Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #49182

Work In Progress: Development of a Decision Matrix Modeled after Common Industry Practice to Help Students and Faculty Make Impactful Career Choices

Dr. Elizabeth Michelle Melvin, Clemson University

Elizabeth M. Melvin a Lecturer in the Chemical and Biomolecular Engineering Department at Clemson University. She earned her BS in chemical engineering from The Ohio State University in Columbus, OH in 2002 and her MS and

Prof. Adam T Melvin, Clemson University

Adam Melvin obtained a BS in Chemical Engineering and a BA in Chemistry from the University of Arizona, a MS in Chemical Engineering (with a minor in Biotechnology) and a Ph.D. in Chemical Engineering from North Carolina State University under the direct

Work In Progress: Development of a Decision Matrix Modeled after Common Industry Practice to Help Students and Faculty Make Impactful Career Choices

Abstract

The focus of this work in progress paper is to share a newly developed tool that utilizes a weighted decision matrix to assist individuals in making "big life decisions". When faced with complex, intricate decisions in industry, many project and safety management programs employ decision matrices or failure modes and error analysis (FMEA) to help teams come to a more comprehensive conclusion as to what direction they should take to make the highest impact based on quantitative analysis. These types of tools could also be helpful to an individual making an impactful life decision in that they allow a user to brainstorm all essential factors that are most important to them and ultimately derive final numerical scores to rank multiple potential opportunities (options). Opportunities include potential jobs, graduate or undergraduate schools. Examples of factors include job location, starting salary, compensation packages, professional responsibilities, scholarship opportunities, potential mentors, or career/livelihood needs for a partner. Decision considerations are grouped by type on separate tabs on an Excel spreadsheet. The user decides how important it is relative to other considerations inputting integers ranging from 10 (highest importance) to one (lowest importance, then grades each factor for each opportunity by entering an additional set of integers ranging from zero (does not have / meet expectation) to five (well above expectations). These values are weighted and summed to generate a score for each option. To date, this tool has been used to help (1) high school students decide where to attend college, (2) undergraduate students choose which job to take or which graduate school to attend, and (3) faculty candidates determine where to start or continue their careers. Future work entails further utilization of the tool in addition to the collection of data from users of the tool to evaluate its impact.

Introduction

A student shyly walks into their professor's office with a palpable air of excited, nervous energy. This student is the student who typically asks all the questions in class and office hours. They are wide-eyed as they tell the professor that they have good news and bad news. As the professor considers all the possible mental health and curriculum and academic issues, the excited student starts to formulate what the actual problem is. The good news: they have been awarded three offers to competitive companies for their first co-op or internship. The bad news: they have no idea which company to choose or even how to begin making that decision. And the truth is, this is not the last time this student will be faced with a potentially difficult, life-altering decision either. Most of the major milestones they will face in their professional career will be a series of intricate decisions that deeply impact their career, finances, relationships, colleagues, and personal life (Figure 1). Educators and mentors can give them the canned response of "Well, there is really no bad choice here" or "Experience is experience, just pick one." But would that really help the student feel more comfortable with their choice or help them formulate the skills to be able to make choices like this one later in life?

When faced with complex, intricate decisions in industry, many project and safety management programs employ decision matrices to help teams come to a comprehensive conclusion as to what direction they should take to make the highest impact. Quality functional deployment matrices, and weighted scale ratings done with a team of people can help teams determine the

"low hanging fruit" or the direction a project could take to get the highest impact in the shortest period (Pyzdek, 2003, Mazak, 2014). Collaborative decision making is a complex, strategic activity that involves team dynamics, team psychology, expertise, data, company culture, and historical events (Pzydek, 2003, Kouses, 2017). Having a clear process to rate and rank important decision nodes is critical to timely success and team member and stake holder buy-in (Booker, 1985). In safety audits or when evaluating safety issues in new processes or projects a Failure Modes and Effect Analysis (FMEA) (Pzydek, 2003, Carlson, 2012, Sharma, 2018) and matrix and statistical based risk analysis (Koulinas, 2021) are commonly used. These tools help direct safety teams to determine the highest impact / highest occurring safety issues to prioritize creating safeguards against those events. These tools are particularly attractive to engineering teams as they add a mathematical rigor to the consideration of multiple options available to the team (Pyzdek, 2003, Carlson, 2012).

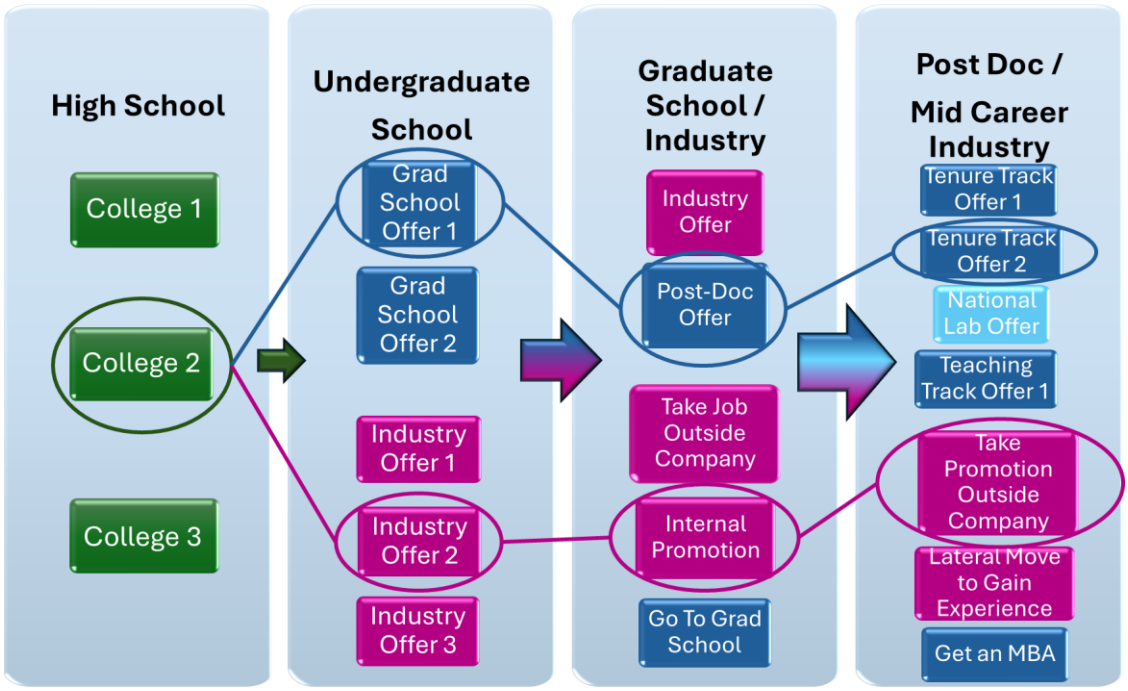


Figure 1: A progression of the increasingly complex set of decisions as individual proceeds through their professional training and career.

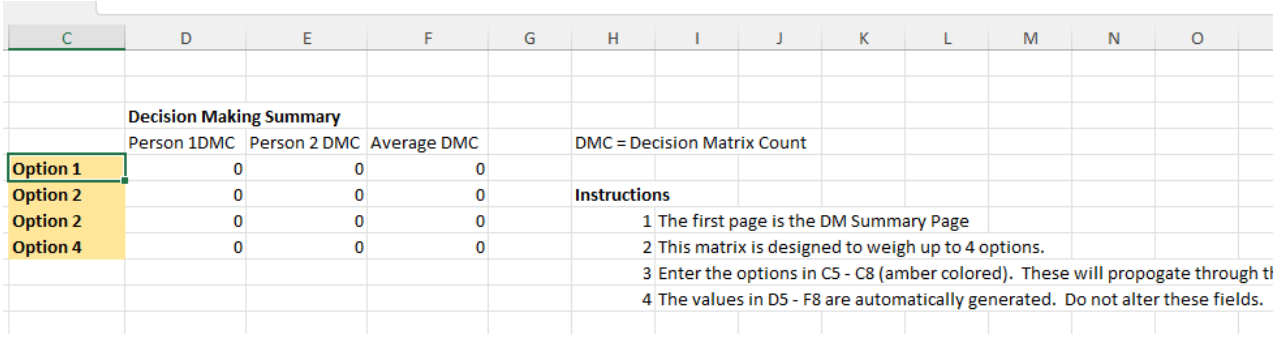
The scope of this work in progress is to deploy these industrial tools to develop a weighted decision matrix tool (WDMT) to help students at all levels (from high school through graduate school) and faculty at all levels (post docs, tenure track, non-tenure track, etc.) navigate complex, multifaceted decisions while contemplating multiple, competing offers. When an individual is faced with an important decision, it is common for them to want to consider all angles; however, short time frames, information overload, outside stressors, and the fear of the unknown can negatively impact a person's ability to analyze options properly leading to diminished decision outcomes (Phillips-Wren, 2020). When life decisions with a major impact are considered, the one making the decision can analyze the situation in circles and not comfortably reach a conclusion. A WDMT uses mathematical weighing of important decision nodes and can be organized in such

a way to ease the stress one feels when making an important decision. The calculated values that result from the weighted mathematical analysis can bring an analytical, numerical rigor that appeals to STEM career-minded individuals.

Methods and Tool Development

The primary goal in developing the WDMT was to put mathematical rigor to the complexity involved in making a major career / life decision. It was to extend beyond a simple pro/con list and add a weighting to these considerations to ultimately end with a numerical value for each option. The WDMT presented here combines the brainstorming and weighting principles developed for Quality Functional Deployment (QFD) matrix and FMEA (Pyzdek, 2003, Mazak, 2014, Carlson, 2012).

The WDMT was developed using Microsoft Excel for up to two simultaneous users. This is particularly useful if a parent wants input on their high school student's decision or if a partner wishes to weigh in on a late-career decision. The second user's inputs are summed alone, separately from Person 1 (Person 2 DMC, Figure 2) and aggregated with Person 1 (Average DMC, Figure 2). To get started, a user lists all their decision options (e.g., locations, colleges, company names) and all the decision considerations (e.g., details about the locations, benefits, salary, tuition, etc.) they would like to consider. The user first enters all their decision options on the WDMT Summary Page in the beige spaces (Figure 2). The default template of the tool was designed to consider four different decision options. The WDMT was also organized such that the user can sort their decision considerations on three separate tabs. For example, a user can put job-related decision considerations separate from location-related decision considerations. Common decision considerations categories include options like location, job specifics, college specifics. Decision consideration points will differ greatly depending on who uses the tool and for what purpose.as seen in Table 1.



	Decision Making Summary												
	Person 1DMC	Person 2 DMC	Average DMC		DMC = Decision Matrix Count								
Option 1	0	0	0										
Option 2	0	0	0		Instructions								
Option 2	0	0	0		1	The first page is the DM Summary Page							
Option 4	0	0	0		2	This matrix is designed to weigh up to 4 options.							
					3	Enter the options in C5 - C8 (amber colored). These will propogate through t							
					4	The values in D5 - F8 are automatically generated. Do not alter these fields.							

Figure 2: Summary page of the WDMT. On this page, the user enters up to 4 options (amber highlighted areas). These option names will automatically propagate to subsequent pages.

On the following Excel sheet tabs in the WDMT, the user would enter the name of each decision consideration in its own consideration section (Figure 3). For each tab, the WDMT has 25 available decision consideration spaces, with a total of 75 available decision consideration spaces available across three Excel sheet tabs. The authors have found that this is typically more than enough for most users so far. Blank spaces do not alter the results.

Table 1: Common Decision Options, Categories and Considerations for Various WDMT Users

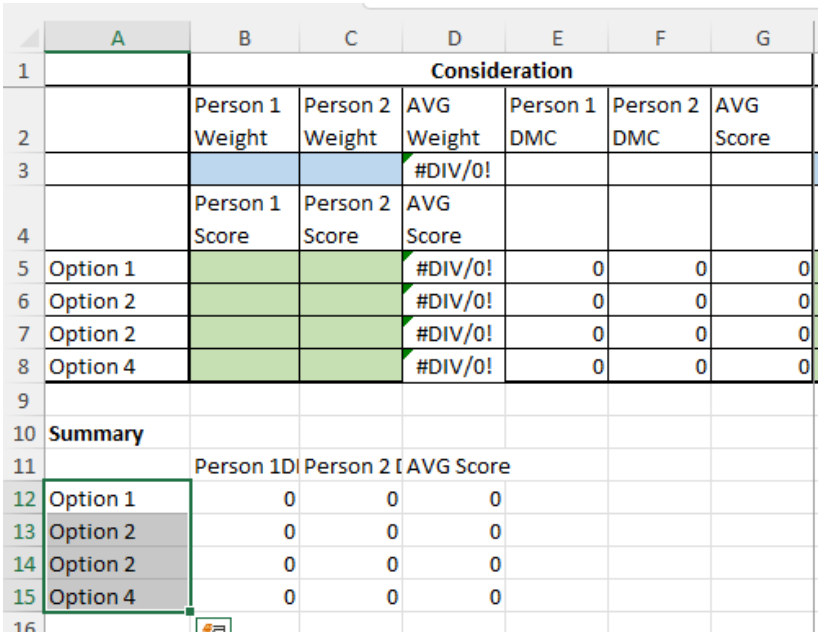
WDMT User Type	Decision Options	Decision Categories	Decision Considerations
High School Student	List of colleges to attend	Campus Amenities, Location, Scholarships / Costs	Academic Assistance programs, fraternities/sororities, dining halls, weather, proximity to family, tuition, room/board, scholarships available
Undergraduate Student	List of grad school / industry offers for after graduation	Location, Offer/Benefits, Position Details	Weather, proximity to family/partner, city vs. country, salary, retirement, fringe benefits, signing bonus, job title, job responsibility, technical application, ability to advance/grow
Graduate Student	List of post doc / industry / national lab offers for after graduation	Locations, Offer/Benefits, Position Details	Proximity to research / collaborators, proximity to research facilities, salary, research start-up packages, accessibility to graduate students, programs to facilitate grant writing, schools for kids, job opportunities for partners
Mid-career Job Change (Faculty / Industry)	List of offers for new position	Locations, Facilities, Offer/Benefits, Position Details, Family-Related	Lateral move vs. promotion, access to research facilities, quality of research facilities, resources / activities for kids, advancement opportunities for self, advancement opportunities for partner

The blue spaces are used for the weights of importance for each consideration. The weights range from 1 to 10 and the distribution of those weights are based on the QFD matrix method (Pyzdek, 2003) (Table 3). The green spaces hold the grade, score, or ranking as to how well the option listed meets the consideration (Table 4). For each consideration, the weights of the consideration are multiplied by the score of each option and is displayed for each user as a DMC (Decision Matrix Count). There is also a field that shows the average score for two users. The distribution of high numbers vs. low numbers with the weights allows for fewer options to rise to the top and should produce 1-2 clear option winners. Each tab has a summary section that automatically sums the scores for all decision considerations. As a user enters values into each consideration section, the sums appear on the summary section for each tab and on the overall summary section on the first tab (Figure 2-3).

Qualitative Evaluation on the Impact of the WDMT

To date, the WDMT has been used by high school students to help them decide which college to attend, by undergraduate students weighing graduate school and/or industry offers, graduate students weighing post doc and/or industry offers, a post doc considering multiple tenure track faculty offers and a mid-career couple looking into career change options. To date, no formal

data on the effectiveness of this tool has been collected, but several users have reflected positively about using the WDMT. Below are three stories of users (shared with the permission of the user).



	A	B	C	D	E	F	G
1		Consideration					
2		Person 1 Weight	Person 2 Weight	AVG Weight	Person 1 DMC	Person 2 DMC	AVG Score
3				#DIV/0!			
4		Person 1 Score	Person 2 Score	AVG Score			
5	Option 1			#DIV/0!	0	0	0
6	Option 2			#DIV/0!	0	0	0
7	Option 2			#DIV/0!	0	0	0
8	Option 4			#DIV/0!	0	0	0
9							
10	**Summary**						
11		Person 1D	Person 2 D	AVG Score			
12	Option 1	0	0	0			
13	Option 2	0	0	0			
14	Option 2	0	0	0			
15	Option 4	0	0	0			

Figure 3: Decision consideration example from the decision consideration tabs. The decision consideration would be typed at the top of the consideration section at "Consideration". Each person types their numerical weight for the consideration in the blue spaces. The grade of how each option rates for a particular decision consideration is entered into the green spaces.

Table 3: Consideration weights and the application limits for each weight (entered in the blue spaces in Figure 3).

Weight Number	Application Limits	Description
10	5 - 10% of the total number of decision considerations or 3 whichever is fewer	The top, most important considerations.
5	10 – 15% of the total number of decision considerations or 5 whichever is fewer	Top considerations, very important
4	20 – 25% of the total number of considerations or 10 whichever is fewer	Top Consideration, important
3	Unlimited	Neither Important nor Unimportant
2	Unlimited	Little Importance
1	Unlimited	Very Little Importance

Table 4: Scoring Range for each WDMT Option (entered in the green spaces in Figure 3)

Option Score	Description
5	Exceptional, 100% meets criteria
4	Extremely well, 90% meets criteria
3	Good / Average meets criteria
2	Somewhat meets criteria
1	Meets criteria very little
0	Does not meet criteria at all

The first user was a high school student who had experience in a university research lab over multiple semesters during their high school career. Although they had spent most of their free time on a college campus working directly with college students and faculty members, they were nervous about making the big decision on where they wanted to study. They were confident in their major choice but needed some help organizing their thoughts. They had gotten into six elite institutions for their major of choice (a STEM major) and had narrowed it to four choices after the campus visits. It was evident that the student kept going back and forth in their internal argument, weighing all the options. The parents of this high school student also had two schools in mind for their child but were reluctant to nudge them too hard one way or the other. The student was made aware of the WDMT by their advisor who showed the high school student and their parent how to use it. Later the parent noted that, despite their reluctance to share their thoughts, it did help to bring to light several important topics that warranted discussion between them and their child. The high school student asked, "What happens if you are disappointed in how the numbers come out?". The reply: "Then the tool has worked to help you focus on the answer you truly are looking to find." This student will be graduating from their chosen institution in two years.

The second user was a post doc who was mentored by a mid-career tenured faculty member through the AIChE Future Faculty Mentoring Program. This mentee was weighing three offers from lucrative institutions that would all benefit from their proposed research. In weighing the pros and cons of each institution, they were each so different that they all appeared to offer equitable experiences without a clear front-runner. In the process of having limited "most important" weighting scores, the mentee discovered that some of the considerations they were weighing were not quite as important as others. When the option scores were multiplied by the weights of the considerations, the faculty candidate more clearly saw which opportunity would serve their needs best for the next step in their career and felt more resolute in their final decision.

[Example 3 eliminated for blind review – the authors used the tool, which is why it was developed in the first place]

Conclusions and Future Work

Making big life choices is a complicated, stressful exercise. Tools like the WDMT can help reduce the stress associated with that decision by offering a mode to organize considerations and

mathematically calculate a score that might make one option as a clear "right" choice. Future work includes data collection to determine a user's:

- Reason for using the WDMT
- Perceptions on the difficult of making the decision
- Perceptions on the efficacy and ease of use of the WDMT
- Final choice and how and why they made that decision
- Satisfaction with their final decision
- Perception of if the WDMT helped them make that decision

Given the positive feedback from current users of the WDMT, we also intend to develop a decision-making workshop for faculty, faculty candidates and students to teach them how to use the WDMT and how they can advise their advisees to use it. This workshop could either be a webinar or a recorded video posted to the authors' research webpage.

References

T. Pyzdek, *The Six Sigma Handbook: A Complete Guide for Green Belts, Black Belts, and Managers at All Levels*. New York, NY: McGraw Hill, 2003.

J.M. Booker and M.C. Bryson, "Decision Analysis In Project Management: An Overview". *IEEE Trans. On Eng. Mgmt.*, Vol. EM-32. No. 1. pp. 3 – 9. Feb. 1985

G.K. Koulinas, O.E.Demesouka, K.A. Sidas and D.E. Koulouriotis, "A TOPSIS – Risk Matrix and Monte Carolo Expert System for Risk Assessment in Engineering Projects. *Sustainability*, 2021 Vol. 13, pp. 11277. https://doi.org/10.3390/su132011277

J.M. Kouzes, B.Z. Posner, *The Leadership Challenge: How To Make Extraordinary Things Happen in Organizations*. Sixth Edition. Hoboken, NJ. John Wiley and Sons, Inc., 2017

A. Mazak and B. Kratzwald, "The Weighted Decision Matrix: Tracking Design Decisions in Service Compositions", *2014 IEEE 7th Intl. Conf. on Service-Oriented Comp. and Appl.* November 17-19, 2014.

C.S. Carlson, *Effective FMEA's: Achieving Safe, Reliable, and Economical Products and Processes using Failure Mode and Effects Analysis*. Hoboken, NJ, John Wiley and Sons, Inc. 2012

K.D. Sharma and D. Srivastava, "Failure Mode and Effect Analysis (FMEA) Implementation: A Literature Review", *J. of Adv. Research in Aero. And Space Sci.* Vol. 5. Issue 1&2. pp. 1 – 17, 2018.

G. Phillips-Wren and M. Adya, "Decision making under stress: the role of information overload, time pressure, complexity and certainty". *J. of Decision Sys.* Vol. 29. Sup. 1. pp. 213 - 225