Engineering Design Notebook Scoring Rubric

Developed November 2018 – January 2019

By Kristen Clapper Bergsman, Center for Neurotechnology

This scoring rubric was developed by Kristen Clapper Bergsman to guide instructors in assessing students' completed work in the *Engineering Design Notebook*, an open-source educational resource developed by Lise Johnson and Kristen Clapper Bergsman and published by the Center for Neurotechnology (formerly, Center for Sensorimotor Neural Engineering). The *Engineering Design Notebook* is available here: http://www.csne-erc.org/content/undergraduate. The notebook was first published in 2017, with iterations being made based on instructor and student feedback and the results of a research study. This scoring rubric is accompanied by a spreadsheet that may be used for recording and calculating student grades on the notebook.

This scoring rubric was inspired by and informed by the work of other engineering education faculty, researchers, and educators. Please see the references list at the end of this document.

REPRESENTING THE DESIGN NOTEBOOK IN YOUR COURSE SYLLABUS

It is recommended that you assign specific notebook pages to students for each week of your course to ensure that they stay on track with their project work.

Assessment guidelines for the notebook were designed to support alignment to ABET criteria for engineering programs. These overall targeted performance criteria for students' use of the notebook during an engineering design course are provided below. These should be communicated to students and included in your course syllabus.

I use my engineering design notebook along with a supplemental blank notebook and digital submissions to….

- Demonstrate my ability to identify, formulate, and solve an engineering problem.
- Demonstrate my ability to design a system, component, process, or device to meet desired needs within realistic constraints
- Demonstrate project planning skills, including the ability to assess skills, develop a plan, delegate tasks, create a timeline with milestones, and identify fallback points.
- Apply my prior expertise in mathematics, science, engineering, and computer science to solving an authentic engineering problem.
- Document all phases of the engineering design process, including prototyping.
- Gain experience with the engineering design process, design thinking, and project planning through engaging in an authentic engineering design challenge.
- Increase my technical knowledge and skills by employing modern engineering techniques, skills, tools, and equipment.
- Engage in the epistemic practices of engineering and design thinking.
- Reflect on my design process, designed product, and teamwork to learn from this learning experience.
- Collaborate and communicate effectively as a member of a multidisciplinary engineering team.
- Develop practices of using an engineering design notebook to support and document my design processes and protect my team's intellectual property.
- Understand why and how an engineering design notebook is used by professional engineers.

Learning outcomes and performance criteria are provided in this document for each of the sections of the notebook. These Learning Outcomes and Performance Criteria Focus on:

- Engineering Design Process
- Project Management
- Design Thinking
- Teamwork and Collaboration
- Reflection
- Notebook Mechanics

ASSESSING THE DESIGN NOTEBOOK

You may use the detailed scoring rubrics provided in this document to guide you in assessing your students' notebooks. Customize the grading criteria to match your objectives for your specific course. The accompanying spreadsheet can be used for inputting points and calculating students' grades on their notebooks. Be sure to customize the spreadsheet as needed. You may choose to create a tab for each student within the spreadsheet.

A three point rubric is provided. For each Performance Criteria within each section of the notebook, you will assign points ranging from 0-3 as described below. The scoring rubric provides guidance for a score of 3 points/Exceeding Expectations.

0 = Blank. Page is blank, has been skipped/omitted.
1 = Developing. Student attempted the page(s) but at a level that is not meeting expectations as outlined in the scoring rubric.
2 = Meeting. Student work on the page(s) meets expectations as outlined in the scoring rubric.
3 = Exceeding. Student work on the page(s) exceeds expectations as outlined in the scoring rubric due to detail, depth, and/or complexity.

The accompanying spreadsheet will automatically total the points a student received for each section of the notebook. The total number of points possible is 99.

Exploring Section (21 possible points)

Targeted learning outcomes:

- I leveraged design thinking scaffolds to engage in ideation and problem definition.
- I consulted with experts to help inform my team's selection of a project.
- I used the scaffolds in the notebook to move through a principled process of brainstorming, problem exploration, generating possible solutions, evaluation, and project selection.

Performance Criteria	Focal Notebook Pages	Blank 0	Developing 1	Meeting 2	Exceeding 3	Feedback (Areas that Need Work; Evidence of Exceeding Standard)
Brainstorming Includes notes from the team's brainstorming around possible project ideas. Includes some kind of diagram (e.g., Venn diagram, concept map) that captures the team's discussion.	Problem Exploration: Brainstorming					
Generate Possible Solutions Description of 2-3 possible design problems. Each of the 2-3 problems is clearly defined with depth and detail. Problem statement includes an intended client, end-user, or market.	Problem Exploration: Evaluation Problem Exploration: Round Robin Prep					
Problem Exploration	Problem Exploration: Evaluation					

A decision tool or rubric is developed to rank possible solutions. The tool/rubric includes criteria and constraints.						
Expert Consultation The notebook captures a reflection of the expert consultation, with detailed responses to each prompt.	Round Robin Expert Consultation Notes					
Team Skills Assessment The notebook includes a comprehensive list of the skills represented by teach team member. A map or diagram (e.g. density plot or concept map) is provided as a visual representation of the team's strengths and weaknesses.	Team Skills Assessment					
Project Selection Each of the 2-3 possible project ideas are restated using expert feedback with an outline of major steps needed for success. The team's priorities for the project are outlined. The project that optimizes the priorities is chosen. Relevant criteria and constraints are identified.	Choose Your Project					

Planning Section (12 possible points)

Targeted learning outcomes:

- I crafted an initial Value Proposition to capture my emerging understanding of the design problem, its potential end-users/clients/market, and the proposed design solution.
- I assessed both the team and my own individual's skills to identify what expertise we possess and what skills and knowledge we will need to acquire to be successful with our project.
- I developed both a team and project plan to organize our tasks and milestones for the remainder of the course.

Performance Criteria	Focal Notebook Pages	Blank 0	Developing 1	Meeting 2	Exceeding 3	Feedback (Areas that Need Work; Evidence of Exceeding Standard)
Value Proposition A statement is written in paragraph form that articulates: o The benefits offered by the proposed project o How it will solve an authentic problem o What distinguishes this project from the competition (novel/innovative)	Craft a Preliminary Value Proposition					
Team Skills Assessment & Assignment of Roles Includes a chart or diagram of the skills that the student and team members have and that they will need to acquire. Includes notes on some kind of plan for acquiring needed skills, with specific steps outlined for the next two weeks.	Skills Gap Assessment					

Includes a chart that assigns roles and detailed, clear responsibilities to each team member.						
Team Plan Includes a plan for how the team will collaborate throughout the course. Includes a timeline, deliverables, and who is accountable for each deliverable. Includes identification of several fallback points with a date by which a course correction will need to be made.	Team Project Plan					
Individual Plan Includes a plan for how the team will collaborate throughout the course. Includes a timeline, deliverables, and who is accountable for each deliverable. Includes identification of several fallback points with a date by which a course correction will need to be made.	Individual Project Plan					

Understanding Section (18 possible points)

Targeted learning outcomes:

- I leveraged design thinking scaffolds to engage in understanding the context of the problem and empathizing with the needs/desires of potential end-users/clients.
- I conducted research and a market analysis on the design problem, its system, and the design solution.
- I carefully considered the ethical implications of my design solution and my professional responsibilities as an engineer.
- I crafted a refined Value Statement that is clearly informed by my market analysis, research, and ethical considerations.

Performance Criteria	Focal Notebook Pages	Blank 0	Developing 1	Meeting 2	Exceeding 3	Feedback (Areas that Need Work; Evidence of Exceeding Standard)
Market Analysis Documents results of a detailed analysis of the market for the proposed solution/product, including a hypothetical user portrait. Identifies end-users and considers the commercial value of the product.	Market Analysis					
Research & Build Knowledge on Design Problem and Possible Solutions Documents how the team carried out research (e.g., online, interview, focus group, observation, survey, lit review) on the design problem and the possible solution(s). Multiple sources and research approaches were leveraged. Demonstrates how research findings were leveraged to learn about the problem, the market, end-users, the system, and relevant cases and products.	Market Analysis Build a Question Guides: Interview, Online Research, Observation					

Ethical Responsibility Demonstrates identification and careful consideration of ethical and professional responsibilities related to the impact of the designed product/device.	Ethical Considerations					
Criteria and Constraints A clear rationale is provided for how the identified criteria and constraints will guide testing and optimization of the design solution.	Refined Value Statement & Revised Project Plan					
Value Statement Provides a value statement that is a refinement of the earlier version. Value statement is clearly informed by market analysis, research, and ethical considerations.	Refined Value Statement & Revised Project Plan					
Sketches Multiple sketches are provided for potential design solutions. Sketches provide sufficient details to communicate each design. Sketches may also be annotated with text (e.g., materials, measurements, functionality).	Sketch Your Concept Look for additional sketches in blank notebook and/or appendix					

Prototyping Section (21 possible points)

Targeted learning outcomes:

- I carefully documented how I designed and built multiple prototypes in an iterative process of prototyping, testing, and optimization.
- I documented how I built a physical or digital working model of my solution.
- I created detailed technical drawings and design specifications for my solution (or annotated computer code).
- I showed that my designed product meets all of the design requirements (criteria and constraints).

Performance Criteria	Focal Notebook Pages	Blank 0	Developing 1	Meeting 2	Exceeding 3	Feedback (Areas that Need Work; Evidence of Exceeding Standard)
Prototyping Model Notebook contains evidence that a physical, mathematical, or computational *working* model was developed. Additionally, provides evidence that a "looks like" prototype was developed (physical or digital).	See blank notebook or online submission					
Prototyping Documentation Notebook contains documentation of an *iterative* process of developing a working prototype. Documentation may include: ○ Ideas/thoughts about project ○ Notes about what is tried ○ Notes about what does or does not work ○ References for courses consulted ○ Sketches	See blank notebook or online submission					

○ Diagrams/schematics/ CAD drawings ○ Photographs or video						
Testing Documentation Notebook includes documentation of an *iterative* testing process of quality, safety, and functionality of the designed solution. Includes explanation of testing specifications based on identified criteria and constraints. Documentation of test results may include numerical data, field notes, and end-user feedback, along with evidence of data analysis procedures.	See blank notebook or online submission					
Optimization Documentation Notebook includes documentation of an optimization process based on the iterative prototyping process, showing clear improvements to the project through iteration. Includes evidence for the strong performance of the optimized design, referencing the criteria and constraints.	See blank notebook or online submission					
Design Specification Provides detailed specifications for the final, optimized design. Includes: ○ Technical design drawings ○ Parts and materials list ○ Equipment used	See blank notebook or online submission					

Documentation of the construction/assembly process						
Application of Math, Science, and Engineering Principles Prototyping documentation provides evidence that math, science, and/or engineering principles were applied in the context of the design and prototyping process.	See blank notebook or online submission					
Technical Merit The notebook provides evidence that the technical basis for the project is of high quality. Results of the design and testing could possibly be publishable and/or patentable.	See blank notebook or online submission					

Pitching Section (9 possible points)

Targeted learning outcomes:

- I am ready to collaborate with my teammates to make a mid-term presentation about our product/device.
- I am prepared to collaborate with my teammates to make a formal business pitch about our product/device.
- I have collaborated with my teammates to create a user manual that includes detailed product documentation.

Performance Criteria	Focal Notebook Pages	Blank 0	Developing 1	Meeting 2	Exceeding 3	Feedback (Areas that Need Work; Evidence of Exceeding Standard)
Midterm Presentation Student shows evidence of planning for and reflecting on the midterm presentation. The actual midterm presentation itself will be graded separately.	Midterm Presentation					
Planning the Pitch Student has included an outline or storyboard of their team's pitch. Student has written out at least their portion of the team pitch in paragraph form (online submission acceptable).	Make Your Pitch					
Product Documentation Planning Student has leveraged the notebook prompts to plan out their User Manual. An outline of the User Manual is included. The actual user manual will be graded separately.	User Manual					

Reflecting Section (6 possible points)

Targeted learning outcomes:

- I have thoughtfully reflected on my design process, designed product, and teamwork experience.

Performance Criteria	Focal Notebook Pages	Blank 0	Developing 1	Meeting 2	Exceeding 3	Feedback (Areas that Need Work; Evidence of Exceeding Standard)
Summative Reflections: Team Student recorded notes during team reflection about the design process and designed product.	Team Process Reflection					
Summative Reflections: Individual Student spent individual time thoughtfully reflecting and recording notes about the design process, teamwork, learning outcomes, and their use of the design notebook.	Individual Process Reflection					

Notebook Mechanics & Quality (12 possible points)

Targeted learning outcomes:

- I am able to demonstrate how to use an engineering design notebook with proper professional conventions.

Performance Criteria	Focal Notebook Pages	Blank 0	Developing 1	Meeting 2	Exceeding 3	Feedback (Areas that Need Work; Evidence of Exceeding Standard)
Completeness 90-100% of notebook pages are complete, not including optional pages.	All					
Process-oriented Evidence that notebook was used as an ongoing-process oriented tool with no or a very small amount of retroactive backfilling (e.g., evolving process, dated entries, mid-term check-ins).	All					
Intellectual Property Intellectual property is protected through proper notebook practices. No torn out pages. No use of pencil. No errors crossed out in a way that they cannot be seen. Loose pages are affixed with tape and signed/dated.	All					
Sketches Sketches are used throughout the notebook to visualize and communicate ideas and make plans. Sketches can be rough, but need to be legible. Sketches are annotated when appropriate.	All					

REFERENCES

COE Senior Design - Engineering Notebook Grading Rubric - UNC Charlotte. Available https://webpages.uncc.edu/.../Engineering%20Notebook%20Grading%20Rubric.docx.

Cunningham, C.M, & Kelly, G.J. (2017). Epistemic practices of engineering for education. Science Education, 101(3), 486-505. Available https://onlinelibrary.wiley.com/doi/full/10.1002/sce.21271.

EPICS Senior Design Grading Rubric. Purdue University. Available https://engineering.purdue.edu/EPICS/purdue/.../SD%20Grading%20Rubric.docx.

Eris, O. (2006). Insisting on truth at the expense of conceptualization: Can engineering portfolios help? *International Journal of Engineering Education, 22*, 551-559.

Householder, D.L., & Hailey, C.E. (2012). Incorporating engineering design challenges into STEM courses. *Publications*. Paper 166. Available http://digitalcommons.usu.edu/ncete_publications/166.

Kelley, T.R. (2014). Construction of an engineer's notebook rubric*. Technology and Engineering Teacher*, Feb 2014, 26-32.

LinkEngineering. (n.d.). *Informed Design Rubric.* Derived from Crismond & Adams (2012) "The Informed Design Teaching and Learning Matrix". Available https://www.linkengineering.org/Explore/Resources/Informed_Design_Rubric.aspx.

Moore, R., Alemdar, M., Lingle, J.A., Haag Newton, S., Rosen, J.H., Usselman, M. (2016). *The Engineering Design Log: A Digital Design Journal Facilitating Learning and Assessment*. Published in the proceedings of the ASEE 123rd annual conference. New Orleans: LA. Available https://www.asee.org/public/conferences/64/papers/14726/view.

Svarovsky, G.N., & Shaffer, D.W. (2006). Design meetings and design notebooks as tools for reflection in the engineering design course. In *Proceedings of the 36th ASSEE/IEEE Frontiers in Education Conference*, San Diego, CA, 2006. Available: http://edgaps.org/gaps/wp-content/uploads/SvarovskyDesign_meetings.pdf.