Faculty Development Plan

Department of Mechanical Engineering

Created: August 2024
Modified: February 2025

Teaching

Self-Assessment

Strengths, Skills, and Competencies

I have been teaching mechanical engineering courses for fourteen years. I have extensive experience teaching heat transfer courses at the undergraduate and graduate levels. I also have completed intensive course development workshops, where I have incorporated modern pedagogy into my courses. Student evaluations consistently rate me as a very effective instructor and find my teaching style engaging.

Areas for Improvement or Growth

I have limited experience teaching courses outside of heat transfer (I taught Manufacturing Processes, ME EN 382, in Winter '24). Incorporating gospel methodologies into my instruction is new to me and I'm still finding the best approaches. My instruction can be lecture heavy, with extensive use of derivations. I would like to increase student participation and add more diversity of instruction (e.g. videos, demonstrations, group work, etc). I could also do more to synthesis course content throughout the semester. Finally, my research and teaching interests could be more aligned. I plan to start teaching a graduate course in radiation heat transfer in Fall '25. I would also like to develop courses in optical diagnostics and electrochemical energy generation and storage.

Teaching Goals

Goals to Complete by Dec 31, 2024 (Heat Transfer, ME EN 340, Fall '24)

- Enhance student engagement by:
    - Adding in-class quizzes where students practice skills with real-time feedback to gauge student mastery
    - ~~Creating extra credit assignment for students to identify and share online videos with meaningful applications of heat transfer. Share video links with students and show selected videos in class.~~
    - Creating three in-class demonstrations using a thermal camera (camera provided by Dr. Webb).
    - Developing a semester project as a culminating and holistic experience for heat transfer, including two computational assignments to better prepare students to use computation in their projects.
    - Creating a 1% Acts of Service activity where students spend one hour serving someone in class and write a paragraph about their experience.

Other short-term plans (1-4 years)

Winter 2025

- Apply for a $500 course development grant to expand in-class demonstrations in ME EN ~~340~~382.
- Create extra credit video assignment for ME EN 382 (manufacturing processes).
- Have student teams bring their own parts to class and describe manufacturing process (supplemented by videos if available)

Fall 2025

- Teach new version of thermal radiation heat transfer that is project based and expands applications for broader appeal (e.g. laser cutting, climate, lidar, etc).

2026 - 2028

- Develop a graduate course in optical diagnostics. Work with interested faculty to build relevant content for our students.
- Develop a 400-level class on applications of batteries, thermal and battery management, integration with motors, control. Work with chemical and electrical engineering faculty to define scope that would be relevant for their students as well.

Long-term plans (5-8 years)

- Join (or develop) a study abroad program in renewable energy and storage.
- Explore collaborative electrification programs with local colleges and trade schools.

Relationship to Department Goals and Needs

The department's goal is to "help mechanical engineering students develop the skills and knowledge necessary to become truly influential engineers in their chosen areas of expertise". The department mission statement further states that our mission is to build a "community of faith focused on superb training and scholarship in the principles and practice of mechanical engineering" and our "big inspired goal" is to "be recognized as the best undergraduate mechanical engineering program in the world and the alma mater for the world's most influential engineers". In addition to these goals, the department also has specific course delivery needs that are increasing with faculty retirements and the transition from a limited enrollment program to an open enrollment program.

My teaching goals support department goals and needs in the following ways:

- Strengthening inspiring learning opportunities through in-class student engagement
- Expanding graduate-level course content to increase elective offerings for our undergraduate program and build our graduate program.

Required Resources

- Opportunity to teach ME EN 340 and ME EN 382 for multiple semesters
- Funds for demonstrations in ME EN ~~340~~382
- TA support
- Time and support to develop new courses
- Travel funds to develop study abroad course
- Department/college resources to build collaboration in electrification (automotive, aviation, marine,…)

Progress to Date

- Taught ME EN 340 and ME EN 382 in Fall ‘23 and Winter ‘24.
- Developed in-class quizzes for ME EN 340 and one demonstration with an IR camera

Scholarship

Self-Assessment

Areas of Interest

My research applies optical spectroscopy to energy technologies, enabling novel measurements of key reactions and transport that are fundamental to device/process improvement.

Strengths, Skills, and Competencies

I have nearly twenty years of experience in optical diagnostic development in a range of energy technologies. My scholarly works applying optical diagnostics to study battery electrolytes has been well received, with many citations and several groups adopting my methods. The interdisciplinary nature of my work has built healthy collaborations with ~~notational~~ natational laboratories and academic researchers in other disciplines.

Areas for Improvement or Growth

Having moved from a primarily combustion-centric research community to one more centered around electrochemistry, I am still in the early stages of building a network of researchers in spectro-electrochemistry (i.e. integration of optical diagnostics and electrochemical measurements). My previous institution had many faculty across several disciplines working in electrochemistry. BYU has fewer faculty in this area, mostly outside of mechanical engineering, with a greater focus on nuclear research. Mechanical engineering students are also not as familiar with electrochemical energy technologies (batteries, fuel cells, recycling, solar-thermal, nuclear, and electrolysis), making recruiting top ME students more challenging. The growing importance of electrochemical systems in mobility (cars, motorcycles, bicycles, drones, and small aircraft) and electrical generation (solar-thermal, battery storage, nuclear), also presents an opportunity to expand our mechanical engineering curriculum to better prepare students to work in these fields.

Scholarship Goals

Goals to Complete by Dec 31, 2024

- Publish two papers
- Have my research presented at two conferences
- Recruit and train undergraduate and graduate students in the following areas:
    - Glovebox operation, including electrolyte preparation and handling
    - Optical spectroscopy, including a new infrared imaging system
    - Optical cell design and fabrication
    - Spectro-electrochemistry, including measuring voltages and currents
    - Data analysis, including machine learning and chemometrics
- Establish a research lab with battery fabrication and testing capabilities, including a suite of optical spectroscopic tools and capabilities

- Leverage existing relationships at national labs and in Colorado to secure battery research funding (DOE and NSF)

Other Short-term plans (1-4 years)

- Identify diagnostic and chemometric methods to better understand solvation behavior
- Establish collaborations with BYU faculty in mechanical and chemical engineering, in electrochemistry with applications in batteries, nuclear energy, and recycling
- Lead proposals in the following areas:
    - Electrolytes for extreme environments (DOD)
    - Electrolyte characterization: Integration of diverse diagnostics with machine learning (NSF)
    - Spectro-electrochemistry for molten salt systems (NEUP)
- Publish three papers each year with BYU students
- Establish ties at INL in nuclear and batteries
- Establish a national reputation in spectro-electrochemistry through publications and presentations at national conferences

Long-term plans (5-8 years)

- Establish funding to maintain a group of 8-10 students (4-5 grad, 4-5 UG) $300k-$400k/year
- Publish five papers each year with BYU students
- Establish an international reputation in spectro-electrochemistry through publications and presentations at national and international conferences

Relationship to Department Goals and Needs

The department's goal is to "help mechanical engineering students develop the skills and knowledge necessary to become truly influential engineers in their chosen areas of expertise". The department mission statement further states that our mission is to build a "community of faith focused on superb training and scholarship in the principles and practice of mechanical engineering" and our "big inspired goal" is to "be recognized as the best undergraduate mechanical engineering program in the world and the alma mater for the world's most influential engineers". My scholarship goals are focused on recruiting, supporting, and mentoring undergraduate and graduate research assistants, providing inspiring learning experiences, and showcasing their accomplishments through publications and presentations on an international stage.

Required Resources

- Lab space with functional exhaust system free of water leaks, including in compressed air system
- Gloveboxes and fume hood for materials preparation
- Spectrometers
- Access to CAD software and Prototyping Lab for design and fabrication of optical cells
- Graduate student researchers

Progress to Date

- Moved into Clyde 160 lab space in October 2023.

- Acquired and transported spectrometers, optical tables, optics, and other hardware from old lab to BYU in November, 2023
- Acquired, installed, and trained on new imaging infrared microscope in
- Acquired and installed one glovebox
- Hired seven undergraduate researchers and one graduate researcher
    - Two UGs (Fall 2023)
    - Three UGs (Winter 2024)
    - Three UGs, One grad (Summer 2024)
- Secured two external research grants (NSF: 4/2024, DOE: 8/2024)

Citizenship

Self-Assessment

Strengths, Skills, and Competencies

I have served on university-level committees and in departmental leadership roles, where I have gained a solid understanding of academic governance and developed leadership skills. My external service experiences include being a conference board member, organizing committee member, serving as session chair, and technical reviewer for numerous publications and funding organizations.

Areas for Improvement or Growth

I am new to BYU and could strengthen my ties/visibility with faculty across campus. I do not currently have a formal role in any external organization and my network within the electrochemical community could be strengthened. I also have not identified a community focused on optical diagnostic development.

Citizenship Goals

Goals to Complete by Dec 31, 2024

Internal service

- Build ties with faculty at BYU who have synergistic research interests (batteries, electrochemistry, characterization of electrolytes, solvents and molten salts)
- Make a contribution to the graduate committee
    - leverage my role as graduate seminar organizer to invite an external speaker with synergistic research interests.
    - Expand graduate recruiting efforts to include international students (online information sessions, recruit at BYU-Hawaii)

External service

- Volunteer to serve on conference organizing committee (ECS)

Other Short-term plans (1-4 years)

- Editorial board member (journals?)
- Or secure a position within the battery group within ECS (ECS journal?)
- Chair a conference session (on optical diagnostics in batteries)

Long-term plans (5-8 years)

- Serve as journal editor
- Organize a conference

- Letter writers: identify optical diagnostics people

Relationship to Department Goals and Needs

The department's goal is to "help mechanical engineering students develop the skills and knowledge necessary to become truly influential engineers in their chosen areas of expertise". The department mission statement further states that our mission is to build a "community of faith focused on superb training and scholarship in the principles and practice of mechanical engineering" and our "big inspired goal" is to "be recognized as the best undergraduate mechanical engineering program in the world and the alma mater for the world's most influential engineers". My service goals are focused on expanding our graduate recruiting efforts, strengthening our ties to industry, academic, and national laboratories, and expanding my participation in professional societies to promote the accomplishments or our students and better connect our graduates with career opportunities.

Required Resources

- Travel funds for first three years
- Staying on the graduate committee for multiple years
- Mentoring by senior faculty on how best to expand my external service

Progress to Date

- I have volunteered to help organize a conference session for ECS in 2025
- I've attended one ECS conference in Winter 2024 and have one presentation at an upcoming international conference in Fall 2024.
- Jacquie Carter and I held two online information sessions for potential graduate students
- I attended one recruiting event at UVU in Fall 2024.
- I've arranged a recruiting trip to BYU-Hawaii in Fall 2024 (coincides with conference travel).

Course Development Project Proposal

Teaching Goals

I would like to increase student participation and add more diversity of instruction (e.g. videos, demonstrations, group work, etc). I could also do more to synthesis course content throughout the semester.

Goals to Complete by Dec 31, 2024 (Heat Transfer, ME EN 340, Fall '24)

- Enhance student engagement by:
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Goal	Progress to date
Add in-class quizzes where students practice skills with real-time feedback to gauge student mastery	Quizzes created in Fall 2023, added to Ypoll, and integrated with Learning Suite.
Create extra credit assignment for students to identify and share online videos with meaningful applications of heat transfer. Share video links with students and show selected videos in class.	I have decided to drop this idea. I will focus my efforts on more in-class examples that closely align with assigned homework.
Create three in-class demonstrations using a thermal camera (camera provided by Dr. Webb).	Created one in Fall 2023. Created one if Fall 2024.
Develop a semester project as a culminating and holistic experience for heat transfer, including two computational assignments to better prepare students to use computation in their projects.	Created project in Fall 2023. ~~Still need to add the two computational assignments.~~Created one computation assignment with three separate sub-assignments spread throughout the semester.
Create a 1% Acts of Service activity where students spend one hour serving someone in class and write a paragraph about their experience.	Created and used in Fall 2023~~. Plan to use again in~~ and Fall 2024.

Scholarship Development Project Proposal

Areas of Interest

My research applies optical spectroscopy to energy technologies, enabling novel measurements of key reactions and transport that are fundamental to device/process improvement.

Topics, methods, and applications

My research team at BYU will focus on applying optical spectroscopy to study liquid electrolyte performance, including ion transport in:

- lithium-ion batteries at high C-rates
- next-generation battery chemistries
- batteries operated at high and low temperature
- solvent-based metal extraction and deposition

We will utilize absorption spectroscopy in the ultraviolet through infrared ranges using laboratory spectrometers, microscopes, and custom optical cells. Our team will also develop battery fabrication and testing expertise so we can develop battery technologies in-house. We will also develop data analysis tools for data interpretation and processing.

Scholarship Goals (by Dec 31, 2024)

Goal	Progress to date
Publish two papers	1 published, 1 submitted, 1 rejected
Present research at two conferences	~~1~~ 2 complete~~, 1 planned~~d
Recruit and train undergraduate and graduate students in laboratory skills	1 grad, 8 undergrad
Establish a research lab with battery fabrication and testing capabilities, including a suite of optical spectroscopic tools and capabilities	Equipment is purchased and installed. Lab renovation completed.
Leverage existing relationships at national labs and in Colorado to secure battery research funding (DOE and NSF)	1 NSF and 1 DOE grant awarded.

Citizenship Development Project Proposal

Areas for Improvement or Growth

I am new to BYU and could strengthen my ties/visibility with faculty across campus. I do not currently have a formal role in any external organization and my network within the electrochemical community could be strengthened. I also have not identified a community focused on optical diagnostic development.

Citizenship Goals

Goals to Complete by Dec 31, 2024

Goal	Progress to date
Build ties with faculty at BYU who have synergistic research interests (batteries, electrochemistry, characterization of electrolytes, solvents and molten salts)	I've met with three ChemE faculty, one Chemistry faculty, and one Geology faculty.
Leverage my role as graduate seminar organizer to invite an external speaker with synergistic research interests.	Initiated department discussions that have identified three external speakers (so far) with research alignment with several faculty. Three

	external speakers are presenting in Winter 2025.
Expand graduate recruiting efforts to include international students (online information sessions, recruit at BYU-Hawaii)	Conducted two online info sessions. ~~Scheduled a visit~~Visited ~~to~~ BYU-H in Oct. 2024.
Volunteer to serve on conference organizing committee (ECS)	Volunteered and assigned as co-organizer of a battery ~~session~~ symposium at ECS in May 2025. Completed abstract review and session schedule. Assigned as chair or co-chair for three sessions.
Create a list of potential collaborators whose work is aligned or synergistic with my own. Identify ways to begin building relationships and reach out to one or more.	Started on list.

Course Development Project Report

February 2025

Teaching Goals

Goals to Complete by Dec 31, 2024 (Heat Transfer, ME EN 340, Fall '24)

- Enhance student engagement by:
  - Adding in-class quizzes where students practice skills with real-time feedback to gauge student mastery
    - Implemented this in Fall 2024. Student feedback was generally positive. Students recommended I more closely align in-class content, including quizzes, with assigned homework. I will do more to review assigned student homework beforehand and integrate portions of the homework or similar problem in class.
  - Creating three in-class demonstrations using a thermal camera (camera provided by Dr. Webb).
    - I used two in-class thermal camera demonstrations in Fall 2024. This will be expanded to two more in future offerings.
  - Developing a semester project as a culminating and holistic experience for heat transfer, including two computational assignments to better prepare students to use computation in their projects.
    - Implemented in Fall 2024. Overall, it was a success. Students worked in teams of two. Having intermediate progress assignments spread out during the semester helps students complete the assignment at a high level. Many students were unprepared for the computational assignment, some found it too difficult, and some expressed interest in choosing their own project. I will likely reduce the computational difficulty in future offerings and add more lecture content on computational heat transfer to better prepare students to succeed.
  - Creating a 1% Acts of Service activity where students spend one hour serving someone in class and write a paragraph about their experience.
    - I have implemented this in two offerings of ME EN 340 (heat transfer) with positive responses. I made this an extra credit assignment. Student participation was 100% and their reports of service were inspiring. I plan to continue doing this.

Other short-term plans (1-4 years)

Winter 2025

- Apply for a $500 course development grant to expand in-class demonstrations in ME EN 340.
  - This has been changed to support ME EN 382 (manufacturing processes) instead. I have submitted a proposal to purchase more hands-on examples of parts made

with different manufacturing processes, with an emphasis on design choices in these parts and better integration of hands-on examples with lecture content.

- Create extra credit video assignment for ME EN 382 (manufacturing processes).
- Have student teams bring their own parts to class and describe manufacturing process (supplemented by videos if available)
    - These two ideas have been combined into one online discussion assignment started in Winter 2025. Each week, teams submit a video or image of a part made using the manufacturing process taught that week. Students either take a picture of a part they identify or post a video of a part or manufacturing process. I highlight selected posts each week that I cover when I review the prior week's topic. I will be evaluating how students are enjoying this assignment in a mid-semester survey.

Fall 2025

- Teach new version of thermal radiation heat transfer that is project based and expands applications for broader appeal (e.g. laser cutting, climate, lidar, etc).
    - I am now assigned this course and will be doing course design in spring/summer 2025.

Scholarship Development Goals Final Report

February 2025

Scholarship Goals

Goals to Complete by Dec 31, 2024

- Publish two papers
  - I submitted two papers in 2024. One was rejected and I will work on a revised version in Spring/Summer 2025. The other is under review.
- Have my research presented at two conferences
  - My research was presented at two Electrochemical Society meetings in May and October of 2024.
- Recruit and train undergraduate and graduate students in the following areas:
  - Glovebox operation, including electrolyte preparation and handling
  - Optical spectroscopy, including a new infrared imaging system
  - Optical cell design and fabrication
  - Spectro-electrochemistry, including measuring voltages and currents
  - Data analysis, including machine learning and chemometrics
  - I have trained ten undergraduate and one graduate student. I plan to hire one more graduate student in 2025.
- Establish a research lab with battery fabrication and testing capabilities, including a suite of optical spectroscopic tools and capabilities
  - All lab renovations are complete and all hardware and key capabilities are in place.
- Leverage existing relationships at national labs and in Colorado to secure battery research funding (DOE and NSF)
  - I have one awarded grant with the National Renewable Energy Laboratory as a co-investigator. I have submitted a proposal to the Department of Defense. I plan to submit an NSF proposal in Spring/Summer 2025.

Other Short-term plans (1-4 years)

- Identify diagnostic and chemometric methods to better understand solvation behavior
  - I have a directed study course with my graduate student to study this topic in Winter 2025.
- Establish collaborations with BYU faculty in mechanical and chemical engineering, in electrochemistry with applications in batteries, nuclear energy, and recycling
  - No collaborations yet, but several discussions. Next step: apply for a BYU seed or interdisciplinary grant.
- Lead proposals in the following areas:
  - Electrolytes for extreme environments (DOD) (Submitted in November 2024)

    - Electrolyte characterization: Integration of diverse diagnostics with machine learning (NSF) (Planned for Spring 2025)
    - Spectro-electrochemistry for molten salt systems (NEUP) (Plan to research this topic this summer)
- Publish three papers each year with BYU students (Three articles in preparation)
    - 1. A new diagnostic technique for measuring ion transport in battery electrolytes.
      2. An optical diagnostic for monitoring battery recycling processes that measures dissolved battery materials in deep eutectic solvents.
      3. A method of quantifying polysulfide distributions in LiS battery electrolytes.
- Establish ties at INL in nuclear and batteries
    - I've met with one INL staff member on battery electrolyte modeling. He provided data that we plan to use in a collaboration with NREL this year.
- Establish a national reputation in spectro-electrochemistry through publications and presentations at national conferences
    - See above.

Citizenship Development Goals Final Report

February 2025

Citizenship Goals

Goals to Complete by Dec 31, 2024

Internal service

- Build ties with faculty at BYU who have synergistic research interests (batteries, electrochemistry, characterization of electrolytes, solvents and molten salts)
    - I have attended group meetings and written one proposal with a ChemE faculty member. I have also written a white paper with another ChemE faculty member. I plan to develop a collaboration plan for at least one ChemE group for a planned submission for a BYU seed or interdisciplinary grant.
- Make a contribution to the graduate committee
    - leverage my role as graduate seminar organizer to invite an external speaker with synergistic research interests.
        - I am trying a new method for invited speaker invitations this year. I asked faculty in each research topical area to meet and identify external faculty that they would like to build great collaborations with. This resulted in five invited speakers in 2024/2025. I'm also improving our advertising for these speakers and getting fliers made earlier, so there is more time for faculty to arrange schedules to participate.
    - Expand graduate recruiting efforts to include international students (online information sessions, recruit at BYU-Hawaii)
        - I presented at BYU-H in Fall 2024. This was a moderate success, but the size of their program probably doesn't warrant regular recruiting efforts unless faculty are visiting Hawaii for other reasons (I was already there for a conference, so it made sense to add the visit).

External service

- Volunteer to serve on conference organizing committee (ECS)
    - I helped organize a symposium on battery research at an international conference to be held in May 2025. I learned a lot about how symposia are organized and met some people in the conference organization and other researchers in the field. The symposium is related to my research, but not directly aligned. I'll try to get assigned to a more closely related symposium in a future conference.

Other Short-term plans (1-4 years)

- Editorial board member (journals?)
- Or secure a position within the battery group within ECS (ECS journal?)

    - I'll volunteer to help with another symposium and continue to build relationships.
- Chair a conference session (on optical diagnostics in batteries)
    - This should be a session or track within a larger symposium on battery characterization.

Course Development Grant Proposal: Integrating Hands-On Manufacturing Examples into Process Design Education

Instructor:
Course: ME EN 382 Manufacturing Processes

Manufacturing processes (ME EN 382) is a sophomore-level mechanical engineering course focused on two skills:

1. Selecting an appropriate manufacturing process for a given part.
2. Modifying the design of a part for a chosen manufacturing process.

These skills are taught in two ways:

1. Class-based instruction: Using a flipped structure, students watch videos on selected manufacturing processes before each class period. Students then practice the two skills listed above by selecting manufacturing processes and designing parts for a given manufacturing process.
2. Lab-based instruction: Students attend labs where lab assistants demonstrate manufacturing processes, including machining, casting, 3D printing, etc. Students also

Students are organized into teams of three to four and most in-class and lab-based activity is accomplished with their team.

I am teaching this course for the second time this semester. Student feedback indicates that student would like more examples of design for manufacturing. One way we do this is through in-class examples (Fig 1). We have a box of example parts made with different processes that we pass around during class. However, not all manufacturing processes have example parts, the parts are not identified or catalogued in any way, and there is no integration of the example parts with lecture slides.

Example of an incomplete casting of horseshoes. This is caused by a low-temperature pour.

This course development proposal will be used to do the following:

1. Procure more example parts for select manufacturing processes
2. Create an inventory of example parts with pictures and descriptions.
3. Integrate example parts with lecture materials (e.g. YouTube videos showing how parts are made or descriptions of design choices evident in each part.).

Funding will be used to procure parts ($200) and student labor to prepare inventory, descriptions, and supporting videos (20 hours at $15/hour = $300). If additional student time is needed, I will approach our department head for further funds (he has expressed a willingness to fund course development efforts).