Aligning Capstone Project Selection and Outcome Assessment

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Agenda

- OBE Alignment.
- Our Experience with Outcome Based Education Alignment
- Types of Capstone Project
- Capstone Project Objectives, and Outcomes
- Aligning Capstone Project with Engineering Program Outcomes
- Virtual Product Development (VPD) Process and Tools
- Modeling, Simulation, and VPD Tools in Engineering Program
- Selection and Assessment of the Capstone Projects
- Conclusions

Outcome Based Education Pillars (from Spady)

- **Paradigm**
  - OBE Paradigm shapes decision making and patterns of concrete action.
  - What and Whether students learn in more important than When and How they learn it.
- **Purposes**
  1. Ensuring that all students are equipped with the knowledge, competence and qualities needed to be successful after they exit the educational system.
  2. Structuring and operating programs so that those outcomes can be achieved and maximized for all students.
- **Premises**
  1. All students can learn and succeed, but not on the same day in the same way
  2. Successful learning promotes more successful learning
  3. Schools control the conditions that directly affect successful learning.
- **Principles**
  1. Clarity of focus on curriculum outcomes of significance.
  2. Expanded Opportunity and support for learning success
  3. High Expectations for all to succeed.
  4. Design Down for ultimate culminating outcome
- **Practices**
  1. Time
  2. Methods and Modalities
  3. Operational Principles
  4. Performance Standards
  5. Curriculum Access and Structuring.

OBE Alignment

- OBE alignment require employing **Design-Down** approach.
- Working from the ground zero to build up coherent and integrated program.
  - Starting from the national vision to identify the direction of the development
  - Identify the market needs and trends: soft skills, hard skills, etc
  - Define the role of the graduates as a set PEOs (keeping in mind that graduates are more interested in: employability, mobility, and versatility).
  - Define the knowledge, skills, and attitudes that graduates must attain at the end of his learning experience. (Program outcomes)
- Define the golden triangle: What to teach? How to teach? And How to assess?

OBE Alignment

1. OBE Alignment requires identification of the **"Outcomes"**.
2. Consequently, define the golden triangle:
   - What to teach?
   - How to teach?
   - How to assess?
3. Bloom's characteristics of the "Mastery Learning" (1968):
   - Criterion Defined Standards
   - Clear and Higher Expectations
   - Establish and teach prerequisites
   - Aligned formative assessment
   - Targeted assistance
   - Expanded opportunity

OBE Alignment - 2

- Definition of Outcome:
  - **It is a culminating demonstration of learning.**
- Outcome requires an **action**, to happen at/or after **the end** and need to **last** into **the future**.
- Action: is *tangible* and requires *competence*, driven by strong *action verb*, happens *on* time, associated with *performance context*, and matters *after* graduation.
- What based means?
  - Define by:
  - Focused on:
  - Designed around:
  - Organized around:

OBE Alignment – 3 (Spady)

The alignment imply matching the action verbs in the outcomes:

1. The learning experience must foster the outcome (the outcome ***words*** must be stated).
2. The instructor must teach those ***words***.
   - The curriculum must contain and continue to reinforce those ***words***.
3. The student must demonstrate those ***words***.
4. The assessment must directly embody measure those ***words***.
5. The transcript must document it.

Capstone Project Alignment

- Capstone Project could be considered as one of the forms of ***design experiences*** as defined by ABET:

"a **culminating** major engineering design experience that:

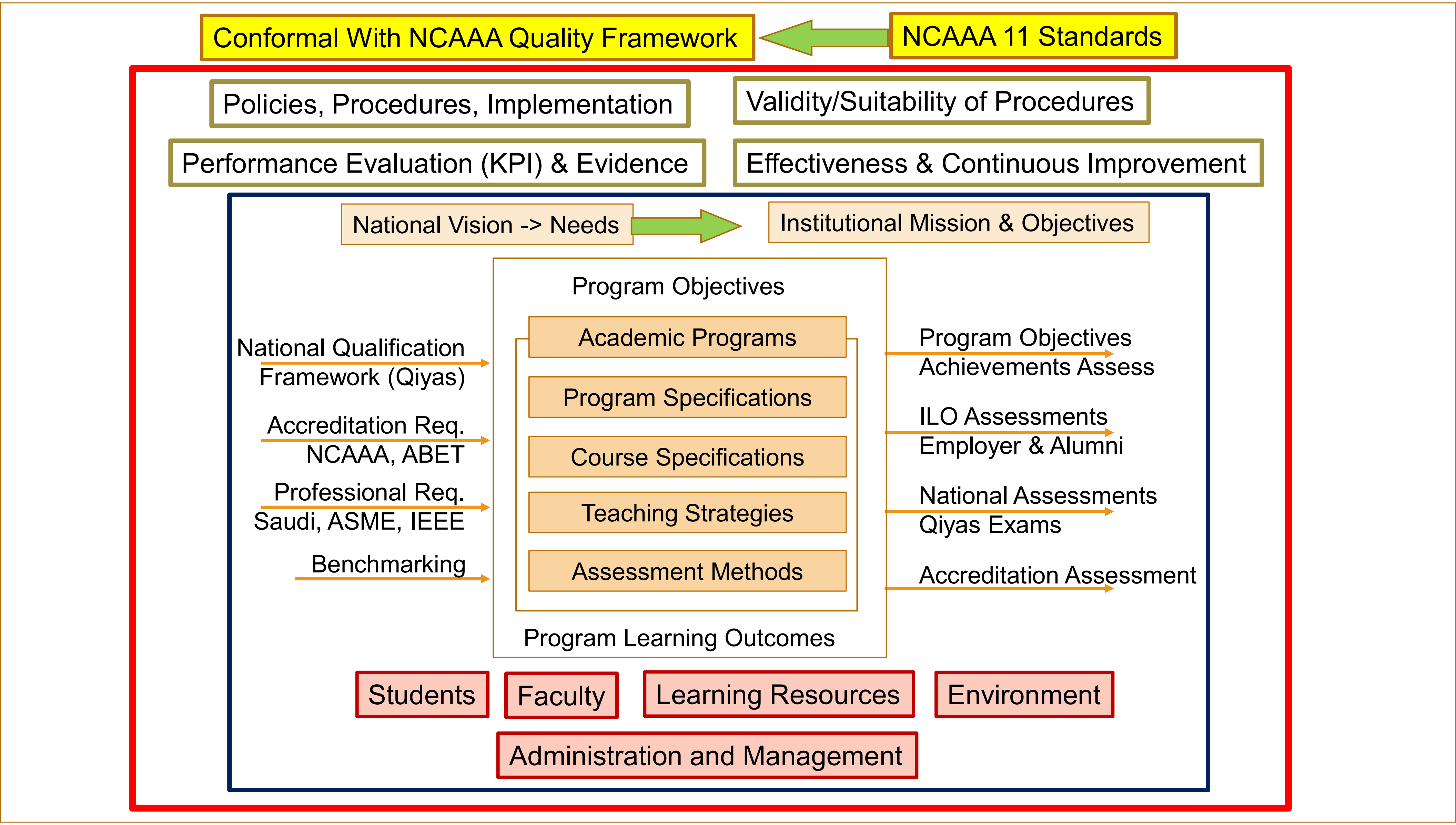
1) incorporates appropriate ***engineering standards*** and ***multiple constraints***,

2) is ***based on*** the knowledge and skills acquired in ***earlier*** course work. "

- This indicate that Capstone is built on accumulated knowledge fro earlier courses.
- Aligning the Capstone MADATES aligning all the courses in the program.

Our Experience with Outcome Based Education Alignment

- The National Center of Academic Assessment and Accreditation (NCAAA) defines the framework (Paradigm) for the academic programs.
- The institutions are responsible for design and implementing the academic programs.
- National Qualification Framework define the degree requirements
- National job qualification descriptions according to our target graduate
- Skills and competence requirements based on the employers, alumni feedback, and advisory board comments
- Professional bodies define professional requirements
- Accreditation bodies define accreditation requirements



Conformal With NCAAA Quality Framework
NCAAA 11 Standards
Policies, Procedures, Implementation
Validity/Suitability of Procedures
Performance Evaluation (KPI) & Evidence
Effectiveness & Continuous Improvement
National Vision -> Needs
Institutional Mission & Objectives
Program Objectives
Academic Programs
Program Specifications
Course Specifications
Teaching Strategies
Assessment Methods
Program Learning Outcomes
National Qualification Framework (Qiyas)
Accreditation Req. NCAAA, ABET
Professional Req. Saudi, ASME, IEEE
Benchmarking
Program Objectives Achievements Assess
ILO Assessments Employer & Alumni
National Assessments Qiyas Exams
Accreditation Assessment
Students
Faculty
Learning Resources
Environment
Administration and Management

Aligning Capstone Project with Engineering Program Outcomes

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Example: Mechanical Engineering PEOs

The mechanical engineering **program educational objectives** are to prepare graduates to:

1. Apply foundational knowledge, critical thinking, problem-solving, and creativity in mechanical engineering practice or in other areas to advance technology and foster innovation.
2. Advance their mechanical engineering profession and/or communities while maintaining the highest societal responsibilities and ethical standards in the global workplace.
3. Seek advancement in their knowledge and careers through continuing professional development and/or graduate studies, updating and adapting their core knowledge, and acquiring new knowledge and skills.

Student Outcomes

- ABET Outcomes were employed in addition to TWO additional outcomes.
- Based on the Country Vision, Virtual Product Development was identified as a new emerging area that will be highly demanding Engineering Graduates.
- The program considers its main characteristic is: **“Computer Modeling and Simulations”**.
- *The new curriculum emphasizes the use of computer applications and Computer Aided Engineering (CAE) tools.*”

		National Qualification Frame: Learning Domain
SLO	ABET	**Knowledge**
SLO 1	4	an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
		Cognitive Skills
SLO 2	1	an ability to identify, formulate, and solve complex mechanical engineering problems by applying principles of engineering, science, and mathematics
SLO 3	6	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
SLO 4	2	an ability to apply mechanical engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
		Interpersonal Skills and Responsibility
SLO 5	5	an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
SLO 6	7	an ability to acquire and apply new knowledge of mechanical engineering as needed, using appropriate learning strategies
		Communication Information Technology and Numerical Skills
SLO 7	3	an ability to communicate effectively with a range of audiences
SLO 8		An ability to carry out literature survey from various resources to extract conceptual information and apply that in the field of engineering.
SLO 9		An ability to use mathematical models to conduct simulations of mechanical engineering systems.

Alignment of Student Outcomes and Program Objectives

SO #	Student Outcome (SO)	ABET SO #	PEO 1: Apply foundational knowledge, critical thinking, problem-solving, and creativity in engineering practice or in other areas to advance technology and foster innovation.	PEO 2: Advance their profession and/or communities while maintaining the highest societal responsibilities and ethical standards in the global workplace.	PEO 3: Seek advancement in their knowledge and careers through continuing professional development and/or advanced studies, updating and adapting their core knowledge, and acquiring new knowledge and skills.
1	an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	4	X	X	
2	an ability to identify, formulate, and solve complex mechanical engineering problems by applying principles of engineering, science, and mathematics	1	X		X
3	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	6	X		
4	an ability to apply mechanical engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2	X		
5	an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	5		X	
6	an ability to acquire and apply new knowledge of mechanical engineering as needed, using appropriate learning strategies	7			X
7	an ability to communicate effectively with a range of audiences	3		X	
8	an ability to carry out literature survey from various resources to extract conceptual information and apply that in the field of engineering.			X	X
9	an ability to use mathematical models to conduct simulations of mechanical engineering systems.		X		

Capstone Project Objectives, and Outcomes

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Capstone Objective

- The Capstone course provides engineering students an opportunity to integrate engineering knowledge and implement it in a professional environment.
- The course is aiming to develop students with a clear understanding of the fundamental principles of the design process and procedures.
- Students work in a team format on selected mechanical engineering projects emphasizing both mechanical systems and thermal science design aspects.

Capstone Objective - 2

The following areas will be tackled by the course topics and student activities:

1. Formulating ill-conditioned design/engineering problem
2. Using a systematic approach for solving an open-ended *engineering* problem
3. Using engineering judgments and assessment
4. Experience economic factors in developing the solution
5. Experience working/managing teams effectively
6. Project planning and management
7. Communication articles: Creating written documents, Giving oral presentations to people with different technical backgrounds
8. Incorporating environmental, economic, and social constraints into the project solution
9. Integrate/Apply knowledge gained in *engineering* and CORE classes

Capstone **Course** Outcomes

Upon successful completion of this course, the students will be able to:

1. identify customer needs, potential problems, and potential for design improvement.
2. formulate a design problem statement with clear objectives as an open-ended engineering design problem
3. conduct market and literature survey.
4. synthesize a systematic approach to generate alternative designs
5. develop potential alternative design solutions for the identified problem
6. judge the proposed design based on: customer needs, ethical, environmental, and professional considerations.
7. prepare a list of specifications for the proposed solution
8. develop an engineering project plan for executing the proposed solution
9. apply the project management skills in budgeting, scheduling, and teamwork
10. integrate knowledge acquired from the various basic courses to develop an engineering design
11. communicate effectively the design problem, solution alternatives, and final design using oral and written means
12. evaluate teammates' performance based on a predefined team contract and assigned roles.

Virtual Product Development (VPD) Process and Tools

Virtual Product Development

- Virtual product development refers to the tools and procedures used in product development during the different phases.
- VPD enables companies to leverage the available resources by optimizing their product designs leading to improved performance, reduced physical prototypes, verifiable quality improvements, and minimized operational problems and failures.
- VPD procedures are implemented through all the product design phases starting from the concept realization and ideation, solution and alternative generation, performance evaluation, progressing towards the final design and analysis, ending with prototyping and launching.
- VPD encompasses tools for integrating the contribution from the individual team members, integrating different subsystems from the different disciplines, enables multi-disciplinary teams/simulation, and utilize the performance and simulation results as feedback to improve or approve product design.
- VPD tools reduce the cost of product evolution through the different product generation.

Virtual Product Development - 2

- At the core of the VPD process is the capability to:
    1. generate CAD models,
    2. use simulation software to represent physical environments and events in evaluating the operability of a product design,
    3. compare the simulation results to physical test results,
    4. optimize the product design to meet the client needs.
- Different products will definitely require different set of tools and may require alternating the sequence of implementation based on the component physics and product type.
- Some product may require FEA analysis, CFD, heat transfer, electronics and controls, etc.

Impeding Modeling, Simulation, and VPD Tools in Engineering Program

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The implementation of VPD has the following benefits

1. Acquaint the student engineers with the necessary fundamental concepts to join the job market. Specific VPD procedures and tools may vary from between companies based on the product line and the companies established policies and procedures.
2. Reduces the number of design iterations during the design phase.
3. Allow the students to perform more design analysis and conduct comprehensive design of experiments.
4. Provide a rich platform for collaboration between teams working on the subsystems and close collaboration between multidisciplinary teams.
5. Reduce the time and effort to finish the students assignments. Students can generate scripts to automate design/analysis scenarios.
6. Improve the students understanding of their design problem and allow them to perform more complicated analysis tasks.
7. Improve the communication between team members and with the client
8. Enhance the quality of students' presentation.

Computer Skills

- **Computer Science (Major programming experience):**
- The students are expected to be prepared to use computers from High school.
- The Mechanical Engineering students are required to study a comprehensive programming course, ME 201, which is based on MATLAB.
- In this course, students are introduced to programming methods, algorithms, data types and structures, data manipulation, file input/output (I/O), and Graphical User Interfaces (GUI).
- The students heavily utilize their programming background in the Numerical analysis course, ME 301, System Dynamics and Control courses, Capstone Design Project, problem-solving, simulations, and modeling in many courses.

Engineering Tools

- The program prepares the students with a variety of engineering tools and software packages.
- In Computer Aided Drawing (CAD), all the engineering students are required to study AutoCAD (GE 104) in their second year.
- Mechanical engineering students are required to study SolidWorks (ME 252).
- For the Computer-Aided Engineering (CAE) students study a selected set of software packages to support modeling, analysis, and simulations.
- Students are required to study MATLAB in ME 201 and use it in ME 301, ME 441, and ME 443.
- For machine motion and dynamics analysis students study MSC.ADAMS in ME 343. For measurement systems and data acquisitions, students learn LabVIEW in ME 344.
- For project scheduling and management, students are required to use MS Project or similar planning tools in the Capstone Design Project.
- Measurement hardware components including sensors and data acquisition systems are introduced in the ME344 course.
- The students are introduced to the different mechanical engineering codes and standards for component selection in ME 351, ME 352, ME 272, and ME 372.

Commercial VS Open Source

- Software training (mastering) vs Experimenting
- Commercial vs Open Source
  - Microsoft office → OpenOffice, LibreOffice, WPS Office, Google Drive, etc..
  - MATLAB → Octave, NumPy, Julia, Scilab, SageMath, etc..
  - SAS → PSPP, SOFA, JASP,
  - CFD → OpenFOAM , FEATFLOW,
  - COMSOL → KRATOS, FEATool Multiphysics,
  - FEA
- Marriage between industry and Academia

Types of Capstone Project

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Problem, Project and Design Projects

Learning Approaches: Problem Based Project

- In the problem based learning students are presented a situation, a case or problem as a starting point.
- The role of the coordinator is to supervise and facilitates the learning process rather than providing knowledge.
- In the problem scenarios students learn how to learn, encourage students to engage themselves in the learning process, and they become independent inquirers.
- Using problems or cases from real life in teaching is effective for motivating students and enhancing learning and development of skills.
- Students need to learn how to get the information when needed, as this is an essential skill for professional performance.

Learning Approaches: Project Problem Project

- In the project based approach, the students need to produce a viable design solution to solve an open-ended problem and they are required to produce an outcome in the form of a report guided by the facilitators.
- The learning process is directed by teaching and focuses on the application and assimilation of previously acquired knowledge.
- This approach prepares engineering students to 'practice engineering' by applying their knowledge to solve the design problems and provide a real outcome for evaluation.
- Also, this approach enhances the self- directed study become a student's responsibility.

Learning Approaches: Design Based Project

- In the design based learning approach is self-directed process in which students initiate learning by designing creative and innovative practical solutions which fulfill customer expectations.
- Design based learning is an effective vehicle for learning that is centered on a design problem solving structure.
- Integrating design and technology tools into science education provides students with dynamic learning opportunities to actively investigate and construct innovative design solutions.
- This approach prepares the students will essential skills as hands-on work, problem solving, collaborative teamwork, innovative creative designs, active learning, and engagement with real-world assignments.

Capstone Project Stages

- The capstone course coordinator plans the course timeline and manages all projects through the following stages over the two semesters:

1. Problem identification: client request
2. Problem formulation.
3. Solution proposal to the client pending for (Client/examining committee) approval
4. Exhaustive research for solution:
    1. Existing solution.
    2. Ideations.
    3. Design alternatives.
5. Alternative evaluation and solution selection.
6. Detailed analysis
7. Detailed design.
8. Prototyping:
    1. Standard components
    2. Market research
    3. Purchasing
9. Manufacturing/assembly
10. Testing and evaluation
11. Iterations.

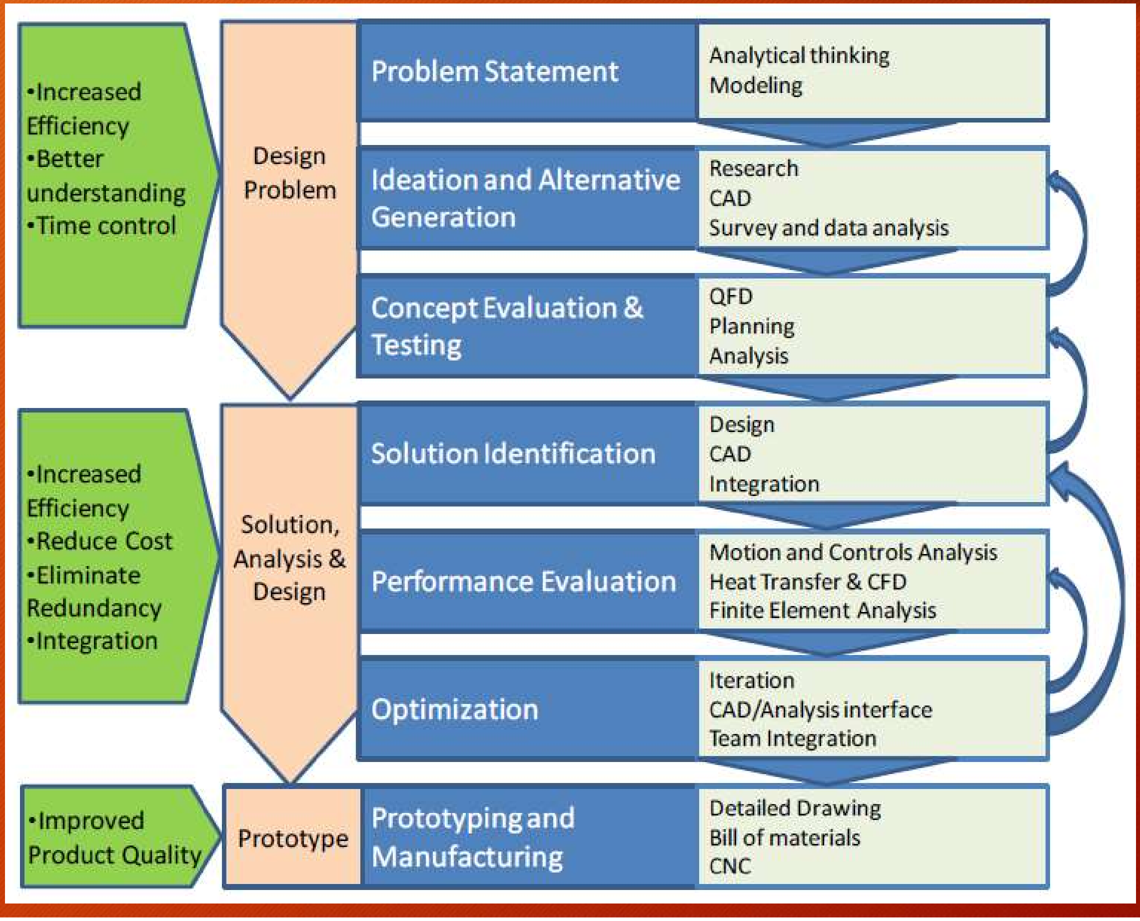
Course Implementation: Course Topics

- The first course of the capstone design (ME 491) consists of a weekly lecture and lab. The lectures are used to cover topics and skills that were not addressed in the regular courses. The topics covered are represented in the following list
- Introduction to class operation
- Projects/teams/advisors assignments.
- The design process
- The Problem formulation
- Proposal writing and iterations
- Engineering Ethics: ASME NSPE codes
- Literature search and data gathering
- Design ideation
- Project management (GANTT) and budgeting
- Design specifications (QFD)
- Written communications and public oral presentations
- Engineering Ethics: case studies
- Engineering design and safety
- Design analysis and synthesis
- Prototyping and testing (with safety)

Project Deliverables

- For the project completion the following items should be submitted:
- Proposal with the list of deliverables: must be approved by the client/examining committee.
- Product design specifications for the proposed solution.
- Prototype: the project team must develop a prototype for the proposed design solution.
- Webpage: the team may develop a webpage for the project progress and the final prototype.
- Written final report.

Phases of using VPD in the Capstone Project:



Selection and Assessment of the Capstone Projects

Capstone Design Project Types and Sources

- **Faculty Member Projects Proposal**
  - The capstone project is proposed by faculty members from the department.
- **Local Industry / Partner Projects**
  - The capstone projects are supported by gifts to the department.
  - Students have an opportunity to work on practical design projects and to interact with outside engineers.
- **Research Partner Projects**
  - Research or University funding to support design activities in research projects.
  - Students have an opportunity to work with leading researchers in the university to develop design solutions and prototypes to fulfill specific requirements in research projects.
- **Students proposed projects:**
  - This type of projects aims to develop a solution for:
    - Industrial problems that students can identify during their summer training
    - Community services: The Two Holy Mosques Services.
    - Innovations for consumer products: investors and entrepreneur.
  - The students submit a description of the problem to be evaluated.
- **Student Organizations and Design Competitions.**
  - Solar car competition.
  - SAE Baja competition… etc

Proposal Assessment

- Each proposal should be assessed before presenting it to the students.
- Proposal Template are available to ensure that all elements are included in the proposal.
- Proposal Assessment Template is used by the committee to ensure that all proposals meets the criteria of complex engineering design problem.
- Feedback could be provided to improve the proposal quality

Capstone Project Proposal and Assessment Rubric

Senior Capstone Design Project Advisor Proposal

Project Name		**Industrial Client**	
Interdisciplinary	☑ Y ☐ N	**Support Department**	
Major Track Name:	System Dynamics	**Major Track Name:**	
Minor Track/ Specialization	Design and Manufacturing	**Minor Track/ Specialization**	

Project Description/Problem Statement (This part only will be shared to the students)

Highlight major courses pre-requisites	**Highlight the extra non-plan courses** None
Highlight the design components •	**Highlight the analysis components** •
Expected tasks and deliverables 1.	**Proposed plan for major activities** **Semester 1:** **Semester 2:**

Check all the major characteristics that apply to the project:

☑ Open ended problem	☑ Wide range of technical issues	☑ Diverse groups of stakeholders	☐ Include many compon parts or subsystems
☐ Have no obvious solution	☑ Problem not encompassed in standards and codes	☐ Involve multiple disciplines	☐ Have significant conse in a range of contexts

Advisor Name:

Co-Advisor(s):		**Percentage:**	10%
Co-Advisor(s):		**Percentage:**	

Software Needed

Software Name	Availability	Estimated Price	Training needed	Ordering Date	Ordering Coordinato

Estimated Budget	2000
Budget Source	Self-funding
Date Budget Needed	

Senior Capstone Design Project

Proposal Assessment Form

(The total score can be used to rank the projects)

Year	Semester	Project Code	Project Name

	Criteria / Assessment	0	1	2	3	4	Suggestions for improvement
	Problem Characteristics						
1	Open ended problem						
2	Wide range of technical issues						
3	Diverse groups of stakeholders						
4	Include many components parts or subsystems						
5	Have no obvious solution						
6	Problem not encompassed in standards and codes						
7	Involve multiple disciplines						
8	Have significant consequences in a range of contexts						
9	From 1 to 8, at least one Characteristic got rating of 4	☐ Yes (Proceed)			☐ No (Reject)		
10	Based on previously studied courses	☐ Yes (Proceed)			☐ No (Reject)		
11	New learning content does NOT exceed 20 %	☐ Yes (Proceed)			☐ No (Reject)		
	Problem Description						
1	Clear and concise						
2	Executable within one year						
3	Should lead to a prototype						
4	Can be executed by undergraduate students						
5	Clear design components						
6	Clear deliverables and task						
7	Contains analysis						
8	Proposal within the scope of advisor's specialization	☐ Yes (Proceed)			☐ No (Reject)		
	Project Scope						
1	Within budget limits	☐ Yes (Proceed)			☐ No (Reject)		
2	Software and training available	☐ Yes (Proceed)			☐ No (Reject)		

Overall Assessment

	Suggestions
☐ Accept	
☐ Modify	
☐ Revise	
☐ Reject	

Evaluator Name	Date	Signature

Students Learning Assessment:

1. Requirement and planning: assessing the student ability to identify the customer needs, the problem formulation, project proposal, and project plan.

2. Conceptualization and assessment: the ability to identify the critical customer requirements, generating different feasible design alternative, quantify performance of different alternatives and define the product specifications.

3. Design and analysis: utilizing the VPD tools to perform comprehensive modeling and analysis, communicating design with other teams, and generating manufacturing ready detailed engineering drawing.

4. Prototype and delivery: assessing the ability to use standards and codes, identifying suppliers, purchasing, realizing a model through different prototyping techniques, and performing comprehensive model testing under different conditions.

- The performance assessment must include two parts: the team performance assessment and the individual contributions assessment.

Assessment Rubrics

- Student assessment in the report writing and presentations are done using rubrics.
- The assessment determine the level of achievement based on predefined performance criteria.
- All the templates and rubrics are distributed to students in the Capstone Project Student Handbook.
- The assessment criteria are explained to the students during the Course orientation seminar.
- Sample Rubric is shown below:

ME 492 Progress Report Rubrics (Spring 2021)

Project Title:

Advisor Name:

SO # 2: an ability to identify, formulate, and solve complex mechanical engineering problems by applying principles of engineering, science, and mathematics		
CLO #: Apply knowledge of mathematics, science and engineering		
1. Appropriate and correct use of mathematics and science 2. Successful use of engineering knowledge	Exceeds Expectation	☐10 ☐9 ☐8
1. Correct use of mathematics and science but lacked supported illustrations or 2. Demonstrated good understanding of engineering knowledge with some lack		
1. Results shown don't match mathematical and scientific analysis 2. Some hypotheses missing or misstated		
1. Essential mathematical and scientific analysis missing or incorrect. Tables/gr 2. No hypotheses or hypotheses not supported by data or any evidence		
SO #: an ability to apply mechanical engineering design to produce solutions th social, environmental, and economic factors		
Use appropriate design process, methodology to produce solution of an open-en		
1. Design solution well described with supported engineering drawings and ana 2. Well distinct and valid potential alternatives presented 3. Selection criteria and procedure well described 4. Impact of solution well defined.		
1. Design solution fairly described. Engineering drawings acceptable but lacke 2. Design alternatives described adequately 3. Design solution selected but selection criteria not well justified 4. Impact of solution barely convincing.		
1. Design solution lacks details. Supporting evidence and analysis require majo 2. Design alternatives not well distinct from proposed solution 3. Selection procedure ambiguous 4. Impact of solution barely mentioned/not well related		
1. Design solution very briefly described with no or unrelated analysis and sup 2. Design alternatives absent 3. No design selection 4. No impact or unrelated to design solution		
SO # : an ability to recognize ethical and professional responsibilities in enginee global, economic, environmental, and societal contexts		
Devise an engineering design that meet client requirements with positive impact		
Provided detailed design specifications including dimensions, environmental er		
Provided acceptable design specifications in response to client requirements tha		

Provided some design specifications that partly satisfied client requirements	Barely Meets Expectation	☐6 ☐5 ☐4
Has not provided any design specifications or specifications do not fulfill client needs	Fails to Meet Expectation	☐3 ☐2 ☐1
SO # : An ability to communicate effectively with a range of audiences		
develop verbal and written communication skills		
Writing is strong and easy to understand; ideas are fully elaborated and connected; effective transitions between sentences; no typographic, spelling, or grammatical errors.	Exceeds Expectation	☐10 ☐9 ☐8
Writing is clear and easy to understand; ideas are connected; effective transitions between sentences; minor typographic, spelling, or grammatical errors.	Meet Expectation	☐8 ☐7 ☐6
Most of the required criteria are met, but some lack of clarity, typographic, spelling, or grammatical errors are present.	Barely Meets Expectation	☐6 ☐5 ☐4
Very unclear, many errors.	Fails to Meet Expectation	☐3 ☐2 ☐1
SO # : an ability to acquire and apply new knowledge of mechanical engineering as needed, using appropriate learning strategies		
Acquire and apply new knowledge built on accumulated course learnings through the different capstone project activities including literature survey, devising a design solution to an open ended engineering problem, developing design specifications towards building a prototype		
1. Strong introduction of topic's key question. Specific problem statement. Strong background research that provided excellent support for the design solution. 2. Design analysis clearly related to main topic/problem. Strong organization and integration of new material for reinforcing the solution approach 3. Graphs, tables, abbreviations well illustrated and described 4. Insightful discussion of impact of the new finding on solution cogency	Exceeds Expectation	☐10 ☐9 ☐8
1. Conveys topic and key question(s). General problem statement 2. All new materials clearly related to main topic decently integrated and logically organized. 3. Sources well selected to support study with some background research in support of study. 4. Graphs, tables, abbreviations were described 5. Discusses impact of new finding on solution legitimacy	Meet Expectation	☐8 ☐7 ☐6
1. Conveys topic, but not key question(s). General problem statement. 2. Most new material clearly related to topic and decently integrated. New Material may not be organized. 3. Sources generally acceptable but not peer-reviewed and/or authentic. 4. Some Graphs, tables, abbreviations were not well illustrated and/or described 5. Shortly discussed impact of new findings on solution potential.	Barely Meets Expectation	☐6 ☐5 ☐4
1. Does not adequately convey topic. Lacks adequate problem statement. 2. Little new material mentioned. Illogically organized into topic 3. Few sources supporting study. Sources insignificant or unsubstantiated. 4. Graphs, tables were not well illustrated and hardly referenced in the text 5. Does not summarize evidence with respect to solution approach. Does not discuss the impact of new findings on topic.	Fails to Meet Expectation	☐3 ☐2 ☐1

Examiner Name: Signature: date:

Assessment Activities:

- **First Semester:**
- Project Proposal/ Proposal Presentation.
- Log-book and Portfolio (Monthly checked).
- Project Plans (GANTT).
- Development of Design Specifications & QFD.
- Progress Report-1 (Preliminary analysis and design).
- Presentation-1.
- Final Exam -1.

- **Second Semester:**
- Progress Report-2 (full analysis & detailed design).
- Presentation-2.
- Project log-book and Portfolio.
- Final Report.
- Final Presentation.
- Prototype Presentation/Completion of Design Project

Assessment

- Observing, measuring, recording, analyzing of students's performance against certain standard of expectation.
- A systematic process of measuring and collecting the data (marks/scores) in a manner that enable us to analyze the achievement of the intended learning outcomes and the effectiveness of learning activities.
- Effective assessment that gauge the student learning is guided by the following questions:
  - Why do we assess?
  - What do we want to assess?
  - How do we want to assess?

Conclusion

- Alignment in OBE requires fundamental changes.
- Outcomes need to be: specifically stated, taught by instructors, assessed, documented.
- Modeling, Simulation, and VPD are fundamental tools for new engineering graduates.
- Embedding VPD in engineering program need to be planned incrementally.