TO: The Engineering Faculty

FROM: The Faculty of the Edwardson School of Industrial Engineering

RE: New graduate course – IE 55100: Digital Transformation in Industrial Businesses

The Faculty of the Edwardson School of Industrial Engineering has approved the following new graduate course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

IE 59000: Digital Transformation in Industrial Businesses (cross-listed with MGMT 59000)

Spring

3 total credits; Lecture

GR Standing; OR (IE 23000 AND IE 33000)

Semesters offered and Enrollments:

Fall 2023: 30 (29/1)
Spring 2025: 29 (27/2)

TO:

IE 55100: Digital Transformation in Industrial Businesses (to be cross-listed with MGMT # TBD)

Spring

3 total credits; Lecture

GR Standing; JR/SR Standing AND (IE 23000 AND IE 33000)

This course provides students with a comprehensive understanding of the key principles and practices of digital transformation (DT) in the context of the modern industrial enterprise. We will explore the factors driving DT, the challenges and opportunities associated with implementing digital strategies, and the key technologies and tools involved in DT. The major focus is on DT in the supply chain & operations of an enterprise through smart manufacturing, digital twins, and Industry 4.0.

RATIONALE:

This course has been very popular in its limited offering so far. This course is part of the expansion of courses on digital twins, digital transformation, and Industry 4.0/5.0 within the School of Industrial Engineering. It is also part of a similar expansion of coursework within the Daniels

School of Business related to innovation management. If numbered, this course would become part of the Innovation Management graduate concentration in DSB, and perhaps others.

DocuSigned by:

Young-Jun Son

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Young-Jun Son
Head of the Edwardson School of Industrial Engineering

Link to Curriculog entry: https://purdue.curriculog.com/proposal:30479

MGMT 59000–108 / IE 59000–071
Digital Transformation in Industrial Businesses
Fall 2023

Note: This is an ambitious syllabus, and we will adjust as needed. Consider this syllabus a draft. I will make every reasonable effort to ensure that no student will be disadvantaged by changes.

Instructor
Stephan Biller
Office: GRIS 382
Email: sbiller@purdue.edu
Phone: 765-494-8943
Office Hours: Thursday 1:00 pm – 2:00 pm (except October 5 and November 2) or by appointment

Bio: Stephan Biller is the Harold T. Amrine Distinguished Professor in the School of Industrial Engineering and the Mitchell E. Daniels, Jr School of Business at Purdue University and serves as Director of the Dauch Center for Management of Manufacturing Enterprises at the Daniels School of Business. His expertise includes Smart Manufacturing, Digital Twin, Industry 4.0, and Supply Chain Management. He is passionate about how AI in the broadest sense and IoT can facilitate the Digital Transformation of large and, especially, small and medium manufacturing enterprises @ scale. Previously, he served as Founder and CEO of Advanced Manufacturing International, Vice President of Product Management for AI Applications & Watson IoT at IBM, Chief Manufacturing Scientist & Manufacturing Technology Director at General Electric, and Tech Fellow & Global Group Manager for Manufacturing Systems at General Motors. He holds an electrical engineering degree from RWTH Aachen, Germany, a Ph.D. in Industrial Engineering & Management Sciences from Northwestern University, and an MBA from the University of Michigan. He is an IEEE Fellow and an elected Member of the National Academy of Engineering.

Teaching Assistant
Fangyuan Li
TA Office : GRIS 157C
Email: li3912@purdue.edu
Office Hours: Tuesday 1:30 pm-2:30 pm, Friday 9:00 am - 10:00 am
Bio: Fangyuan Li is a third-year Ph.D. student in the School of Industrial Engineering at Purdue. She obtained her bachelor's degree in Industrial Engineering from Tsinghua University in 2020.

Class Schedule
Date: Tuesdays & Thursdays
Time: 10:30 am - 11:45 am
Instructional Modality: Lectures, Labs, Face-to-Face
No electronic devices allowed… please turn off cellphones… exceptions with permission of instructor.

Locations:
- RAWLS 2077 (lectures),
- Lambertus Hall Room 1263 (Build @ Scale Lab),
- Dudley Hall Room 3447 (Analytical Tools lectures)

Assignments and Delivery: You will form teams of three (3) students. These teams will stay together throughout the entire course and submit most deliverables as a team. **Teams will be formed at the beginning of week 2.**

Prerequisites
- Basic Probability & Statistics
- Working Knowledge of Excel

Reference Materials
1. Assigned Course package
2. Postings on Brightspace

Grading
Grades will be based on:

• General Case Presentation & Write-up (1)	15%
• Technical Presentation and Report (1)	20%
• Technical case studies (2)	20%
• Labs (4)	10%
• Final Presentation and Report (1)	20%
• Participation (4 grades, lowest dropped)	15%
• Introduction, Course Evaluation	1% each (extra credit)

ChatGPT: Generative AI will undoubtedly change businesses, jobs, and education. It is therefore impossible to ignore its impact on our class. In fact, DT itself cannot be executed without the consideration of Generative AI's impact. While it is too early to teach this technology formally in a Business School class, we will adopt a "hybrid" approach, where I will allow students to use generative AI tools (such as ChatGPT) IF they choose to do so. However, since students who use it gain a significant advantage over those who do not, the grading of assignments will differ for ChatGPT-aided submissions. Each of your assignments must state at the top of the paper whether you used ChatGPT or any form of generative AI together with the honor code.

- Option 1: "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. I did use generative AI during this assignment. ", or
- Option 2: "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. I did NOT use generative AI or any similar help during this assignment."

Difference in grading:
- Option 1: If you use Generative AI, one of your major tasks is checking for factual mistakes, figuring out references, making sure ChatGPT got it right, reorganizing paragraphs, adding graphs and tables etc. I have found lots of factual mistakes using ChatGPT and often the answer is very general. Grading will be stricter if you chose to use ChatGPT. I will reduce your grade substantially if your paper has factual mistakes, references are incorrect or non-existent, etc. The work aided by ChatGPT still needs to be YOUR work and its quality needs to higher if you use Generative AI.
- Option 2: If I suspect that Generative AI has been used, I will run assignments through an analysis to determine if you used generative AI. If the result is positive, I will assign a zero for that assignment. Grading will be generally generous. If you make factual mistakes, a few points will be deducted.

Overall, ChatGPT provides an incredible new opportunity for you to change the way you learn and work. Note that you can always use ChatGPT to help you understand concepts (e.g., "What is a real option?") but once it comes to deliveries, I expect you to disclose usage as outlined above. The amount of work you will have to do for deliveries will be similar for option 1 or 2.

Grading Scale

A+   95 – 100%
A   94.9 – 90 %
B   89.9 – 80 %
C   79.9 – 70 %
D   69.9 – 60 %
F $\leq$ 59 %

Regrades of submissions will be considered only if students provide the submissions with a written statement explaining why they believe it was misgraded. Requests must be submitted to the instructor in paper form in class (original copy of submission plus written statement) within 7 days of the assignment's return or the grade's posting (whichever comes first). No email will be accepted. You are always welcome to ask questions about assignments to understand the material better. You can bring your assignments to office hours and ask as many questions as you like. However, no regrades will be discussed in person and no points will be added during such discussions.

NO QUIZZES -- NO MIDTERMS -- NO FINAL

CAPS Information: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765)494-6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or through its counselors physically located in the Purdue University Student Health Center (PUSH) during business hours.

Purdue Honors Pledge: "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

Overarching Values

Integrity – Respect – Excellence – Collaborative Spirit – Kindness

Course Overview

This newly designed graduate-level course provides students with a comprehensive understanding of the key principles and practices of digital transformation (DT) in the context of the modern industrial enterprise. We will explore the factors driving DT, the challenges and opportunities associated with implementing digital strategies, and the key technologies and tools involved in DT. The major focus is on DT in the supply chain & operations of an enterprise through smart manufacturing, digital twins, and Industry 4.0. Students should note that DT is still a developing area and class participants will be expected to research and present topics where a definite answer is still emerging.

The course will have six broad goals:

- S**trategy development, culture, and leadership**: Developing a digital strategy that aligns with business goals, leverages emerging technologies, and addresses the needs of customers and stakeholders. Understanding the importance of digital culture and leadership and developing the skills and knowledge necessary to lead successful digital transformation initiatives. (12 case studies, 10 of which will be led by student teams, 2 by instructor).
- **Innovation**: Exploring the latest digital innovations and emerging technologies and understanding how they can be leveraged to drive business growth and innovation (10 student-led presentations on the latest DT technology)
- **Software tools**: Exposing students to critical decision-making under uncertainty tools to quantify uncertainties and their financial implications. We will use @Risk software for risk management. These tools are installed in the computer lab at Dudley Hall. (2 team case study submissions)
- **Implementation**: Exposing students to DT implementation in the new Lambertus Hall (4 Labs)
- **Thought leadership:** External speakers will share their (or their customers) journey in DT.
- **Companies:** Familiarizing yourself with DT-leading companies and software providers. The final report will be secondary research-based and focus on DT in your chosen firm or software provider. This will allow the entire class to have access to a DT company briefing, which might be helpful for benchmarking and interview prep.

Lecture and External Speakers: We will use the lecture method for introduction to DT and @Risk. We will have four external speakers. **Deliverables: Participation**

General Case studies: All cases are on Brightspace und Content -> Course packet. Case studies are generally considered the best method to learn how to analyze business situations. This course will give you ample opportunities to improve your ability to analyze business situations, which will be helpful to you during case interviews (especially if you are planning to go into consulting) and your first job. I expect you to be thoroughly prepared before coming to the class. If you are not prepared, please send me an email before class. Questions for each class session provided in this syllabus will guide your thinking about the readings and cases. Teams of three will lead most of these case study discussions during a 40-minute period of class. This team will also have to write a 3-page (11pt) case analysis that includes their perspective on the questions related to the case and must be submitted on Brightspace before class. During case discussions, we will build a complete analysis of the case situation and address the problems and issues it presents. Students will be asked

to make recommendations and will discuss the implementation of those recommendations. Whenever possible, we will follow the case with a Technology presentation (see below) on the subject. I consider the classroom a safe laboratory in which you (students) can test your ability to present your analyses and recommendations, convince your peers of the correctness of your approach to complex problems, and illustrate your ability to achieve the desired results through the implementation of that approach.

Teams must rank the cases from their most preferred to their least preferred (in order) at the beginning of week 2 (August 29, 5:00 pm); the instructor will then assign topics considering these preferences. Note: Technology deliverable and case deliverable on the same topic will not be assigned to the same team. **Deliverables: (a) Preparation for every class, (b) Participation, (c) One case lead and write-up due at the beginning of class.**

Technical Presentation & Report: To enable us to capture the vast amount of technology related to DT, each student team will present one core technology during 30 minutes of class (20 minutes of presentation plus 10 minutes of questions). They will also provide a write-up about the technology based on secondary research. Please keep it to 10 pages (11pt, 1.5 spaced). These reports will be shared with your classmates through Brightspace. Please take the view of an internal or external consultant providing senior management an overview so they can decide whether they should purchase and implement the technology and what provider they should pick. This presentation and report should include (but not be limited to) an explanation of the technology, benefits (financial and intrinsic), major providers, pros and cons of major providers, implementation framework, integration with other systems, and recommendations. You could have graphs, tables, and pictures in the appendix. Also, make sure you have referenced all the sources that you based your paper on.

Teams must rank the technology topics from their most preferred to their least preferred (in order) at the beginning of week 2 (August 29, 5:00 pm); the instructor will then assign topics considering these preferences. Note: Technology deliverable and case deliverable on the same topic will not be assigned to the same team. **Deliverables: (a) Participation, (b) One technology presentation and write-up**

Technical case studies: All cases are on Brightspace und Content -> Course packet. One of the most important tasks in DT is to financially quantify the value of DT. Since DT primarily enables decision-makers to reduce risk, it is imperative to understand the uncertainty of decisions and their financial impact. We will spend a considerable amount of time learning a software tool called @Risk. Lectures will be in the computer lab in **Dudley Hall Room 3447.** You will also do your case study assignments in this new computer lab. There will be two (2) @Risk case studies. While you can not become an expert in the time allowed, it will provide you with a solid foundation on how these tools work and how they should be used in DT. To maximize your learning and to obtain the possible maximum grade, there will be two submissions: The first submission will be graded, and feedback will be provided. The points earned will account for 10% of this assignment. The final submission will count for 90% of this assignment. For example, if you get 80% in the first submission and 95% in the final submission, your grade will

be 10%*80% + 90%*95% = 93.5%. Note that the minimum grade for the final submission is the grade of the first submission; hence, if you got 100% on the first submission, there is no need to submit the final submission. **Deliverables: (a) Preparation for every class, (b) Participation, (c) Two case study write-ups (First Submission and Final Submission). All pdf submissions for technical case in Gradescope. Please upload your Excel/@Risk file in Brightspace.**

Labs: Four hands-on Labs will be conducted during the semester by Craig Zehrung, Ph.D., and Lab Director David Kotterman in **Lambertus Hall Room 1263**. Attendance for these is mandatory and no make-up labs can be provided. In case of illness or other emergencies, please email Dr. Zehrung and me before the Lab. Dr. Zehrung will grade these assignments.

Lab 1: Assessment and Improvement of Operations
Goal: Students review current state of manufacturing operations and make recommendations on improvements.
Task: Given the current state of operations, finances, and customer demand, students should make recommendations on the addition of additional shifts, machinery, improved layout, and digitization of equipment.
Deliverables: None at this time

Lab 2: Assessment of Suppliers, Inventory, and Forecasting
Goal: Students review improvements made since the last lab and assess the current state of operations relating to suppliers, inventory, and production forecasting using existing data.
Task: Given a budget, ordering constraints, and available data, what path should we choose to ensure we are able to meet our customers' needs? Students to make recommendations to be implemented in next lab.
Deliverables: None at this time

Lab 3: Integration of Automation and Advanced Quality Control
Goal: Students are presented options of equipment that are available for automating portions of the factory floor and make decisions on what should be used.
Task: Given budgetary constraints and available equipment, what areas are best suited for automation and why?
Deliverables: Students analyze their findings from the first three labs and provide their thoughts on future improvements to the factory that would allow it to move to the next level.

Lab 4: How to deal with Design Changes and Review of Advanced Technology
Goal: Students are presented with the dilemma of customer requested design changes and how that plays into current operations. Also, students are introduced to new technologies available for future advancement.
Task: What must be done to accommodate customer requests for production changes? How does some of the newly presented equipment impact training, working conditions analyses, and real-time data tracking?
Deliverables: No deliverables due.

Final Presentation and Report: Your team will have 20 minutes to present your analysis about the digital value chain transformation that is currently occurring at a firm based on secondary research. This can be a user of DT technologies (e.g., Ford) or a provider of DT technologies (e.g., C3ai); I suggest you avoid companies and providers we discussed in cases unless you can provide substantial new developments at these companies. You should focus on the key elements to their value creation process, changes to execution as well as the potential challenges that they might face in this transformation. Finally, predict where the firm might be in 5 years with this transformation – what will be the impact? What could happen to the competitive landscape? Your report should have more details on your analysis and follow the following format. Please keep it to 10 pages (11pt, 1.5 spaced). You could have graphs, tables, and pictures in the appendix. Also, make sure you have referenced all the sources that you based your paper on. These reports will be shared with your classmates. **Deliverables: (a) Presentation, (b) Report**

Possible content outline for the final report
1. Executive Summary
2. Background on the firm/industry
3. What is the innovation that you are discussing?
4. What is the competitive essence of the firm in your opinion (use the framework)?
5. What are the key values that the firm is trying to provide and how are they impacted by the technology?
6. Perform a SWOT analysis on this initiative.
7. Predict where you see the firm/industry in the next decade based on this innovation.

Date	ClassTopic	Case / Speaker	Submission due
22-Aug-23	Introduction / Syllabus	None	
24-Aug-23	Digital Transformation Intro		Short bio of yourself (including prefered name, picture, pronouns, expectation for the course, professional goals. Personal information welcome.)
29-Aug-23	GE Digital: Industrial Internet	GE Digital: What went wrong	Team formation, Case preferences, and Technology preferences due
31-Aug-23	@Risk Week 1: Introduction	@Risk Week 1: Visisan Case	
5-Sep-23	Case 1	Tech 1	
7-Sep-23	@Risk Week 1	@Risk Week 1	
12-Sep-23	Case 2	Tech 2	
14-Sep-23	@Risk Week 2	@Risk Week 2	C-Energy Case First Submission (Technical Case)
19-Sep-23	Case 3	Tech 3	
21-Sep-23	@Risk Week 2	@Risk Week 2	C-Energy Case Final Submission (Technical Case)
26-Sep-23	GE Digital Speaker		
28-Sep-23	Case 4	Tech 4	
3-Oct-23	Lab		
5-Oct-23	Lab		
10-Oct-23	October Break		
12-Oct-23	@Risk Week 3	@Risk Week 3	Merck Case First Submission (Technical Case)
17-Oct-23	Case 5	Tech 5	
19-Oct-23	GM Speaker		
24-Oct-23	Case 6	Tech 6	
26-Oct-23	@Risk Week 3	@Risk Week 3	Merck Case Final Submission (Technical Case)
31-Oct-23	Case 7	Tech 7	
2-Nov-23	Lab		
7-Nov-23	Lab		
9-Nov-23	Case 8	Tech 8	
14-Nov-23	IBM Speaker		
16-Nov-23	Case 9	Tech 9	
21-Nov-23	Asynchronous lecture : Simio Digital Twin		
23-Nov-23	Thanksgiving Break		
28-Nov-23	HP Speaker		
30-Nov-23	Case 10	Tech 10	
5-Dec-23	Final Presentations	Final Presentations	
7-Dec-23	Final Presentations	Summary / Conclusion	Course Evaluations, Final Report
NO FINAL			