Incentives for Innovation in Engineering Design

Blake Linnerud
Dr. Gregory Mocko
Graduate Research Assistant ▪ Clemson University ▪ bjlinne@g.clemson.edu

Background

- Pahl and Beitz define innovation as a "product that realizes new functions and properties, often through novel or new combinations of existing solutions." [1]
- The National Science Foundation has pointed out that innovation is essential for companies to remain innovative in today's economy [2]
- I have seen this need on two fronts: working on my senior Capstone Design Project and as both an undergraduate and graduate researcher on the JCI project
  - 402: our group was tasked with coming up with an innovative way to flip large rubber tubes inside out
  - JCI: within the JCI project, there was an overarching need to develop innovative concepts for the automobile seat they produce
- Different methods to find innovative solutions have become more widely researched lately → Crowdsourcing is a powerful resource for finding innovative solutions [3-5]
- Creating an environment that promotes innovation is essential to motivating employees to be innovative → This may include allowing early failures to promote long term success [6-9]

Frame of Reference

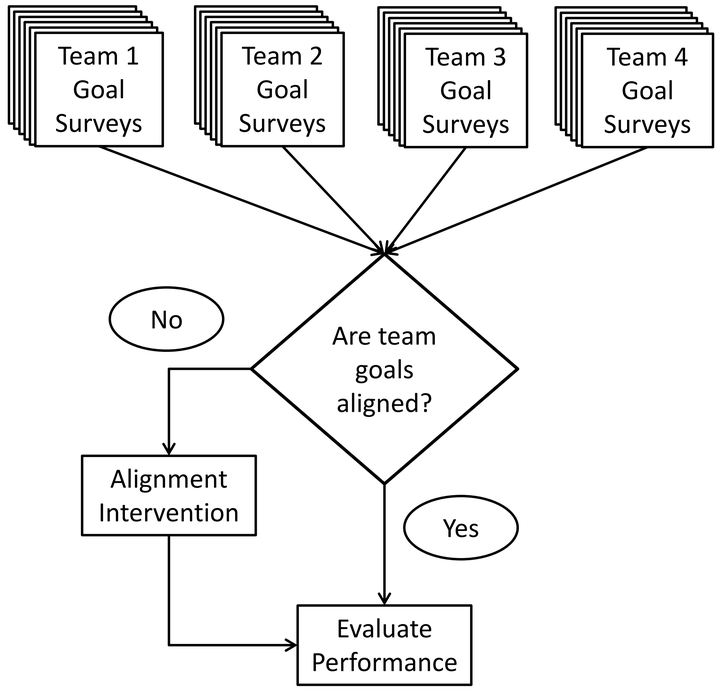
- Advances in innovation research is confined to the fields of psychology, finance, and business → What about engineering?
- Innovation research deals primarily with monetary incentives within the workplace → What about students and non-monetary incentives?
- Innovation research primarily deals with incentivizing individuals → What about groups?
- The methods to finding innovative solutions presented in the field of engineering is all too esoteric: you need the right people, at the right place, at the right time [10-12]
- Tuckman's four-stage model proposes that only after teams have defined common goals can they start to perform at a high level [13-14]
  - Forming → Storming → Norming → Performing

Research Questions

1. Which incentives most effectively push engineers to be innovative?
2. How does motivating a group to be innovative differ from motivating individuals to be innovative?
3. Can interventions be used to align the goals of a group working on an engineering design project resulting in the development of more innovative solutions?

Innovation Experiment

Step 1: Administer incentive and goal surveys to senior Mechanical Engineering students working on their Capstone design projects
Step 2: Check to see if the motivation and goals of the students are aligned
Step 3: Give alignment interventions to the groups that do not have aligned goals.



Note: The initial interventions are given initially during the 4th or 5th week of the semester. A follow up meeting will be held during the 8th or 9th week to ensure that the groups are working as a team towards common goals. During the interventions, the following will take place:

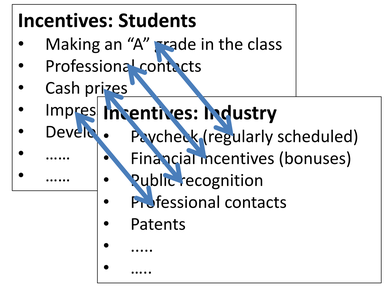
- Discuss the importance of innovation in engineering
- Discuss the importance of working towards common goals
- Explain the steps of group projects as defined by Tuckman
- Show the students their initial goals and have them rank what they think are the goals that they want to work towards collectively

Anticipated Results:

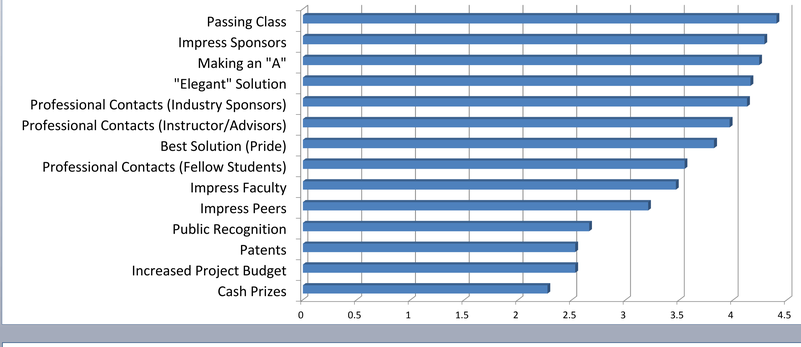
- Having explicitly stated team goals will enable to students to enter the "performing" stage early
- Working towards common goals will result in increases of weekly motivation and performance levels
- Teams that showed similar level of performance throughout the first 5 weeks will not show the same improvements

Incentive Surveys

- Surveys are given to Mechanical Engineering students working on Capstone design problems and design engineers working in industry
- Comparisons will be drawn between the students and industry surveys.



Initial Results: The results show which incentives are the most effective for students (scored out of 5); still awaiting industry results.



Group Agreement on Incentives

- Fleiss' Kappa values were calculated for the three survey questions to determine if students agreed on which incentives are most effective

Project	Group	Fleiss' Kappa Q1	Q2	Q3
BMW	A	0.16	0.48	0.27
BMW	B	0.31	0.33	0.43
BMW	C	0.25	0.43	0.38
Boeing	C	0.31	0.33	0.17
Dr. Murdoch	A	0.28	0.69	0.69
Dr. Murdoch	B	0.02	0.12	-0.14
Dr. Murdoch	C	0.39	0.33	0.43
Electrolux	A	0.12	0.43	0.22
Electrolux	B	0.00	-0.04	0.07
Rotary	A	0.14	0.22	0.33
Rotary	C	0.15	0.17	0.27

- Few teams had moderate agreement (0.41-0.60)
- Only one team had substantial agreement (0.61-0.80)

Takeaway: Students do not generally agree on incentives

References

[1] Pahl, G. and W. Beitz (2007). Engineering Design: A Systematic Approach, Springer.
[2] Schunn, C. D., P. B. Paulus, et al. (2006). "Final report from the NSF innovation and discovery workshop: The scientific basis of individual and team innovation and discovery." Washington (DC): National Science Foundation.
[3] Aaron, D. S., J. H. John, et al. Designing incentives for inexpert human raters. Proceedings of the ACM 2011 conference on Computer supported cooperative work. Hangzhou, China, ACM.
[4] Scotchmer, S. (2004). Innovation and Incentives. Cambridge, Mass, MIT Press.
[5] Antikainen, M., M. Mäkipää, et al. "Motivating and supporting collaboration in open innovation." European Journal of Innovation Management **13**(1): 100-119.
[6] Manso, G. (2011). "Motivating Innovation." The Journal of Finance **66**(5): 1823-1860.
[7] Roberts, E. B. (2007). "Managing Invention and Innovation." Research-Technology Management **50**(1): 35-54.
[8] Ederer, F. and G. Manso (2011). Is Pay-for-Performance Detrimental to Innovation?, SSRN.
[9] Shellenbarger, S. Better Ideas Through Failure --- Companies Reward Employee Mistakes To Spur Innovation, Get Back Their Edge. Wall Street Journal. New York, N.Y., United States, New York, N.Y.: D.1-D.1.
[10] Hsiao, S. W. and J. R. Chou (2004). "A creativity-based design process for innovative product design." International journal of industrial ergonomics **34**(5): 421-443.
[11] Lin, C. C. and D. B. Luh (2009). "A vision-oriented approach for innovative product design." Advanced engineering informatics **23**(2): 191-200.
[12] Salter, A. and D. Gann (2003). "Sources of ideas for innovation in engineering design." Research Policy **32**(8): 1309-1324.
[13] Tuckman B. W., 1965, "Developmental Sequence in Small Groups.," Psychological bulletin, 63(6), pp. 384–99.
[14] Tuckman B. W., and Jensen M. A. N. N. C., 1977, "Stages of Small-Group Development Revisited," Group & Organization Management, 2(4), pp. 419–427.