Authentic assessment example in Maths

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## Context

I am Lecturer of Applied Mathematics at the National University of Ireland, Galway. My teaching, spanning various Science and Engineering modules, is primarily focused on *Mechanics*, which is also the core subject of my own research.

**“Mechanics Tales” for teaching and assessment**

The supporting theme of my lecturing style is that linking research and teaching is the key to lifelong learning. I have strived for many years to find a systematic way to create this link in my own lectures, until the spread of the Covid pandemic forced me to find new ways to engage and assess my students.

I have always liked “stories” around my own research subject, mechanics. I should here clarify that by “story” I mean any piece of information on how a concept was born and evolved in time (*an example: the word “mechanics” comes from the ancient Greek word* *mekhane**, identifying a crane used in theatre to lift an actor into the air, usually representing flight*), on the lives of thinkers and scientists of the past and the struggles around their discoveries (*another example: it is little known that Isaac Newton had a strong rivalry with Robert Hooke, the father of the theory of Elasticity, to the point that after Hooke’s death, Newton allegedly* *destroyed* *the only known portrait of Hooke*), or still on how Mechanics can be fruitfully exploited to explain effects spanning a broad range of scales, from the structure of DNA to the pattern of fingerprints, from the optimal shape of bridges to the maximum size of planets.

These stories fed my own passion for research and shaped my taste for the problems I pick to study: henceforth, they were fundamental to engage me as a researcher and for providing a lifelong guidance in the way I approach problems. I thus felt that the same may be true for my students and decided to bring this experience into my teaching.

The problem of how to embed this rather sparse corpus of anecdotes in my lectures was not trivial. I have learned most of them in conferences, or while talking – often chatting – with colleagues, or by reading articles, books, or by randomly surfing the web. Pre-pandemic, I was using fragments of these stories to fill the breaks of my lectures, and I noticed something: rather than taking advantage of the break to run out of the venue or to chat with friends, students were captivated by the stories, they wanted to know more, they asked questions. Often, it was hard to get back to the “real” lecture.

As the Covid pandemic spread, I was teaching large first-year Engineering classes and I immediately faced the problem of student engagement. I then decided to deal with this challenge by introducing 10-minute weekly slots, which following Geoffrey Chaucer I named the *‘’Mechanics Tales’’*: an out-of-syllabus window on the outer world, where I was illustrating examples of the far-reaching predictive power of mechanics, from cells to trees, from bones to airplanes, and more. I need to emphasise that this experiment took place in a first-year module (“Engineering Mechanics”, +270 students), where students learn general and abstract concepts with a rather narrow (and somehow old-fashioned) set of examples and applications.

This idea was an immediate success: students were fascinated to discover the beauty and the breadth of mechanics, and they genuinely engaged with the core material of the module, achieving excellent results. Signs of appreciation were clear from emails:

• *“I am a student in your first year Mechanics class. I really enjoyed hearing about the practical application of Mechanics in today’s lecture. I would be delighted if you included these going forward (B.K.)”*

• *“Your little story at the start was very interesting […] I would love to hear more in future (C.M.)”*

*• “It was interesting to hear how the maths is applied in a real-life situation and how it makes a difference in the world! I hope you continue with these stories :)” (J.S.).*

Seeing the success of this initiative, I was naturally led to exploit an analogous format for the second important challenge of online teaching: ***assessment***. Having worked for many years in Italy before joining NUI Galway, I know well that in the Italian Higher Education system there is a strong tradition of using oral assessment, to the extent that some oral element is normally compulsory on degree programmes. Despite the limitations of oral examinations – mainly in terms of homogeneity of the evaluation, due to subjectivity for example – I nonetheless consider that they permit the assessment of an element of creativity in the student.

More specifically, and in the context of Applied Mathematics, what I mean by creativity is the capacity to exploit the tools learned in the module, in order to approach a new problem that the student has never seen before (neither in class nor in the tutorials), or even better, the freedom to ***find*** new problems where such tools can be applied. This type of assessment is normally absent in the Irish Higher Education system, at least for Applied Mathematics disciplines, where students are mainly assessed through written examinations that must cover problems already seen in lectures or in tutorials.

Based on these observations, for another module (“Mechanics 1”, 2nd year Science, ~70 students), I decided to challenge individuals or small groups to create “Mechanics Tales”. To motivate them, I asked the cohort to imagine they would be able to get a grant of up to €2 million if they could produce the best 120 seconds video, or scripted text, or PowerPoint presentation (depending on their technological capabilities) in which they could explore any topic taught in the module through any problem they liked, even new ones, not mentioned in class. This exercise is also inspired by the current format of highly competitive grants (like the ERC for example) where candidates are given short time frames to pitch their innovative idea and the tools they will need.

Knowing that not all the students have the technological skills to undertake, for example, motion video production, I made sure that they were focusing on the creativity of the ideas and their flexibility in presentation techniques, not making technical production values the central purpose of the task.

The result was astounding. The whole class genuinely engaged with this new type of test, proposing kaleidoscopic, deep, and funny tales, all wrapped up professionally. In any case, all tales were clearly showing an incredible – and yet, almost completely unexplored – potential in terms of creativity. Remarkably, although I had given the possibility to work in small groups, most of the students worked individually at the tale, which indicates that they liked the challenge:

“*I enjoyed the format, it was a challenge to squeeze it into only 2 minutes, but that was part of the fun*” (W.K.).

*“Personally, the assignment was very beneficial to my learning especially while online. So I hope this will help in forming new teaching methods*” (C.R.).

I have been asked to share this approach more widely across my university, and examples of what they produced are provided, with students’ permission and with deleted personal information, at these links:

[1] <https://youtu.be/7jobFlGdCac>

[2] <https://youtu.be/CClPmmoFMig>

[3] <https://youtu.be/KXFdgtUUowI>

[4] <https://youtu.be/RsBjvt_-7rw>

When the Covid pandemic started to spread in Ireland, I feared that my teaching would have been negatively impacted by the restrictions of online teaching. Now that we are almost out of this challenging period, I can safely say that the feedback I have received from my student surveys in 2020 was the best I have ever received so far, and most likely this is due to the merit of “Mechanics Tales”. Of course, this does not imply that the students’ learning experience was better this year than in previous ones – most likely, and for many reasons, this is not the case – however it indicates that I should try to keep the “Mechanics Tales” format also when (if?) normal face-to-face teaching resumes.

This experience also leads me to reflect on the nature of the Applied Mathematics curriculum in the Irish Higher Education system. This subject is highly interdisciplinary, and not only does it require an Applied Mathematician to possess a well-equipped bag of mathematical tools, but also it relies upon its ability to establish and maintain links with researchers from neighboring fields (like Biology or Medicine), to find and solve completely new problems, and to communicate (which means also to *translate* the mathematics in simpler terms, that can be more transparently appreciated by non-specialists). I find that these important skills are not sufficiently developed in the Irish Applied Mathematics curriculum, which certainly indicates an interesting direction to improve the teaching of this beautiful and important subject.