

Engaging an Industrial Advisory Board for Curriculum Development

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With rapid changes in STEM careers, gaps still exist between skills required by industry and learning objectives created by colleges and universities. Even well-designed curriculum must be constantly reevaluated and adjusted. Data Science and Industrial & Applied Mathematics are fast-evolving programs whose graduates are highly sought by industry. Prior research has provided valuable general insight into skills valued by industry and pedagogy effective for teaching these skills (Ferns et al., 2021; Jang, 2016; Lamancusa et al., 2008; Schwab-McCoy et al., 2021; SIAM and COMAP, 2016).

In this poster, we will describe how we engaged our Industrial Advisory Board to provide external input for our newly developed Data Science and Industrial & Applied Mathematics programs. We will then show how we have applied that feedback and made changes to our curriculum and pedagogies. Our Industrial Advisory Board consists of nine volunteer members representing multi-national companies with headquarters or having a large presence in the local metropolitan area. This includes several Fortune 500 companies. Specifically, Industrial Advisory Board members were queried for their open-ended responses on topics such as: What do you look for when you hire? What is the appropriate balance between developing technical and nontechnical skills, in terms of preparing students for careers in industry? What computer applications and programming languages are beneficial to integrate into an undergraduate mathematics and statistics curriculum? For which career paths?

There was strong agreement among our board members on the importance of the following technical skills: Multiple linear regression, logistic regression, machine learning techniques, model formulation and model building (choosing the appropriate model and communicating why a specific model is chosen) and being able to interpret and explain results. Familiarity with an object-oriented programming language is typically required for all industries represented by the board members. Most importantly, students need to have the ability and drive to learn different applications as they will likely have to learn multiple new programming languages, modeling techniques and business practices throughout their careers.

The primary focus of non-technical skills is on communication. Specifically, our board members stressed the importance of students learning to communicate technical details to both technical and non-technical audiences. Another essential non-technical skill is the ability to work in teams and have project experience.

We describe how the recommendations have been incorporated into the Data Science and Industrial & Applied Mathematics programs. Initial feedback from students and the Industrial Advisory Board members to both programs has been positive. In particular, the students like working on the open-ended problems and enjoy working on projects in teams. We identify areas we would like to further emphasize or add to our curricula. They include additional model formulation activities, more PowerPoint presentations (emphasis on summarization of results), code documentation, asking questions of clients and importance of continuous education and learning of new skills. The Advisory Board has also provided guidance on several career-readiness items such as resumes, networking and interviewing which we are expanding on.

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Introduction

- **About Metro State University:**
 - Mathematics and Statistics Department historically offered an Applied Mathematics BS degree
 - Students are frequently location-bound adult learners
 - Financial factors frequently require students to seek employment in the corporate sector after graduation
- **Key theme of 2017 survey of Applied Mathematics alumni working in the corporate sector:**
 - Mathematical skills are valuable, but
 - Increased background in statistics and computing would have improved marketability and preparation
- **Actions taken by Mathematics and Statistics Department:**
 - Creation of a Data Science BS and Industrial & Applied Mathematics BS
 - Creation of Industrial Advisory Board to provide curricular guidance and learning experiences for the two new programs

Industrial Advisory Board Members

- **Role of Industry Advisory Boards**
 - Assist university departments in ensuring that academic programs prepare students with the skills and capacities currently valued and expected by industry.
 - Provide external input on additional ways to enhance the student learning experience, such as providing data sets, guest lectures for courses, and real time experiences such as internships, capstone design projects, and mentoring opportunities
 - Serve as external reviewers to evaluate and adjust specific curriculum
- **Our industrial Advisory Board consists of nine volunteer members representing multi-national companies with headquarters or having a large presence in the Twin Cities metropolitan area.**
 - Best Buy
 - Target (2 members)
 - Traveler's Insurance
 - General Mills
 - US Bank
 - SPS Commerce
 - Cargill
 - CH Robinson
- **Board members were queried for their open-ended responses on several topics.**

Industrial Advisory Board Survey Questions and Summary of Responses

Question	Responses
What do you look for when you hire?	• Soft skills: Strong communication skills, effectively work in teams, time/project management skills • Programming experience: Python, R, Pearl, Java, SQL • Ability to learn; interest in learning; ambition • Experience working on projects: Want them to be able to effectively communicate their train of thought as they discuss prior work that they've done • Problem solving: Perseverance, willingness and ability to ask questions • Work with vendors effectively • Understanding of models: Being able to choose appropriate models and communicate rationale, understand advantages and disadvantages of different models
What is the appropriate balance between developing technical and nontechnical skills, in terms of preparing students for careers in industry?	• Individuals need both • Communicating technical details to technical and non-technical audiences is difficult but essential • Being able to make a clean, concise PowerPoint presentation is essential • Need to be interested in taking ownership for projects and have the drive to do it as well as possible • It's important to be able to ask (the right) questions • Problem solving strategies are important: (One board member asks the following of her employees: If a problem is not clearly stated, what could you do? What are some other strategies you can try?)
What computer applications and programming languages are beneficial to integrate into an undergraduate mathematics and statistics curriculum?	• Python and R: Most widely used; May or may not be a deal-breaker for hiring • SQL: Not a deal-breaker for hiring, but definitely helpful for database queries • Java: Helpful, but not essential • SAS and Excel VBA: Used at one company • Excel: Familiarity with spreadsheets is essential; VBA is helpful, but not essential • MATLAB: Not essential, used primarily in engineering applications • In general, familiarity with an object-oriented programming language is important • Data visualization software (Tableau, Power BI): Used at several of the companies represented, but not essential • Amazon Web Service (AWS): Helpful • If employees have the ability and drive to learn different applications, they can generally pick up what they need to know

Industrial Advisory Board Recommendations

- **Technical Skills**
 - Academic background must include multiple linear regression – what it is and when it works well
 - Knowledge of logistic regression and machine learning techniques are plusses
 - Model formulation is critical
 - Training versus validation versus test data
 - Be able to understand and translate business problems into a math / stat problem
 - Interpret and explain results
- **Non-technical Skills**
 - Communicating technical details to technical and non-technical audiences
 - Ability to work in teams and have project experience
 - Time/project management skills
 - Ability to lean new things (programming languages, modeling techniques, and business practices)
- **Overall**
 - Include project-based or inquiry-based classes
 - Open-ended problems which require practical skills, especially formulating and selecting models
 - Present results of projects in non-technical industry terms
 - Embed mini-projects into the curriculum
 - Emphasize code documentation

Implemented Recommendations

- **Industrial & Applied Mathematics**
 - Four-course sequence in modeling focused on formulating models and problem-solving
 - Incorporation of a team-based investigation of a large open-ended real-world problem
 - Instruction in technical communication
 - Communication of analyses, results, and recommendations to both technical and non-technical audiences
 - Completion of a statistics or mathematics internship, a Statistical Consulting course or a Mathematics Capstone
- **Data Science**
 - Project-based interdisciplinary focus with courses in Math/Stat, Computer Science, and Management Information Systems
 - Programming courses in R, Python, Java, SQL, and Tableau
 - Integrative experience through a statistics or data science internship, Statistical Consulting or a Data Science Capstone
- **Both Industrial & Applied Math and Data Science**
 - Regression Analysis course with a focus on model formulation
 - Career Center presentation on career opportunities
 - Courses with team- based projects with data analysis in R and presentations to both technical and non-technical audiences
 - Creation of student portfolios

Future Work

Initial feedback has been positive. Students like working on open-ended problems and team-based projects.

Areas of further curriculum emphasis:

- Model formulation activities
- More PowerPoint presentations with an emphasis on summarization of results
- Code documentation
- Asking pertinent questions of clients
- Importance of continuous education and learning of new skills

Work with the Industrial Advisory Board on expanding career-readiness guidance:

- Resume construction
- Importance of networking
- Job interviewing skills

Regular surveys of recent alumni for ongoing evaluation