Panel 2A
Team Formation Techniques

Capstone Design Conference 2023
Wednesday, June 14, 2023
1:00-5:30pm EDT

Facilitator: Bridget Smyser (Northeastern University)
Sidekick: Joanna Tsenn (Texas A&M University)
Scribe: Bob Buckner (University of Tennessee, Knoxville)

Panelists:
Robin Fowler (University of Michigan)
Beverly Kris Jaeger-Helton (Northeastern University)
Roger McCarty (BYU-Hawaii)

Description: How do you create cohesive, functioning teams in capstone?

Starting Questions:

1. How does your individual program form teams?
2. Do you use any particular program or software? Why or why not?
3. What strategies do you use to get a good mix on each team? Do you consider race and other demographics? Skills? Enthusiasm about the project?
4. Did you ever try anything that didn't work? Why didn't it work?
5. If you had to give one piece of advice about this topic, what would it be?

Notes:
Initials…
RF Robin Fowler
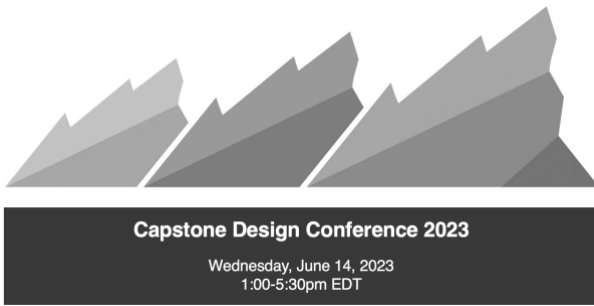**KJ** Beverly Kris Jaeger-Helton
RM Roger McCarty
BS Bridget Smyser
JT Joanna Tsenn

1. How does your individual program form teams?

   RF There's not a system that's used by all faculty (we all do different things!). UMich has ~1200+ seniors doing design each year. Most are in single-major courses (some 1 semester, some 2). There is a small MDP program and there are a couple folks from UM here who can speak to that (but I think they are in the other session). Speaking for
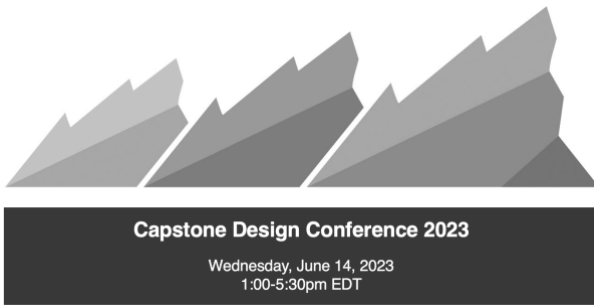
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myself personally, I think my largest goal is to put students on teams that I think will have the most opportunity for growth for all students– this means matching people w/skills they want to practice and projects, and it also means putting teams together where I don't think one or a few team members will take over the project and prevent others from contributing and where I think all team members bring useful skills to the project team.

KJ

- I will first acknowledge my work partner Hugh McManus who helps out immensely with this process and co-coordinates Capstone with me.
- I will note the collaboration with Bridget on the ASEE paper, cited again below: "How Did We End up Together? Evaluating Capstone Project Success as a Function of Team Formation"
- We tell them in our Pre-Capstone orientation that, while they cannot pick their own teams, a core of 4 people is a safe request, but they may end up with 5 on their team.
- - We have coordinators and faculty Advisors; each team will conduct a different project.
- There are 2 possible scenarios/paths for Team Formation:
  - (1) Student-initiated project: They could be on a team ONLY if they were instrumental in developing an approved project. O/W, they get their team filled out with the same process as an advisor-developed project.
  - (2) Advisor-developed project ← this is most common, so I'll focus here
- Team Formation is done in concert with Project Rankings.
- Students review project descriptions and proposals before the Day 1 of Capstone. The documents are posted on our Capstone LMS for all to read over.
- We have a Capstone Project Introduction Expo on Day 1
  - There are Stations in the classroom for each Faculty Advisor
  - In person, small posters are made for each project from Advisor's ppts (by the Capstone Coordinator)
  - Advisors stand by at their Stations and are visited by interested students.
  - As is fitting, External Clients may Zoom in, meet students, and answer questions at the stations with the associated advisors
  - We do this twice, so that students get questions answered AND see who else may be interested
    - This is where some interesting alliances are made
    - This is when deeper questions are asked.
- Students will then fill out a Project/Team Preference form

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- ○ They can submit once, in team of 5, 4, 3, 2, or solo
- ○ That submission ranks all projects – We have not had any problems with rankings
- ○

RM Companies submit projects and desired student majors, students submit preferences for projects, Algorithms are possible, Instructor forms final teams
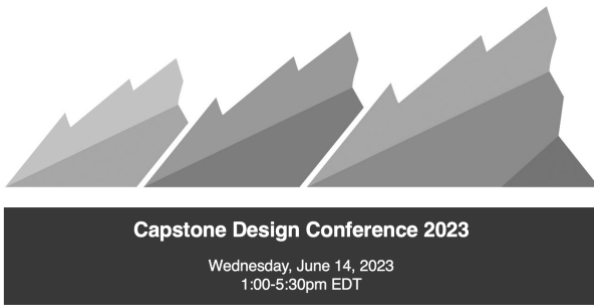
2. Do you use any particular program or software? Why or why not?
   RF I use Tandem (https://ai.umich.edu/software-applications/tandem/) --which is similar to other team formation tools I have experience with (CATME's a popular one - https://catme.org/login/index). It allows me to prioritize/weight different aspects (diff skill sets, diverse teams w/o stranding individuals). Tandem doesn't yet address project preference so in some courses I do a lot of adjusting after Tandem has created teams (but it still "scores" them for me based on what I've said I care about, so I can adjust and see what the algorithm says).
   https://ai.umich.edu/software-applications/tandem/

   KJ
- We use formulated Excel and it works well given our unique teammate-request submission sizes
- We have an algorithmic program that we have affectionately called the *Matrix of Minimum Misery* (SO positive!).
    - ○ It built from some of the work Bridget Smyser started when helping to make teams in Mechanical & Industrial Engineering
    - ○ With Hugh McManus in IE we have advanced (or complicated!) the computational algorithm with pivot tables and weightings over time.
    - ○ Top preferences get a value of 1 and lower interest in a project is assigned a higher number by the students.
    - ○ The idea is for the total representative score of the class to be as small as possible, making workable trade-offs to accomplish this
    - ○ Any final adjustments come from heuristics or late-breaking information.

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- Example: We had a sponsor who really wanted to mentor a couple female team members.
- Example: We had an advisor who determined that the team should only have 4 members as they would be observing in a surgical suite.
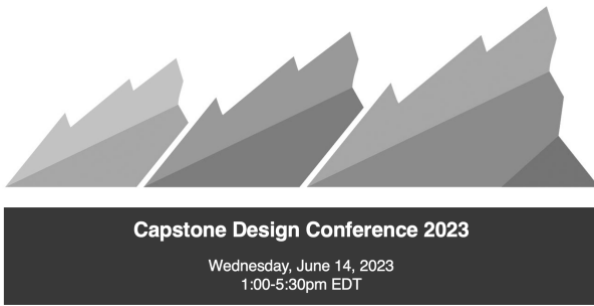-

RM I created a Database management program in 2010 and it is now the largest user created managed database program at BYU. Amazing program. BYU Hawaii could not manage that large of a program so we subscribed with Edusourced which was modeled after the BYU program and I further helped them upgrade their program. Excellent program.

3. What strategies do you use to get a good mix on each team? Do you consider race and other demographics? Skills? Enthusiasm about project?
RF Yes, I say to make diverse teams by gender and race/ethnicity (but to avoid stranding). I mix by skill set. I've played with some other responses, like procrastination... I'll explain that further in the next question. :) Goal is machine learning to predict team outcomes! :) and then we can measure different interventions. I've been in classes (as support) where teams self-formed. Really interested in KJ's "passion"-- I think this might map onto our "motivation" values in Tandem.

KJ Our multiple regression research using data from many years and team types has shown that two factors are clearly significant in contributing to success: (1) Perceived Teammate Contribution Potential: i.e., confidence in teammates to pull their weight, remain committed and contribute selflessly, and (2) Passion (yes we measured passion) Passion in general, not for the project topic, but to maintain dedication, positivity, and intensity and to motivate teammates in the face of challenges and setbacks, no matter the status of the project.

RM Recruiting heavily from the different majors is critical to gather the needed skill sets for the diverse projects. Both BYU and BYU H have broad mixes of international and ethnic diversity. BYU Hawaii is the most diverse campus in the US with with 70 countries represented and more than 60% non US students (mostly Oceana and Asian students). So you have to consider culture issues on the teams. The students generally worked

well together, but different cultures assert themselves differently so we had to manage for differences on the team and the willingness of the teams to be assertive in attacking the project. Most college students will need some sensitivity training about how different cultures and personality types approach a project and team. You need to help the more forcefully assertive students to bring into the team discussion all of the team members. Homogeneous teams come together quicker but tend to give one dimensional cookie cutter answers. Heterogenous teams require longer to get started but find richer more diverse results. Some schools let students form their own teams, but I am concerned that in the real world you are placed on teams with people you do not know and do not relate well to. I think it is helpful to model the real world and not an academic counterfeit.
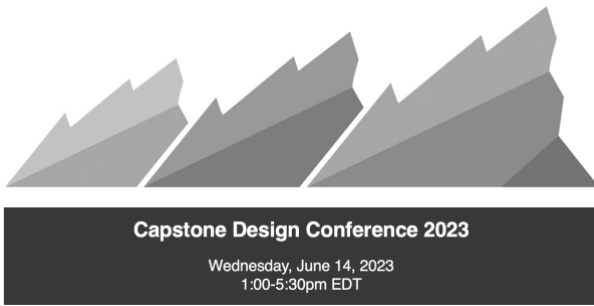
4. Did you ever try anything that didn't work? Why didn't it work?
RF I feel like a lot of team conflict comes from procrastinators grouped with non-procrastinators, so I "grouped similar" based on student responses to a question about that (in a first year course). Had a number of teams that really struggled to get started.

KJ
- Yes. Before I was Director, they tried letting students choose their own teams – the linear algebra did not always work: $4X + 5Y$ = Enrollment; $X + Y$ = number of teams/advisors/projects – Example: 12 teams of 5 proposed versus 15 teams of 4 needed! Breaking up teams and reforming new ones was odious.
- Yes. Pre-Capstone recruiting did not work for the system – more in person on that, but faculty should not be allowed to recruit/create a team without developing a pre-approved project.
- Yes. As a Coordinator, I tried to convey to the students when orienting them that we would do all we could to support their requests for teammates and project preferences. They got the impression that they could pick their teams and were universally disappointed if things did not work out perfectly. Now we tell them they cannot choose their teammates nor their projects, but can express preferences through the form.

RM We formed a team of Samoan students for a project in Samoa. The original team had a Senior, Junior, Sophomore and 2 freshmen. During the first 2 weeks the 3 upper classmen dropped the class and the only replacements we could find were all freshmen. It took the team a lot to get going and they needed significant hand holding to succeed. Problems with academic readiness and culture hesitation to attack the project.

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5. If you had to give one piece of advice about this topic, what would it be?
   RF Think about how you're gathering info re: project choice. In interviews, I've heard lots of students talk about having used this question to try to position themselves to be placed with friends on the team...

   KJ
● Remind the students that in any other course, they may be assigned teams and projects with no prospect of a choice or preference and sometimes all teams get the same project. Reframing it so they appreciate any input they can provide at all has shifted the tone of this aspect of Capstone.
● We cite the research findings about the significance of various factors in their association (and prospective contribution) to a project's success.

> Tables & Figure from: Smyser BM & **Jaeger BK** (2015). "How Did We End up Together: Evaluating Success Levels of Student-formed vs. Instructor-formed Capstone Teams", *Proceedings of the American Society for Engineering Education*, Seattle, WA.

Table 3. Regression Statistics for Factors Present versus Passion/Level of Personal Commitment for Capstone project.

Multiple $R = 0.795$	$R^2 = 0.632$
FACTOR	**Significance?**
CON – Contribution	$p < .0001$*
ADV – Project Advisor	$p = .072$
SEL – Team Selection	$p = .337$
DEV – Development	$p = .446$
PAL – Friend Level	$p = .524$
TOP – Topic Ranking	$p = .819$

Table 4. Regression Statistics for Factors Present versus Final Prototype Score (level of success) for Capstone project.

Multiple $R = 0.812$	$R^2 = 0.659$
FACTOR	**Significance?**
CON – Contribution	$p < .0001$*
DEV – Development	$p < .002$*
PAS – Passion Level	$p < .007$*
SEL – Team Selection	$p = .477$
TOP – Topic Ranking	$p = .414$
PAL – Friend Level	$p = .256$
ADV – Project Advisor	$p = .184$

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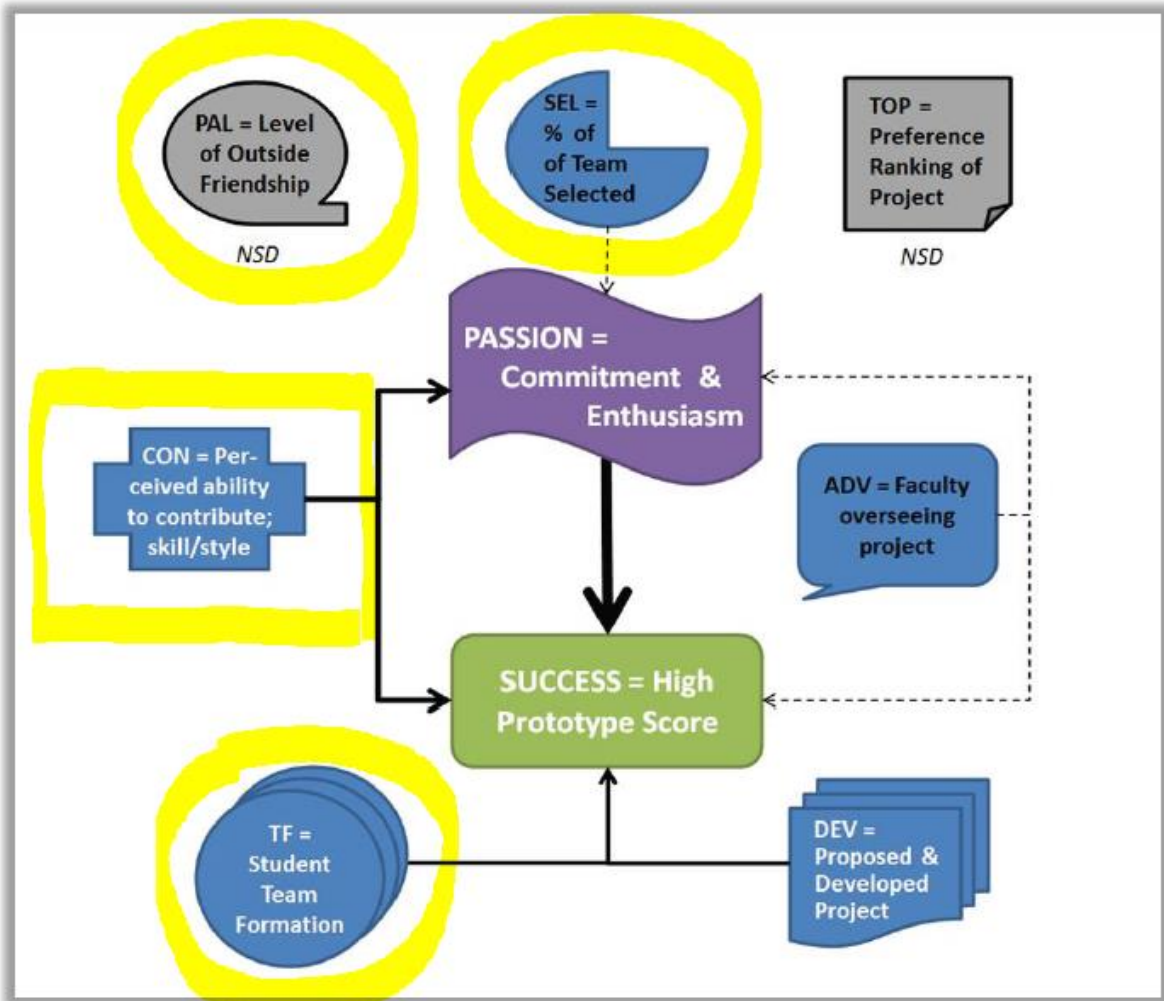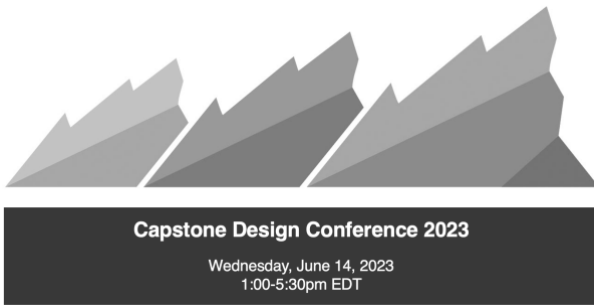1:00-5:30pm EDT

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Figure 4. Strength of relationships among factors present at the outset of Capstone and subsequent components of success. Solid line = statistically significant relationship, thicker = more significant connection; black lettering = no statistical difference; dotted line = showing a bearing trend, but not a statistically significant factor; unconnected factors = no significant connection or trend found at all.

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RM When you ask the students for preferences for which projects they want, use rating and not ranking. You can't tell how much difference between the top 3 and the top 10 with ranking, but ratings show the amount of differences between preferences

6. New question…
   RF
   KJ
   RM

Notes:

How do you form teams?
RM - Solicited projects, students ranked top 10 projects to match skillsets. Became complex with 100-150 students. Created a database with matching criteria - majors, skillets, outcomes. Shifted to rating vs ranking - likert scale.

RF - 1200 students taking senior design annually across ~13 disciplines. UM rebranded as "people first." Use a variety of information to appropriately match people to projects.

KJ - 80 students per year. Cannot pick your own team or project; preference of core of 4 people may be a safe request. Student developed projects are possible; advisor developed projects are most common. Holds project information expo to better understand projects; visit stations; talk with advisors; see who else is interested.
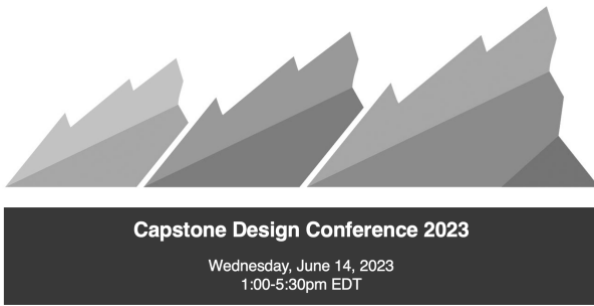
What tools or programs do you use or have rejected?
RM - Created a system to manage team selection and full process/project; took IT ~1 year to develop. Found external partner to commercialize and then lease back.

RF - Built their own; CATME was exasperating challenges

KJ - Use formulated excel. Customized algorithm developed "Matrix of Minimum Misery". Strategies for good team mix

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RM - Girls - more important who you're with vs what you're doing. Boys - the inverse. There is value in putting friends together. In the "real world" most times you don't get to pick your teams. Transition to real world experience where you may have to work with people you don't like. Homogeneous teams begin working faster, but answers are often shallow (lack broader perspective). Heterogeneous teams took longer to bond, but realized better outcomes. Consider training on how to operate as a team.Cultures are very different regarding how they operate; coaching is important to success.

RF - Set goals of diversity (not being stranded) more important in first year vs future years. Can't always avoid stranding; creates "buckets"

KJ - Two predictors of success 1) Perceived teammate potential/contributions 2) general passion (it can be measured!)

What have you tried that didn't work?

RM - Lost senior level students. Leveraged mentors to help them come up to speed and provide tools to help them along the way. Create the opportunity for dissatisfaction through ranking where there is no real difference in their mind.
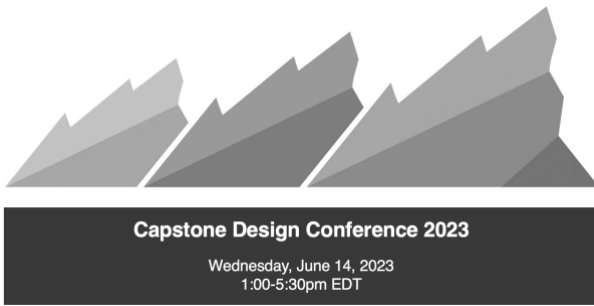
RF - Team conflicts due to poor work habits - procrastination etc.

KJ - Picking you own team causes a number of issues. No longer allows this.

One piece of advice

RM - Rating vs ranking. Example - students want projects due to company name, even if they're not qualified. They rank everything high, everything else low.

RF - Don't allow students to pick their own teams. Its not realistic in the workplace. Likely will not have the best learning or outcomes.

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KJ - Don't give students the impression they can choose their own teams. Ensure teams understand goals and objectives clearly. You will bring skills, but you must learn something new - this is a given.

Have you had students who didn't want or agree with capstone?
RF - A student who didn't buy into capstone.Company paid for students to travel overseas to install filters. Students were disillusioned by ROI (cost ve result).

RM - Capstone a a required course - forces students into something they don't want to do. How can we create alternatives or variety that make it less distasteful?

KJ - It's going to happen. Make it sound engaging. "You get to work on a real world project!" Ask students "What's cool about your project?"

Should you use GPA to form teams?
RM - have never collected GPA. May be a good measure of effort, but not necessarily creativity.

Have you dealt with the "coalition of the damned?"
RF - I've done this intentionally. Idea is to get them to step up.

Zoom Chat

Q: For Robin fowler: how do you perform such detailed analysis when you have ~ 1200 students to assess?
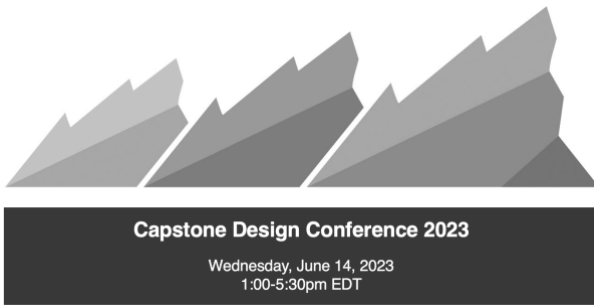RF: can't do it by hand! We've got a tool, https://ai.umich.edu/software-applications/tandem/
RF: BUT no one is doing it for 1200 students. Largest classes are just over 100 I think. My largest is supposed to be capped at 60
Rungun: @Robin Fowler (UMich) Can you access Tandem without UM account?
RF: Yes, but would need to write to Tandem support and ask them to open an account for you.
RF: yes, but you have to have something set up on the backend. I think you can email tandem-support@umich.edu and they'd set you up. Or email me (rootsr@umich.edu) and I'll connect you w/the right people

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Q from Morgan McArdle HMC: Speaking of passion, has anyone had experience with students not buying in to a capstone program in general? What did you do about it?

Rungun: @Morgan not had this happen, but we take time to excite them about Capstone project in their junior second semester. I would have one-on-one meeting with the student and try to address the issue. Lastly the threat - it is a required course to graduate.

Mark Ruegsegger (OSU): Have the undergrads in your program go to the Sr Design Showcase (end-of-year event). They will likely be awed and impressed by the prototypes they see.

KJ: We do that - Announce the Sr Design Showcase and if they are on campus and not on co-op, they can go. We also show this < 4min video:
  https://vimeo.com/path8/review/706020269/8bb5a3cde4

Q from Rungun (Penn State Perks): Is what Roger saying generalizable to all girls/boys - Boys do what they want and do not care about company, while girls want to stay with company and not really what they do?   Can other chime in? I did not find this in my Capstone students for over 8 year - approximately 250 students so far. @Roger - can you please give the reference - about homogenous/non-homogenous teams?

RF: I don't know the one he's talking about, but that's a fairly common finding re: heterogeneity/homogeneity in teams.

Randall, Utah: I think you misunderstood what he was saying. He learned that from his experience with his girls, but it was not intended to apply to just girls. For some people the project is more important and others the team is more important. You need to find your own way to determine what is important to the individual (not necessarily boy vs girl).

Sarah Oman (Oregon State Uni): It's important to also consider those that do not identify on the binary of male/female.

RF: Page, S. E. (2019). The diversity bonus: How great teams pay off in the knowledge economy. Princeton University Press. is a good book that summarizes some of this
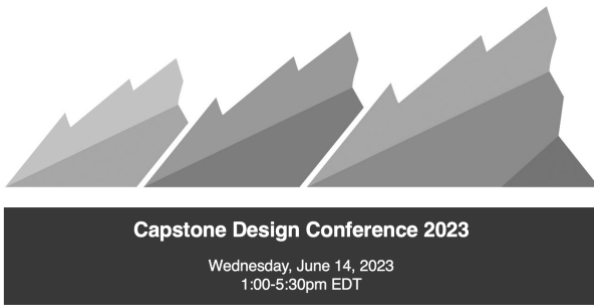
RM: Sorry, I read the study I the 1990s and I did not keep the Texas A&M reference

Robert J. Ryan (Temple University): here are a couple references: A Multimethod Examination of the Benefits and Detriments of Intragroup Conflict

Author(s): Karen A. Jehn

Source: Administrative Science Quarterly, Vol. 40, No. 2 (Jun., 1995), pp. 256-282

Published by: Sage Publications, Inc. on behalf of the Johnson Graduate School ofManagement, Cornell University

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Q Mike Thorburn - Cal State Univ LA: I have an issue - does anyone else experience the same thing?   80% of my students have jobs. So they are balancing their senior classes, their jobs and senior design.   Sometimes senior design teams have difficulty finding times during the week that fit within all of their schedules.   This seems to be worst now than it was prior to Covid …. but it existed before too.

Robert Ryan (Temple University): We schedule the class and use that time for team meetings. Students are expected to be available during class time as they would for any other class

RF: ^we try to do this too, but it's not enough I think. We do have a place students indicate if they have other extenuating circumstances (a job, caregiving responsibilities, ROTC whatever) and we try to distribute those folks across teams so the rest of their team can be as flexible as possible

KJ: @Robert we do the same. We also aske them if they can try 7:00 am and 9:00 pm as well. Life issues aside, sometimes it does not occur to them.
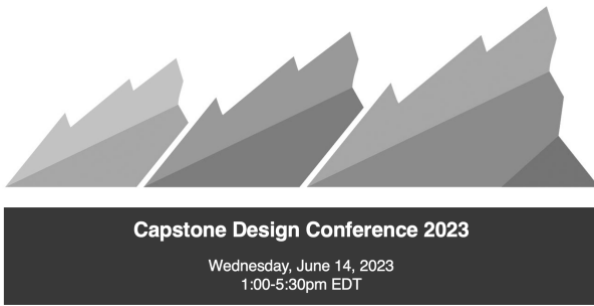
Rungun: We tend to have this problem. So our first semester has 3 contact hours/week and second semester has 6 contact hours/week scheduled that students must attend class. We generally have two sections - and there are "no Major classes" during those 3 or 6 hours and so they can essentially get 6 hours in the first semester and 12 in second semester

Edward Latorre, U. of Florida: In my project ranking form, I ask them about outside fixed commitments (e.g. jobs). I will avoid teams where all have these.

Dustin Rand UVM: We have 3 x 2 hour labs /week carved out. All new content is online and we meet in person 5 x 1 hour each semester. Having dedicated time to work as a team without listening to the instructors, it works pretty well. They have to show progress every 3 weeks.

Q Melodie Lawton - Univ of Rochester: Interested in understanding the specifics of the team/communication training and how TAs are utilized

Mike Thorburn - Cal State Univ LA: One effort I made last year that was successful. I hired 5 graduate students (MSEE and MSME) to be available as technical consultants for all the teams. The teams utilized the grad students quite effectively.

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Q Alan Marks: Interesting comment, Kris. I'm very curious if other folks allow teams to self-select.

Mike Thorburn: We collect preferences and make assignments.   Then after we make announcement of assignments, we do give students one week to try to "trade" for a place on another team.   Trying to balance the factor of engagement when a student really wants to be on a team.

Rungun: No self selection, only preference asked

Mark Ruegsegger (OSU): I allow students to list preference of teammates they would like to work with, and a student they know they would not work well with. Only occasionally do they nae someone they do not want to work with, but it is interesting when multiple students name the same student! :)

Comment Mike Thorburn: Sometime students want a particular team because of the topic or the client …. and not at all about their friends.

Rungun: I tell students that when they start working - they do not always get the teams they want, it is better to learn the skill now

Question: How long into the semester does it take to develop the teams? Are you in a 1 semester or 2 semester CapStone?

RF: yep, but you can let them express preference for topic/client

RF: I do let students list someone they do not want to work with. I started doing this when someone asked what I do if a student has a restraining order against another student (this hasn't come up as far as I know)
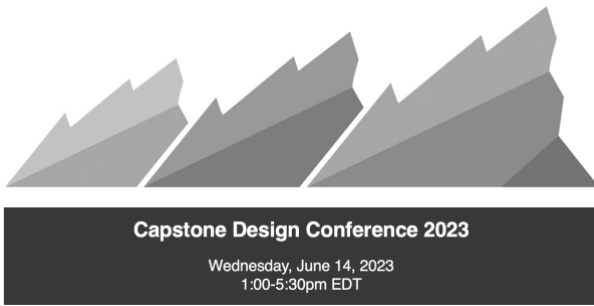
Sarah Oman: I had a student who had recently broken up with another in the class, so it definitely helped to know to not put them together.

Q Steve Larimore - University of Arizona: Does anyone use GPA team balancing

RF: we've considered but haven't done, no. Have also considered GPA team imbalancing. 🙂 don't know what's best!

Mike Thorburn: Our CS department does

Meg Harkins UNC Charlotte: I try to get similar average GPA across all the teams.

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Sarah Oman (Oregon State Uni): I find GPA hard to use because so many students have multiple jobs so they sacrifice their GPA, but they are still very hardworking.

Rungun: Never use GPA - PERIOD

Meg Harkins: It has become less useful since the COVID influence on GPA, causing some students to have lower or higher GPA

Michael Hirsch (Boston U.): Sometimes very high GPA students that mastered doing well in standard classes score very poorly in Senior Design.

Comment Robert J. Ryan (Temple University): @robin fowler was anything done with the student who traveled internationally to get them to consider how to improve the system (ie how can support be given to communities at lower cost by perhaps supporting students in community or nearby, etc)

RF: good Q, and I don't know. I saw this as anonymized responses from an interviewee as part of a diss on how we can make community-embedded engineering ed more effective

Robert J. Ryan: I advise EWB at Temple and I have the same concern. We spend thousands just to get to the community. There is a clear educational benefit to the students, but it makes me wonder how we could be more financially efficient

Q Mike Thorburn: Does anyone have teams that are embedded at an industrial client site?   Like an apprenticeship?

RF: a small proportion of our students do an MDP instead of senior design in their discipline; some are kind of this. We should investigate buy-in/motivation across contexts!
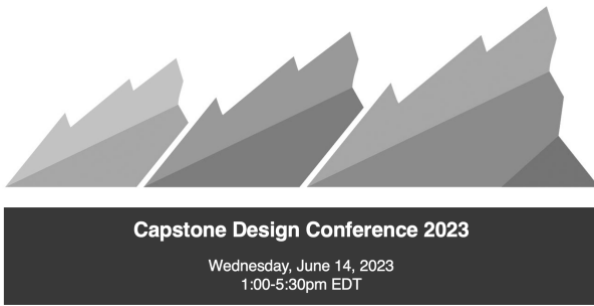

Discussing capstone as a required vs. elective course

William Miller Univ. Tennessee, Knox: Roger McCarthy: Did I hear correctly that Capstone is optional at Brigham Young. Was there a transition? UT Knox MABE has Capstone as a requires course.

Roger McCarty: I do not work with the Mechanical Engineering Capstone, so I do not know if it is required.

Lisa Barranger - BYU: @William Miller - Capstone is required for Engineering and now many other majors, but the internship experience that Roger originally coordinated was not required.

Nathan M. Kathir. George Mason: Capstone cannot be optional for engineering if going for accreditation by ABET EAC

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Rungun: @Nathan - ABET says "major design experience" and not "Capstone Design". (I am stating this from memory). A research project can meet the major design experience and it is upto to the program to show this

Mark Ruegsegger: We have multiple faculty that work in Capstone and we have "flavors" or themes of projects for BME: sensors and systems; mechanical; general medical devices; rehab and assistive technologies. These are based on faculty expertise. This could be a way to let students "select" their course section.