



## **WIP: Impact of Role-Playing Simulation for a Design for Manufacturing Course**

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## **Abstract**

Role-playing has been used in psychology, history, nursing, language instruction, and other areas to increase student engagement and improve learning outcomes. Here it is utilized for an injection molding project in four week-long online exercises in a quarter-long Design for Manufacturing course. The course covers manufacturing basics, comparative analysis of processes, and manufacturing fitness for design. For the simulation, groups are formed into groups representing assembly, customer satisfaction, marketing, and purchasing to develop design requirements for an imaginary customer. Teams are then formed with representatives of each group to develop new, combined design requirements and use them to create a design to present to their "customer." All communication between the groups and teams were in an online discussion forum and coded for their breadth and depth with respect to the course learning objectives. An anonymous summative survey was used to assess the student response to the activity.

## **Introduction**

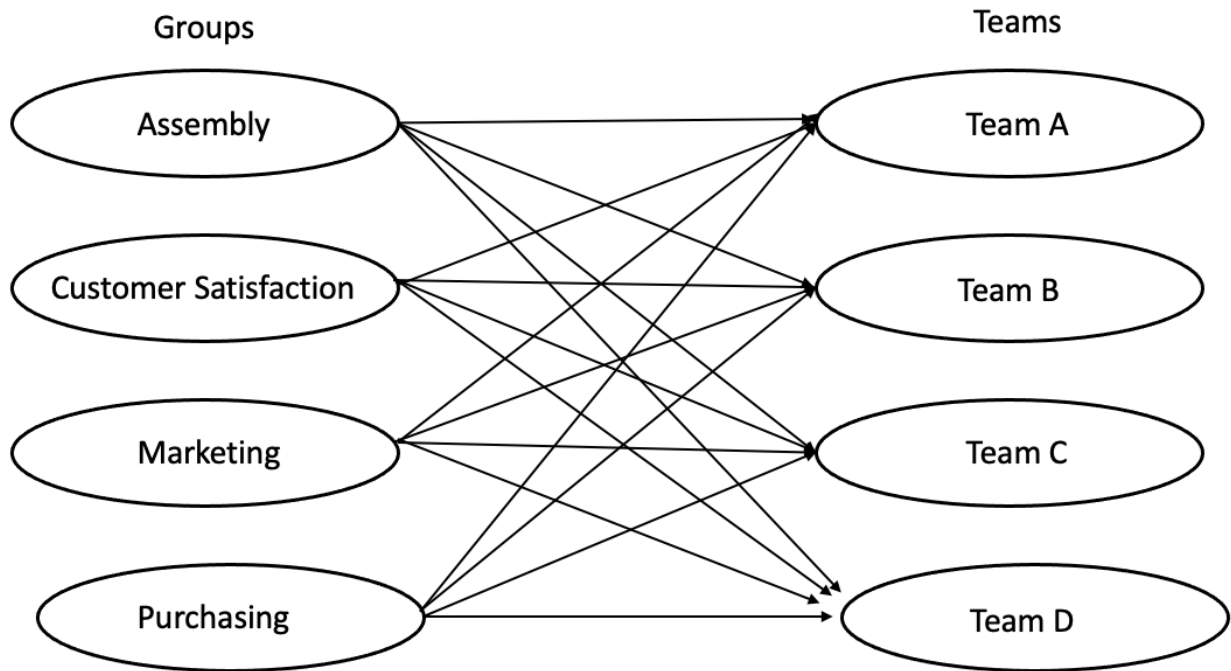
Design for manufacturing is a broad topic that continues to get broader. The central concepts of considering manifold needs, working within manufacturing constraints, and finding ways to add value can be challenging for undergraduate engineers without manufacturing experience. The consideration of multiple points of view while designing for a specific manufacturing process can be particularly challenging.

Simulations using role-playing have been used to help college students consider the many perspectives involved in making historically significant decisions [1] or chemistry students as they learn analytical chemistry techniques [2]. They have been shown to improve student self-efficacy [3], reduce stereotype threat [3], and even improve creativity [4]. With these considerations in mind, role-playing simulations were utilized as part of a four week exercise in a quarter-long design for manufacturing course.

Feeling immersed in the role they play in a simulation is critical because "Role-playing is immersion to an outside consciousness ('a character') and interacting with its surroundings" [5]. Comfort in operating as an engineer, the students "character," in the simulated company environment of the simulation requires some confidence as to their goals and approach. This is achieved via collaboratively developing design

constraints that represent their character's, and their group's, viewpoints within the company. The conflict that arises from a collaborative endeavor allows the students to explore both the simulation and design spaces [6] and is achieved in the simulation by forming design teams with a representative of each group to develop team design requirements from their combined group requirements. These role-playing goals serve the learning objectives of the course by allowing design and manufacturing concept exploration prompted by discussion and conflict between group members.

Role-playing is used here in a required Junior/Senior level Design for Manufacturing class in a mechanical engineering department in a midwestern technical college to improve the breadth and depth of consideration. The simulation was done asynchronously via an online forum over four weeks starting in week seven of a ten week quarter. Student teams representing assembly, customer satisfaction, marketing, and purchasing developed design requirements for an imaginary product in week one based on their groups function within the "company" (the class). A representative of each group was assigned to a team, as in Figure 1, so that each team would have a representative from each of the week one groups. These teams then evaluate a proposed design and develop new, comprehensive design requirements as a team.



*Figure 1: Groups and redistribution into teams*

Note that in the rest of this paper, "Group" will refer to the functional groups, i.e. each "Group" is wholly composed of members who represent either Assembly, Customer Satisfaction, etc., while "Team" will refer to the teams formed from one

representative from each "Group" , i.e. every person in each group represents one Group, so there is one representative each from Assembly, Customer Satisfaction, etc.

## **Implementation**

An introductory presentation involving an imaginary customer, a medieval-themed restaurant that desired custom restaurant pagers consistent with their brand image from the class "company." 42 mechanical engineering students, mostly juniors and seniors, in a STEM focused midwestern college were assigned to groups concerned with assembly, customer satisfaction, marketing, and purchasing and given readings and supporting materials to guide them as they developed design requirements in week one. Pagers were chosen as the target of the design analysis to increase comfort and familiarity as students had designed one earlier in the term and developing design requirements in week one helped introduce them to their role and give them confidence for week two.

In week two, Teams were created with one representative from each of the week one Groups to develop a common team criteria from each of their group requirements to evaluate a proposed pager design. The conflict between the week two Team and week one Group requirements were explored as students reconvene in the Intra-Group forums with their week one Groups in week three to discuss and resolve conflicts.

In week three the Teams designed a pager that met their week two design requirements. The forum entries were lower than other weeks as teams used shared online documents to work out the design, despite instructions to the contrary.

Week four brought comparisons of each team's design to the design of three other teams to develop a design comparison report that used radar plots to perform a relative evaluation of how well each design met evaluation criteria for injection molding, assembly, guest quality, staff quality, and innovation and integration. The report also required calling out the best and worst designs for each criteria.

An Intra-Group online forum was introduced in week three and continued into week four. The Intra-Group forum allowed students to reconnect with their Groups to discuss their thoughts, struggles, and conclusions as they developed their team design criteria in week three and evaluated designs in week four.

## **Theoretical Framework and Research Design**

A forum was created for each week of the study in learning management software to collect and store student interactions over the four weeks of the simulation. A forum

was created for each of the weeks of the exercise as well as an anonymous forum to capture feedback. After reviewing the forums, coding categories were created to capture the exploration of both the topic breadth and depth using qualitative data coding techniques [7]. Each week was coded for forum entry type via the forum entry categories in Table 1, to characterize the type of entry (adapted from categories in [8]).

*Table 1: Forum Entry Coding Categories*

<b>Category</b>	<b>Code</b>
New Idea	N
Modification/Revision of an entry	Mod
Agreement	A
Disagreement	D
Meta comment	Me
Question	Q
Response	R

As you will see in the Results and Discussion, not all forum entry categories were present during all weeks. For example, forum entries in the Agreement category appear during week one but are not present during any subsequent week's entries.

The depth and breadth of the forum entry was evaluated based on the scale shown in Table 2. Each forum entry was coded from Level 1 for superficial or trivial entries, e.g. "OK," "Thanks," etc., to Level 5 for entries with both breadth and significant depth. Breadth of an entry is judged by its incorporation of more than one concept area, i.e. not just assembly but also materials, customer satisfaction, etc.

*Table 2: Depth and breadth coding categories*

<b>Code</b>	<b>Depth/Breadth</b>
1	Superficial/Trivial: Statement with no argument or reasoning
2	Some Depth: Some depth of consideration with limited argument or reasoning
3	Significant Depth: Significant consideration with supporting arguments and reasoning
4	Breadth with Some Depth: Considering multiple design requirements with some depth
5	Breadth with Significant Depth: Considering multiple design requirements with significant depth

The instructions provided to students and those provided via the LMS forum are in the Appendix after the References.

## Results and Discussion

### Week One

There were 113 entries in the week one forums to determine their group's design requirements for each of the four groups. The results for the week one forum categories are presented in Table 3 and the depth of those forum entries are presented in Table 4.

*Table 3: Forum entry category entries by number and percentage*

Category	Number of Entries	% of Responses
Agreement	7	6
New Constraint	59	52
Modification	30	26
Question	16	14
Response	1	1

Most of the responses in Week 1 were new ideas, as expected, as the Groups establish their design criteria. Each group only considered the design requirements for the function of their own group in week one, so depth (coding categories 1-3) was the only consideration - breadth (Levels 4 and 5) was not considered.

*Table 4: Week One Forum Entry Category Entries and depth by number and percentage*

Category	# Entries	Level 1		Level 2		Level 3	
		#	%	#	%	#	%
Agreement	7	3	43	4	57	0	0
Modification	30	3	10	18	60	9	30
New Idea	59	12	20	24	41	23	39
Question	16	4	25	12	75	0	0
Response	1	0	0	1	100	0	0

Table 5: Depth of Week One Forum Entries

Level	%
1	19
2	50
3	31

Table 6: Week One Forum Entries by Category

Category	#	%
Response	8	7
Modification	30	27
New Idea	59	52
Question	16	14

Table 5 shows the depth of entries with 81% of entries having some depth (Level 2 or greater). Table 6 shows that 51% of the entries were new ideas and 41% were interactions about those ideas (Modifications and Questions), showing significant interaction over ideas rather than presentation of new ideas without rejoinder.

## Week Two

In week two the Groups were split into Teams such that one representative of each Group was there to speak for that aspect of the pager design. There were 157 entries to the Team forums to develop common criteria from each Group's criteria. Table 7 shows the detailed breakdown of the entries by Category and Depth.

Table 7: Week Two Forum Entry Category Entries and depth by number and percentage

Category	# Entries	Level 1		Level 2		Level 3		Level 4		Level 5	
		#	%	#	%	#	%	#	%	#	%
Modification	53	6	11	10	19	3	6	24	45	10	19
New Idea	57	1	2	21	37	6	11	17	30	12	21
Question	20	0	0	5	25	3	15	12	60	0	0
Response	27	11	41	4	15	1	4	9	33	2	7

Table 8: Depth and Breadth of Week Two Forum Entries

Level	#	%
1	18	11
2	40	25
3	13	8

4	62	39
5	24	15

The results of Table 8 indicate that 54% of entries had breadth and depth (Levels 4 and 5) and 89% had some depth (Levels 2-5). As expected, there was significant interaction as shown by the Modification, Questions, and Response results of a combine 64% in Table 9.

Table 9: Week Two Forum Entries by Category

Category	# Entries	%
New Idea	57	36
Modification	53	34
Question	20	13
Response	27	17

### Week Three

The 41 forum entries from week three pager design evaluation were disappointing in the quantity of interaction. This may be in part due to the presence of the Intra-Group forum that was introduced in week three.

Table 10: Week Three Forum Entry Category Entries and depth by number and percentage

Category	# Entries	Level 1		Level 2		Level 3		Level 4		Level 5	
		#	%	#	%	#	%	#	%	#	%
Modification	2	-	-	2	15	-	-	-	-	-	-
New Idea	12	1	50	3	23	-	-	7	32	1	25
Question	-	-	-	-	-	-	-	-	-	-	-
Response	27	1	50	8	62	-	-	15	68	3	75

Table 11: Depth and Breadth of Week Three Forum Entries

Level	#	%
1	2	5
2	13	32
3	-	-
4	22	54
5	4	10



As Table 11 shows, the breadth and depth of the discussion was not disappointing, with 95% of entries having some depth (Level 2 or above) and 64% having some breadth. Table 12 shows there was a good level of interaction, with 71% of entries modifying or responding to ideas.

*Table 12: Week Three Forum Entries by Category*

Category	#	%
Modification	2	5
New Idea	12	29
Question	-	-
Response	27	66

### Week Four

Each team chose to ignore the instructions to interact via the forum and instead used online documents, i.e. Google Docs or MS Word, to interact and generate their final report. As a result the submitted design comparison reports are the only entries (eight entries). No category data is presented as they would all be categorized as "New" since there is no history of the interaction that created the reports. As Table 13 indicates, seven of the 8 reports had some level of depth and breadth with half of them showing significant breadth and depth. These results are impressive given that this activity was conducted in the last week of the term.

*Table 13: Depth and Breadth of Week Four Forum Entries*

Level	#	%
1	-	-
2	1	12.5
3	-	-
4	3	37.5
5	4	50

### Intra-Group Forum

The Intra-Group forums were introduced in week three and continued into week four to allow the original group members to meet with their functional group to discuss conflicts and difficulties as they worked on the design evaluations. There were 74 entries that contained rich, broad discussions considering materials, processes, and customer – both the staff using the pager as well as the restaurant customers.

Table 14: Intra-Group Forum Entry Category Entries and depth by number and percentage

Category	# Entries	Level 1		Level 2		Level 3		Level 4		Level 5	
		#	%	#	%	#	%	#	%	#	%
Modification	0	-	-	-	-	-	-	-	-	-	-
New Idea	28	-	-	-	-	1	100	19	49	8	57
Question	0	-	-	-	-	-	-	-	-	-	-
Response	46	1	100	19	100	-	-	20	51	6	43

Table 15: Depth and Breadth of Intra-Group Forum Entries

Level	# Entries	%
1	1	1
2	19	26
3	1	1
4	39	53
5	14	19

The breadth and depth of the discussions were strong as Table 15 shows – 99% had some breadth and depth and 19% had significant breadth and depth. The interactions were strong also, with 62% of entries being responses.

Table 16: Intra-Group Forum Entries by Category

Category	#	%
Modification	-	-
New Idea	28	38
Question	-	-
Response	46	62

Table 17: Intra-Group Forum Entries by Group

Group	#	%
Customer Satisfaction	27	36
Purchasing & Product Quality	17	23
Marketing	16	22
Assembly	14	19

The forum entries in the Intra-Group forums are broken down by Group in Table 17. Not surprisingly, Customer Satisfaction had the largest number of entries – over a third of the total entries – as students worked out how they would incorporate it into their designs. Purchasing & Product Quality and Marketing were nearly equally represented while Assembly was slightly underrepresented, possibly indicating a comfort, or a perceived comfort, with the topic.

## Summary

There were a total of 393 entries over the four weeks of the exercise (see Table 18). The number of entries peaked at week 2 as students worked out their team’s design specifications from each of their group requirements – almost 70% of the entries happened in weeks one and two. After week two, the Intra-Group forums had the most traffic.

*Table 18: Number of Forum Entries by Forum Category*

Forum	#	%
Week 1	113	29
Week 2	157	40
Week 3	41	10
Week 4	8	2
Intra	74	19
Total	393	100

The percentage of forum entries with some breadth and depth, i.e. Level 2 or greater, were always above 80%. They were almost 90% for week two and 95% or higher every week after as groups developed their design requirements and applied them to evaluate designs.

*Table 19: Percentage of Level 2 or Greater Forum Entries*

Forum	% 2+
Week 1	81
Week 2	89
Week 3	95
Week 4	100
Intra	99

## Activity Student Evaluation

Twelve students responded, of 42 enrolled, to a three question Likert scale request for feedback. Table 20 shows the response average was neutral overall; there were no

responses of 5 (Strongly Agree) or 1 (Strongly Disagree). Select comments are below. The responses were neutral with no “Strongly Agree” responses but also no “Strongly Disagree” responses.

Table 20: Evaluation results on 5 point Likert scale (5=Strongly Agree, 1= Strongly Disagree)

Statement	Response Average
I enjoyed the Analysis Project	3.1
I learned much from the analysis project	3.0
I would enjoy more learning activities like the analysis project.	2.7

#### Student Feedback Comments:

- “I think the analysis project was beneficial for me to see what I truly knew and allowed me to put to practice the things I learned in class.”
- “I feel like it is just filling a void in the class while we wait for time in the shop. I understand why it is there, but I cant say I am getting as much out of it as the other projects.”
- “I enjoyed working through the project, but felt it hard to get started at some points. I think having any sort of example would have made the entire process easier.”
- “We should have the project more formally, like create teams channel for each group, have a class for groups to meet teammates, etc.”
- “Working in teams is important, but over [LMS] discussions it is really hard to get ideas together. I like to start an assignment and finish it in one sitting, but this is impossible with the [LMS] discussion setup.”
- “I think it wasn't detailed enough for us to really learn anything but also we had already covered a lot of the material in the pager project already.”

### Conclusions

Performing this series of exercises on an online forum yielded a benefit for course learning objectives without consuming class time or requiring a significant investment in preparation from the instructor – two of the most significant barriers to adopting research-based instructional approaches [9] – and offers a good learning outcomes for a modest investment by the instructor. It will also be very easy to modify and repeat in future courses without significant effort as the instructions can be dropped in any LMS forum (or Slack<sup>®</sup> or Discord<sup>®</sup>). The significant majority of conversations had depth and breadth but were also interactive.

Finally, potentially the most significant outcome of this approach was not explored here because this activity concluded at the end of the term. The ability to use the learning outcomes of this activity to launch into additional explorations of manufacturing from the perspectives achieved here. Future work will adjust the deployment timing to allow for activities to build on the foundation created with this activity.

## References

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- 3- Stroessner, et. al., "All the World's a Stage? Consequences of a Role-Playing Pedagogy on Psychological Factors and Writing and Rhetorical Skill in College Undergraduates," *Journal of Educational Psychology*, 101, pp. 605-620, 2009
- 4- Dumas and Dunbar, "The Creative Stereotype Effect", *PLOS One*, Feb 10, 2016, DOI:10.1371/journal.pone.0142567
- 5- Pohjola, Mike, "Autonomous Identities: Immersion as a Tool for Exploring, Empowering, and Emancipating Identities." In *Beyond Role and Play*, edited by Markus Montola and Jaakko Stenros, 81-95. Helsinki, Finland: Ropecon
- 6- Hammer, Jessica, et. al., "Power and Control in Role-Playing Games" in *Role-Playing Game Studies, Transmedia Foundations* edited by Jose P. Zagal and Sebastian Deterding. Routledge, 2018
- 7- Richards, Lyn, *Handling Qualitative Data: A Practical Guide*, 3<sup>rd</sup> Edition, SAGE Publications, 2014
- 8- Guzey, S. Selcen, Aranda, Maurina, "Student Participation in Engineering Practices and Discourse: An Exploratory Case Study," *Journal of Engineering Education*, Vol. 106, Issue 4, pp. 585-606
- 9- Borrego, Cutler, Froyd, Prince, and Henderson, "Faculty Use of Research Based Instructional Strategies," *Proceedings of the 2011 AAEE Conference*, Fremantle, Western Australia

**Appendix:**  
**Student Instructions and LMS Forum Instructions**

*\*\* Instructor's Note: Instructions start below and are numbered 1-7 over the four weeks. The entries for the LMS (or Discord or Slack) forums are indented and interspersed as they are referred to in the instructions\*\**

1. **Start here!!!** You need to read this carefully. We will not dedicate class time to lectures on this project because of our asynchronous schedule. Of course I'm happy to discuss this project with any student that has questions though. I just want the questions to be better than "What do I do?" or "When is this due?".

Design for manufacturing is rarely performed in isolation. As engineers, you will be required to consider the design perspective of others on the team while representing your perspective in a collaborative manner. Some of the perspectives that I'm referring to are manufacturing, assembly, marketing, purchasing, product quality, and customer satisfaction/customer experience.

Every student in this course is developing knowledge to make them credible representatives of a manufacturing perspective and you are expected to represent that perspective during this project. Additionally, we need to grow your understanding of another design perspective. Each student in this course was assigned to one of four new design perspectives:

1. customer satisfaction and product experience
2. purchasing and product quality
3. marketing
4. production and assembly

You will not become an expert in the assigned perspective. Instead, our goal is to start seeing the interconnectedness that these perspectives share with manufacturing and design.

2. **Read** the [analysis project overview](#).

**\*\*[Assigned Reading of PPT – see PPT File]\*\***

3. Your assignment during the first week will be to read some introductory material for your assigned perspective and develop a few product requirements that represent your perspective. Details of your first week assignment can be found in the [perspective requirements assignment](#) forum. You will only have access to the forum posts to which you are assigned.

We ask that you keep any project discussion to the forums that we use for this project.

## Week 1 Forum: perspective requirements assignment

**Due:** Monday, January 31, 2022, 11:00 AM

1. Follow the instructions in the draft requirements post for your perspective.
2. There are materials in there to get you started on the topic but you are encouraged to use other sources, knowledge you already have, the Medieval Times website, discussions with perspective group members, etc.
3. This exercise is open ended which means there isn't a right answer, it's nebulous, and some people will find that uncomfortable.

4. Note that you should plan on the analysis project being structured around weekly deliverables (like the first week) through the end of the quarter.

5. You are now part of a team with other students that represent each of the perspectives that we introduced during week 1. Complete the [analysis project week 2 assignment](#). There are due dates throughout the week and must be finished by next Monday. The [perspective discussion forum](#) is a place where you can ask questions and share information with other students from your perspective group. It may be helpful when answering teammate questions.

## Week 2 Forum: analysis project week 2 assignment

**Due:** Monday, February 7, 2022, 11:00 AM

You have been grouped with students from each of the perspective groups. Note, there may be more than one representative for one or two perspectives.

1. Reply to the [share requirements](#) post in order to share the requirements you developed for your perspective with your new team. **[DUE Tuesday, 2-1-22 by midnight]**
  1. Indicate what each requirement is and why it is important to your perspective.
  2. Ask clarifying questions about the requirements of others.
2. Analyze the initial [medieval pager](#) design with respect to both perspectives, perspective requirements, and injection moldability. Your analysis isn't restricted to your perspective, but as a group, you should cover all aspects completely. Make multiple replies to the [initial design analysis](#) post. There isn't a number of posts



required per person, but as a team, your analysis should be complete. Remember to keep all discussion in the forum. You'll be graded based on contributions there. **[DUE Thursday, 2-3-22 by midnight]**

3. Reply to the **brainstorming post** with at least three design suggestions/proposed features/proposed characteristics. Your suggestions should not be complete designs but should be significant. For each suggestion be sure to indicate what perspective(s) (or injection moldability) it impacts positively and negatively. **[DUE Monday, 2-7-22 by 11:00 AM]**

6. Complete the **analysis project week 3 assignment**. This week you will develop a complete concept that you will share for competitive analysis next week. There are due dates throughout the week and must be finished by next Monday. The **perspective discussion forum** is where you share potential difficulties within perspective groups. It will be necessary to complete the first part of the assignment.

## Week 3 Forum: analysis project week 3 assignment

**Due:** Monday, February 14, 2022, 11:00 AM

1. Identify at least one source of tension/conflict/problem that exists between your perspective and another. Share it in the **perspective discussion forum**. Give at least one other feedback on their post. **[DUE Tuesday, 2-8-22 by midnight]** An example for the assembly perspective is that reducing the number of parts by eliminating fasteners is good from an assembly perspective, but increases costs of molds for injection molding. (Assembly should post a different example.)
2. Create a conceptual design. You can use any method(s) you want to represent the design, but the goal is to show it to another group next week, so they need to understand your design features. Make as many **design posts** as needed so that your team creates a single concept. Make posts with your iterations and discussion of the design. If you haven't updated to SW2021, now would be a good time. **[DUE Monday, 2-14-22 by 11:00 AM]**

7. Complete the **analysis project week 4 assignment**. This week you will evaluate a set of designs.

## Week 4 Forum: analysis project week 4 assignment

**Due:** Monday, February 21, 2022, 11:00 AM

1. Each team should post ONE reply to the **design post** below with the design that they want evaluated. **[DUE Tuesday, 2-15-22 by 11:59 PM]**
  1. The post should include: the group name (e.g. analysis\_group\_A), the requirements used to create the design, and the design.
2. **NOTE: I will look at the posts on Wednesday morning to make assignments for step 3. Please wait for my email before proceeding.**
3. Each team must now compare four designs: their own and three other group designs that are indicated in the table below **[DUE Monday, 2-21-22 by 11:00 AM]**
  1. Perform the comparison by completing the **design comparison report**.
  2. Post the **design comparison report** as a reply to the **evaluation post**.
  3. The text in your post should indicate what group you are.

**Groups To Compare: Find your group on the row header, every column marked with an 'x' is a group that you are assigned to evaluate. For example: group A is assigned to evaluate groups A, B, C, and D.**

	A	B	C	D	E	F	G	H
A	x	x	x	x				
B		x	x	x	x			
C			x	x	x	x		
D				x	x	x	x	
E					x	x	x	x
F	x					x	x	x
G	x	x					x	x
H	x	x	x					x

**\*\*Design Comparison Report Requirements:**

## Analysis Project Comparison Report

Instruction text is highlighted. Fill out the table and subsequent sections. See section text for specific instructions. Delete the instructions before you turn in the report and any example images.

Group:		Date:	
Engineer(s):			

1. The first step is to edit the data in the radar plot below. This will be how we visualize the comparison. Right click on the plot and select **Edit Data** then **Edit Data** again. An Excel

style table will appear in a pop-up with designs listed on the column headers and evaluation criteria listed on the row headers.

- a. First edit the column headers to be the set of designs that your team is evaluating.
  - b. It is currently setup for group A.
  - c. Leave the dummy column header and column data. I think it improves the formatting.
2. The comparison will be performed on a scale of -2, -1, 0, 1, and 2. This is a comparison in the style of a Pugh chart, not a rating. In other words, 2 is better than a 1, 0, -1, and -2, it doesn't mean an absolute value of 'excellent'.
- a. To complete the comparison, first choose a datum and set all of its values to 0. In the example, I chose design C.
  - b. Next compare all of the designs to the datum on each of the evaluation criteria. A rating of 0 means that it performs about as well as the datum design on that criterion, a positive rating means better (1) or much better (2) and a negative rating means worse (-1) or much worse (-2).
  - c. When you are done, if the datum that you chose was the best design or worst design, choose another datum and repeat the exercise.
3. Finally, for each evaluation criterion, cite rationale for why you rated the best design the best, and the worst design the worst.

## Evaluation Criteria

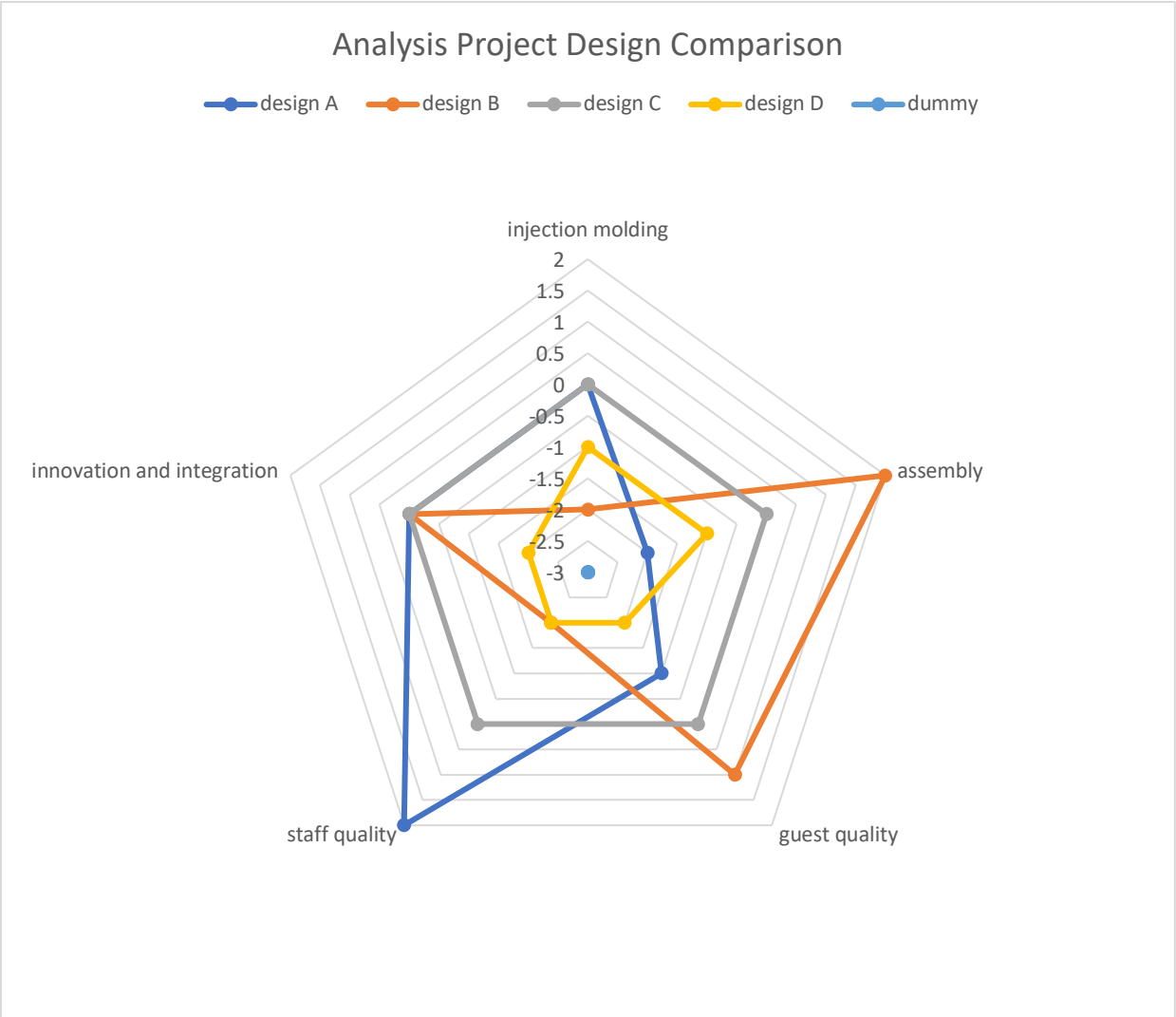
**Injection molding:** This criterion is a combined assessment of feasibility, design quality, cost, etc.

**Assembly:** This criterion is a combined assessment of feasibility, design quality, cost, etc.

**Guest quality:** This criterion captures the quality of the user experience from the perspective from the perspective of a Medieval Times visitor. Consider aesthetics, human factors, theme, use in ideal conditions, long terms use (wear), and use in adverse conditions (e.g. drink spills)

**Staff quality:** This criterion captures the quality of the user experience from the perspective from the workers at Medieval Times visitor. Consider human factors, stacking/storage (e.g. for charging), long terms use (including wear and washing), and use in adverse conditions (e.g. drink spills, wet tables, dirt floors)

**Innovation and integration:** This criterion captures the idea that sometimes a product is more than a sum of its parts. Use this criterion to consider a design's innovative feature or the integration of standard features into a desirable product.



### Rating Rationale

Injection molding

- Best design:**
- Rationale:**
- Worst design:**
- Rationale:**

Assembly

- Best design:**
- Rationale:**
- Worst design:**
- Rationale:**

Guest quality

**Best design:**

**Rationale:**

**Worst design:**

**Rationale:**

Staff quality

**Best design:**

**Rationale:**

**Worst design:**

**Rationale:**

Innovation and integration

**Best design:**

**Rationale:**

**Worst design:**

**Rationale:**