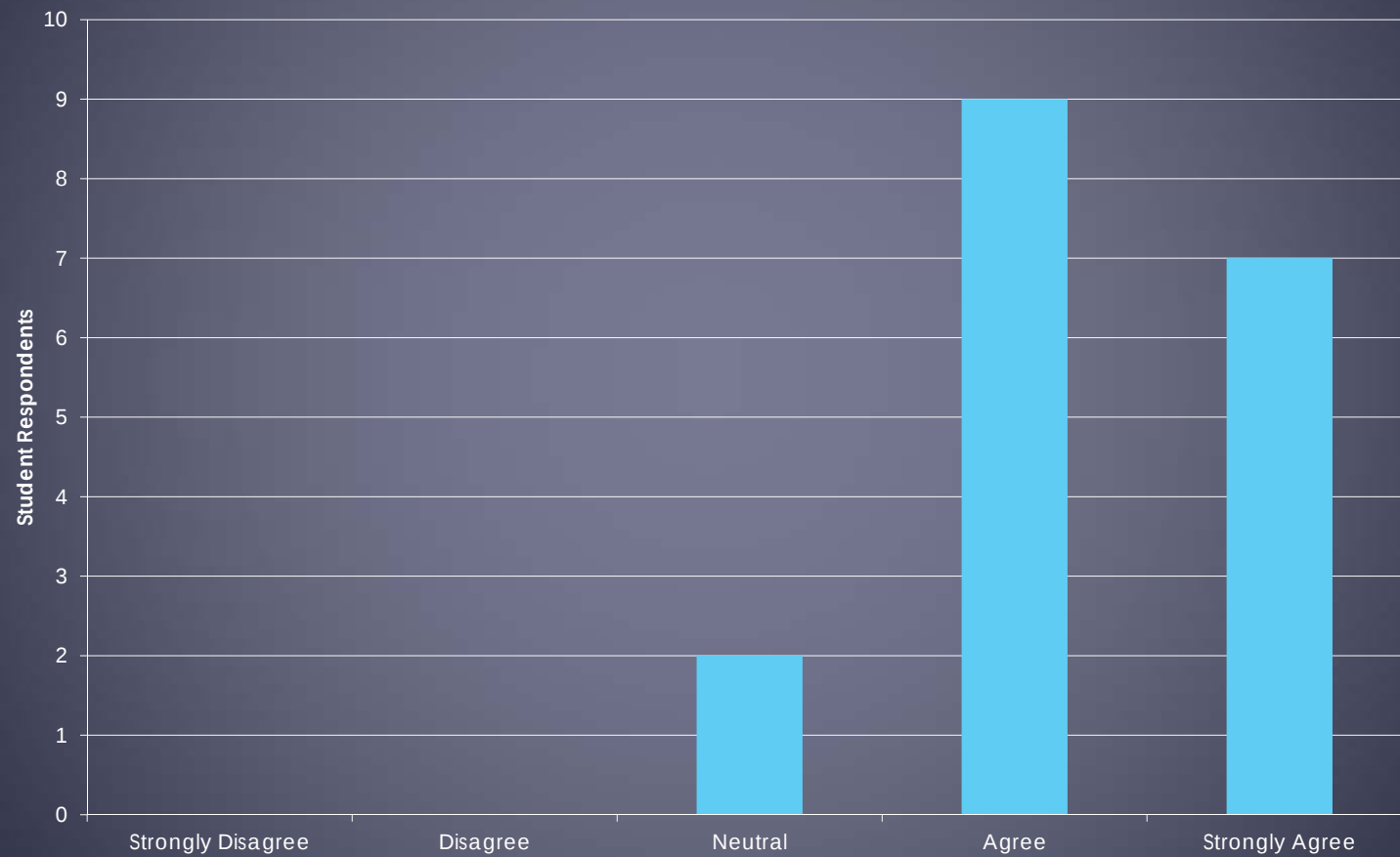




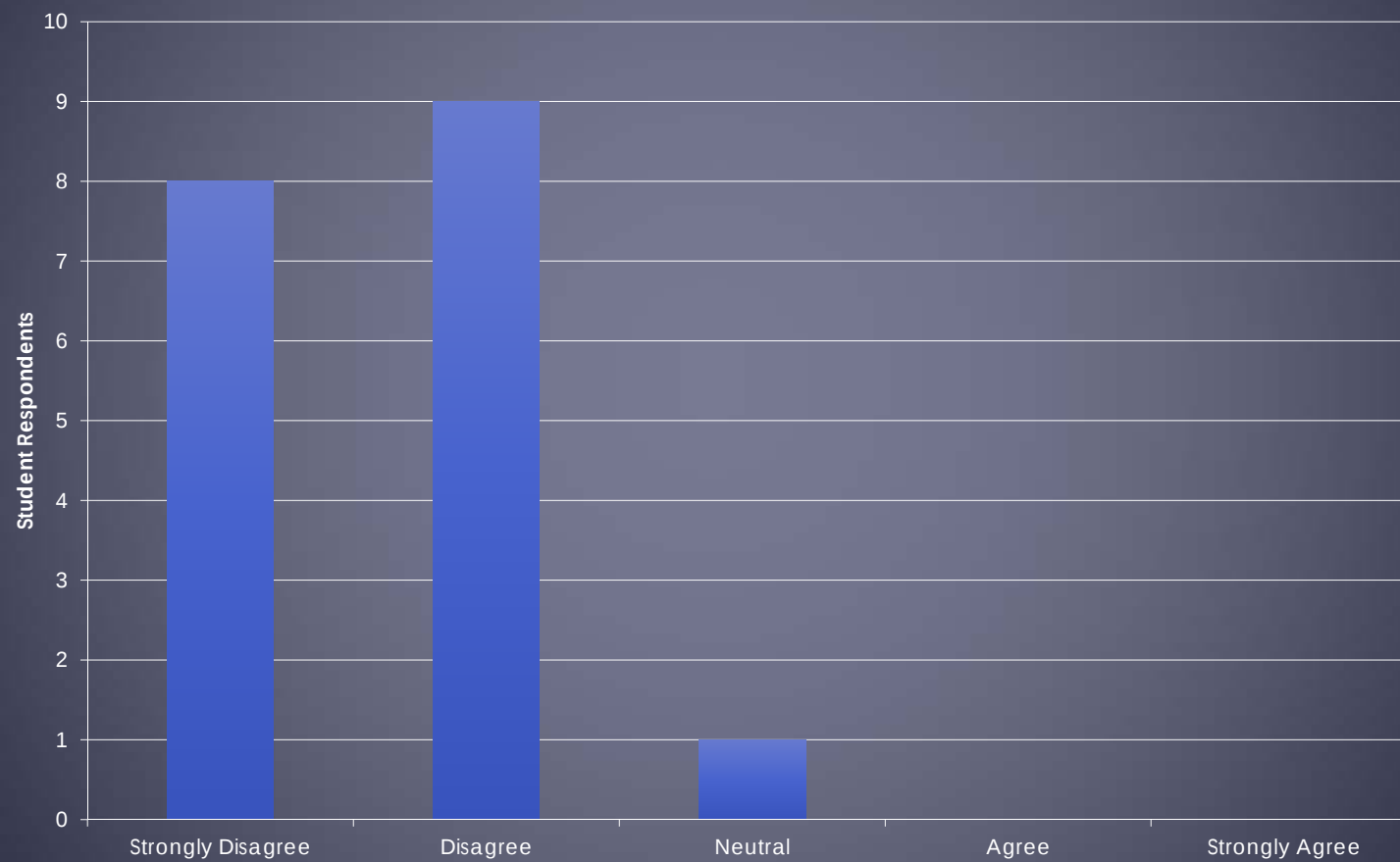
University of Connecticut Senior Capstone Laboratory



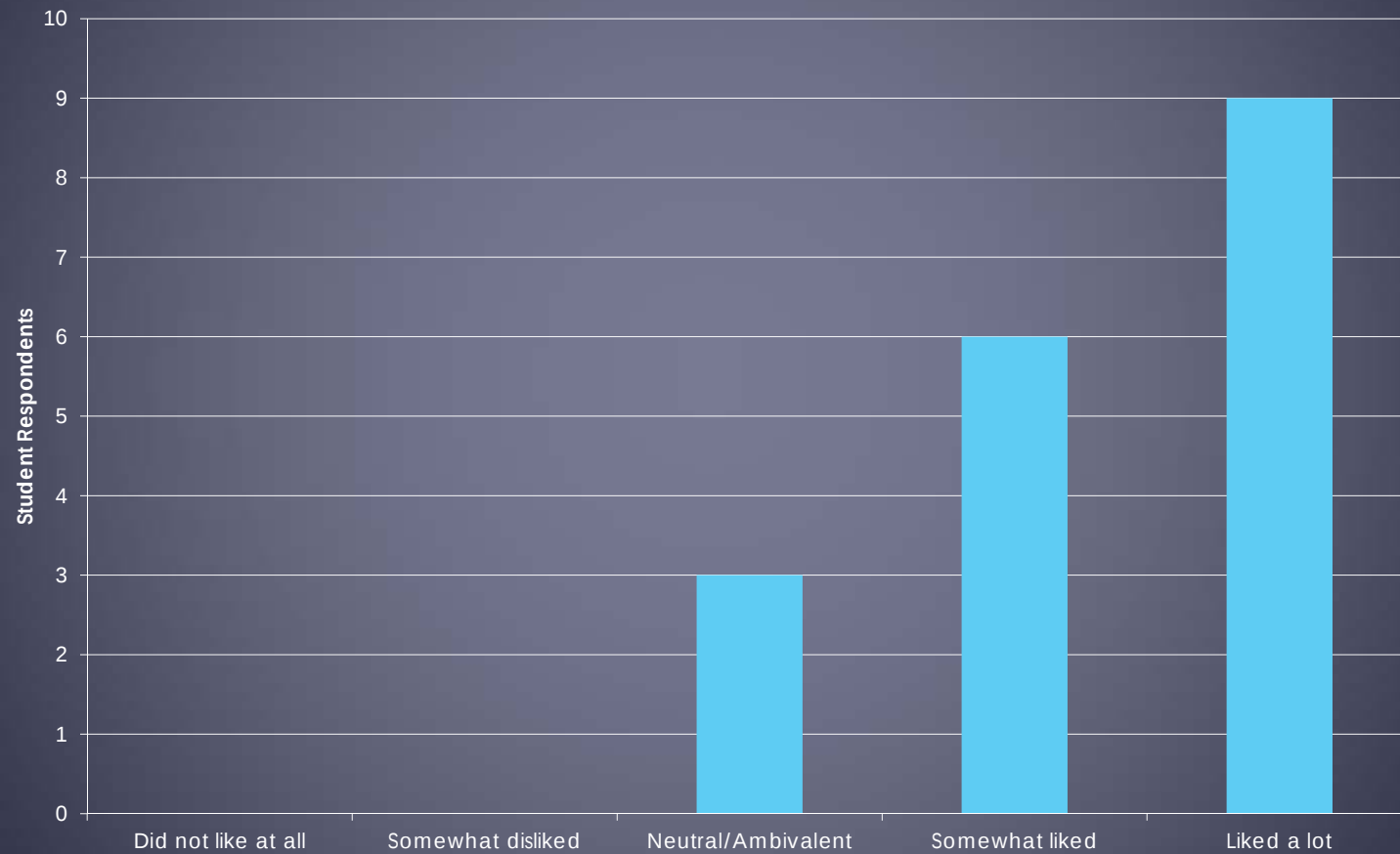
**The game elements made me think about Senior Lab more
than I would have otherwise...**



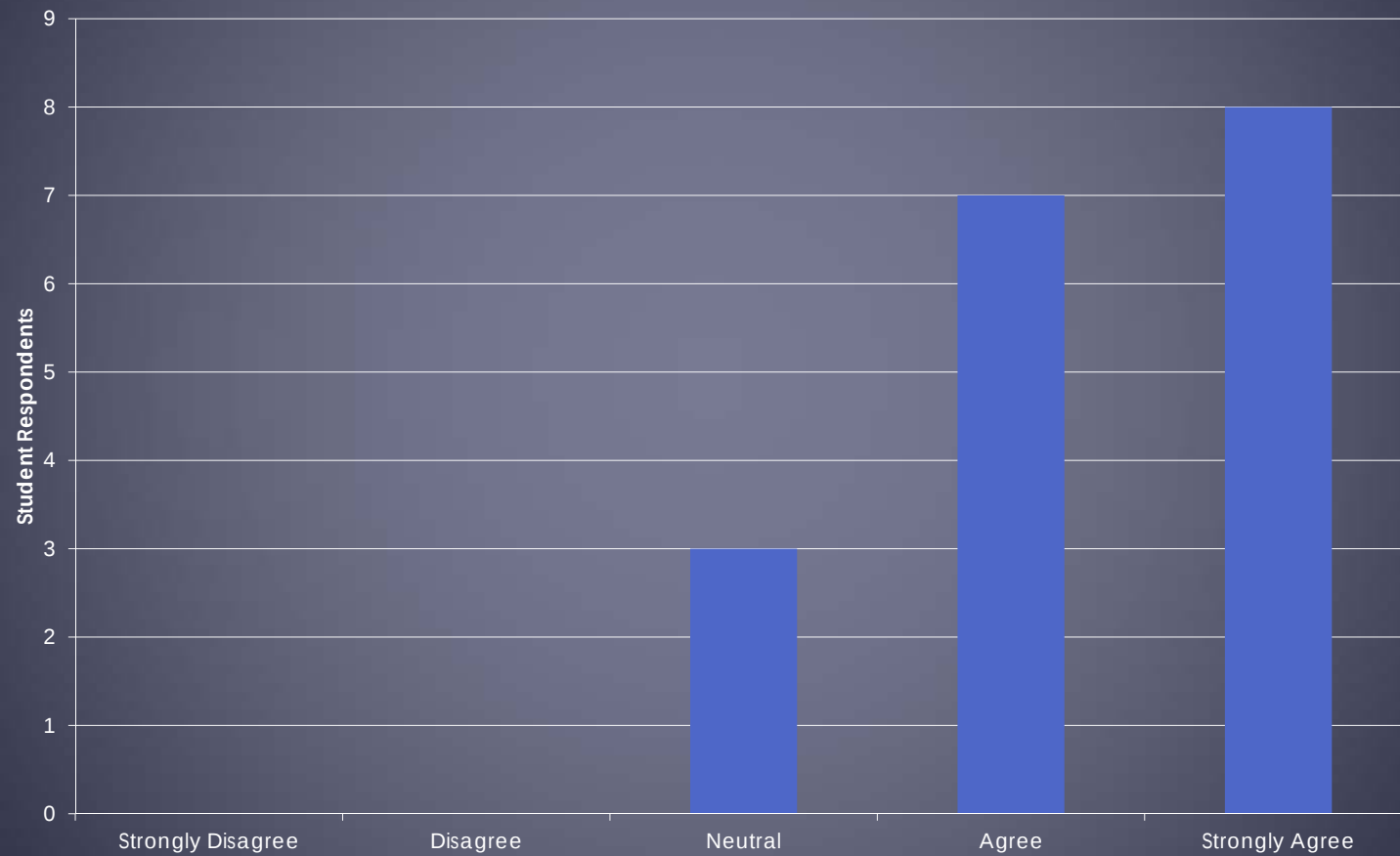
The game elements were distracting and negatively impacted my understanding of the course...



Overall, how do you feel about the game as it was run this semester?



The inclusion of game elements made me feel like the instructors cared about teaching this course...



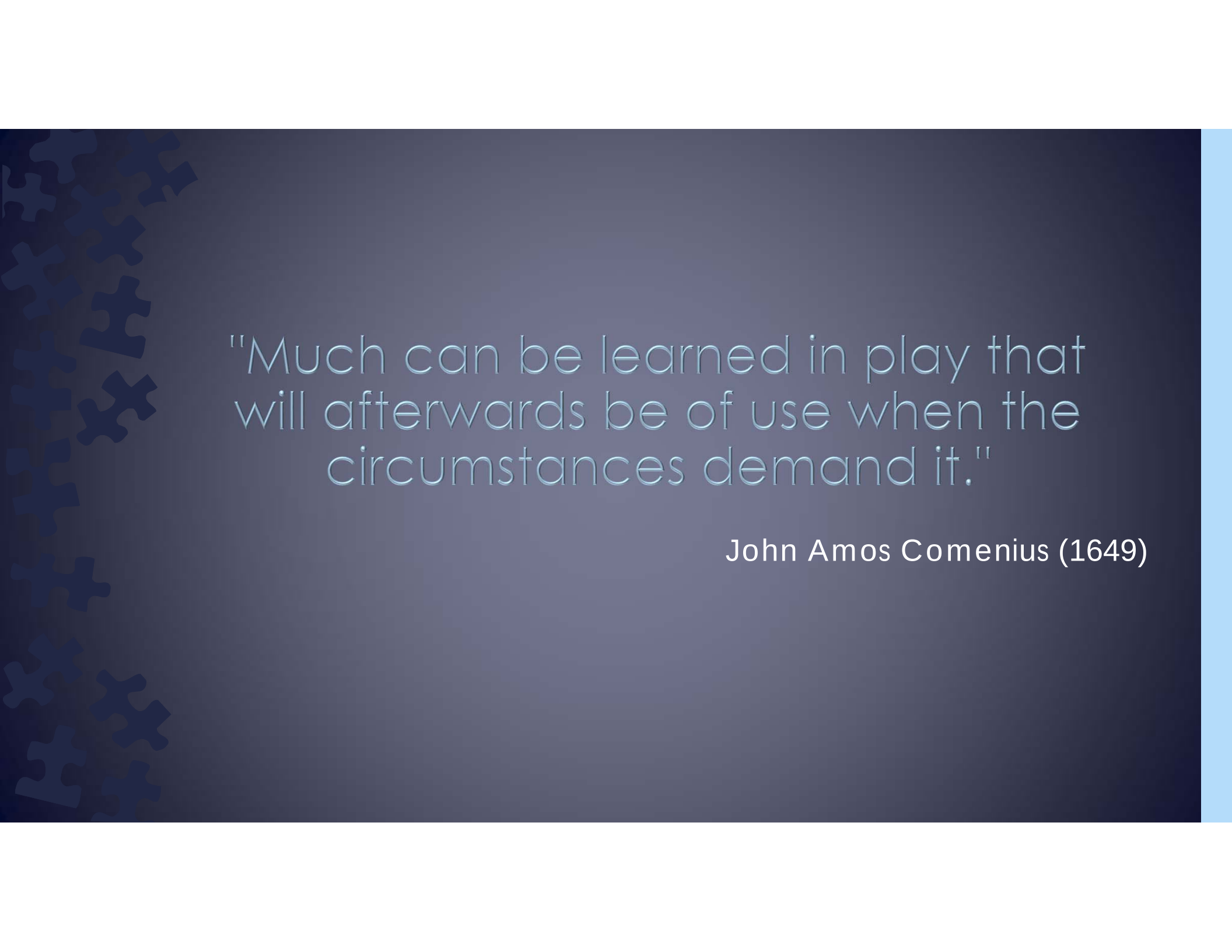
Conclusions

- Games have been utilized for centuries as teaching tools
- Only recently are games being adapted for use in engineering education
- Games serve the potential of reaching a new generation of students and engaging them in technical content
- This form of educational research program relates to students interests while building their technical skills



Future Directions

- Publication of Systematic Literature Review within Journal of Engineering Education (currently under revision for journal)
- Preparation of a multi-university game based learning proposal
- Development of a game-based learning workshop for Chemical Engineering Summer School 2017



"Much can be learned in play that will afterwards be of use when the circumstances demand it."

John Amos Comenius (1649)