EMPOWERING MASTER STUDENTS TO SOLVE REAL-WORLD ENGINEERING PROBLEMS

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ABSTRACT

In engineering, the importance of multi-disciplinarity and the need to "think outside the box" are obvious. However, subjects in engineering education are often treated in an isolated fashion. The kind of problems solved in these subjects are often just simplified artificial exercises. To ensure employability of new engineers, students need to practice how to "convert a mess into a problem", and then use the scientific method in context to solve it.

Good data skills (including data collection, exploration, and modeling) are essential to solve problems. These data skills are the "backbone" of the scientific method. The use of real data (coming, for example, from real applications in industry) can be motivating in teaching and stimulating to connect engineering topics.

This paper explores possible reasons why many subjects in engineering are still taught in a way disconnected from real life. It also suggests solutions, and shares teaching tools and resources to improve student employability.

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1 INTRODUCTION

1.1 The importance of multi-disciplinarity and real-life problems

If we ask engineering teachers if they think multi-disciplinarity is important in their field, probably all of them will answer affirmatively. However, when we look at subjects in engineering degrees, they often look isolated. How many subjects are taught together by teachers from different departments? Real-world problems bring multi-disciplinarity in a natural way. One given situation in a process may require chemical knowledge, but also statistical analyses to make the process stable, and economics to make it viable, plus an environmental study, and so on.

Students in engineering degrees are usually young. Most of them have never worked in industry or business. However, it is obvious that we wish our students learn the skills needed to solve real-life problems. How can they learn these skills at university if they are only exposed to prepared “artificial” exercises? While these exercises have the benefit for the teacher making reviews easier, it is not what happens in real situations where problems are more complex and somewhat blurred [1].

A hands-on approach with cases that use real situations and data also require many soft skills as needed today, like being able to learn autonomously, working in teams or communicating efficiently.

If we agree on the importance of multi-disciplinarity and the need to prepare students to real-world problem solving, why do we have difficulties in achieving this?

1.2 Some difficulties when using real world problems

Facing students with real world problems implies shifting the focus from the teacher to the students. There are still many teachers that feel comfortable conveying knowledge in a unidirectional way: the teacher speaks (and sometimes fills blackboards), and the students listen and take notes. Probably something similar happened before Gutenberg invented the printing press: it was the only way to make copies of written knowledge. This passive approach is no longer possible when using real-world problems, that necessarily encourage discussion. The teacher becomes more a supervisor, a colleague who walks together with the students through a discovery process. Therefore, a required first step is changing the paradigm in how we teach engineering subjects [2].

The second requirement is having case studies to be used in the classroom. This teaching material could mainly come from three sources:

1. The teacher (or team of teachers) invents an industrial or business situation that looks realistic, adds the context information, and simulates the data. This is extremely difficult to do well. The teacher needs more imagination than J.K. Rowling writing Harry Potter and requires a deep subject understanding of the process at hand. Even if this can be done at the end, it is very time consuming.
2. The teacher has done some consultancy work or research with a company, perhaps working together with operators and technicians in industry for many months. She/He has learnt a lot about the process, and the data are accessible

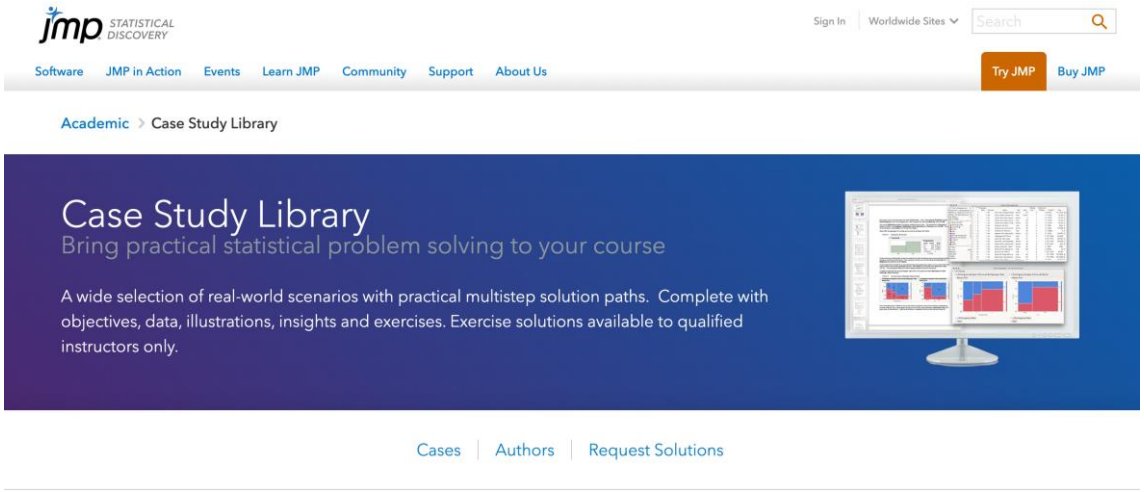
that can also be used in the classroom. Teachers can then write a case study but will probably need the help from the industry people also involved in this collaboration. Finally, the result can be good, but it also requires a lot of time.

3. The teacher uses cases from a collection of well-curated real-world situations. As before, these cases often come from commercial projects, but they are already designed for classroom use. The fact that these case studies are used by many educators also implies that they can be improved in every iteration of use. Also, the range of topics is huge: something that cannot be achieved otherwise.

The next chapter introduces a good example for the third option.

2 THE JMP CASE STUDY LIBRARY

More than 50 problems are shared for teaching use in the JMP Case Study Library [3] (Fig. 1), listed by field, subject, statistical concepts, and complexity. Each case can be downloaded for free including dataset(s) and a PDF documentation. Many cases have been directly developed by practitioners in industry. Some companies are named in their cases, while others are anonymized.



Title		Field	Subject	Concepts	Complexity
JMP001	Medical Malpractice	Healthcare	Insurance Claims Management	Summary Statistics & Box Plot	
JMP002	Baggage Complaints	Operations	Customer Care	Time Series Plots & Descriptive Statistics	
JMP003	Defect Sampling	Engineering	Manufacturing Quality	Tabulation & Summary Statistics	
JMP004	Film on the Rocks	Marketing	Research Methods	Chi-Squared Test & Distribution	
JMP005	Improving Patient Satisfaction	Life Sciences	Quality Improvement	Correlation & Summary Statistics	

Fig. 1. Examples from the JMP Case Study Library published at jmp.com/cases

All case studies follow a consistent format and scenario which starts with a description of the problem, followed by questions or tasks at hand and a description of the data. This is followed by a multistep illustration of the solution followed by a summary of the statistical and managerial insights. These are followed by exercises that expand or pose “what if” scenarios, which solutions can also be shared upon request.

While educators can use case studies for in-class demonstrations, the most effective use are assignments to students as homework or group projects. The cases can stimulate discussions about which steps to take or comparisons of alternative solutions. Students can also be asked to present the learning outcome to “other decision makers”, or to explain why and how certain methods have been applied.

2.1 Compliance with GAISE recommendations

As outlined in [4], the JMP case studies support extremely well the recommendations for teaching statistics to college students, especially these four: 1. Teach statistical thinking 2. Focus on conceptual understanding 3. Integrate real data with context and purpose and 4. Foster active learning.

More information about the JMP Case Study Library and hands-on experience using some select cases for engineering will be offered during a SEFI workshop [5].

3 SUMMARY AND CONCLUSIONS

Multi-disciplinarity and empowering students to solve real-world problems are needs in engineering education nowadays. The use of case studies can facilitate achieving these objectives. When you talk with former engineering students who have entered the workforce, they invariably explain the value that real case studies had in their learning. Moreover, they can remember and refer to many case studies. The authors have confirmed this by talking to engineering students some years after they finished their degrees (the live presentation of this paper does include some of these video testimonials).

As creating realistic case studies from scratch is difficult and time consuming, good case study libraries can be very useful. As an example, select engineering cases from the JMP Case Study Library have been introduced. All cases from that collection are freely available, proven by hundreds of educators worldwide and will be continuously enhanced to cover more problems, applications, and engineering skills in the future.

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