2.9 Engaging students in research with ‘real-world’ outputs

Making an impact outside of the lecture theatre

Dallas Roulston

Department of Microbial Diseases, UCL Eastman Dental Institute; now at Middlesex University

with Professor Rachel McCrindle

School of Systems Engineering, University of Reading

I really enjoyed reading your chapter. Connecting students with research and external audiences through real-world outputs has many benefits, and it is great to see how you are making a strong case to promote this approach.

Professor Rachel McCrindle

1. Introduction

Universities have long been thought of as places where students are provided with the knowledge essential to become a valuable part of the workforce. In such a knowledge-focused environment, the course content (lectures, practical demonstrations, etc.) is often initially designed to provide the student with the knowledge necessary to understand the subject matter. Assessment is subsequently devised to evaluate whether the student, typically individually, can retain and recall this core knowledge. To better prepare students for life after university, knowledge must be accompanied by the ability to apply the knowledge in the real world. To enhance the design of the curriculum, one should initially focus on
the tasks required to both understand the subject matter and apply and demonstrate the appropriate skills. These skills should be used to shape the assessment, and, further, the assessment should shape the course content and provide the students with the skills necessary to complete the assessment. As opposed to the traditional assessment tools, students may be tasked with undertaking a research project or assignment, possibly as part of a small group, in which the students produce an assessable output. To greatly add value to the students’ outputs, it may be desirable to focus on outputs directed towards, and with impact to, external audiences. Learning through research is the major concept underpinning the UCL Connected Curriculum initiative.

Students choose a university in part because they want to be where knowledge is created, not just imparted. (Arthur 2014)

The focus of this chapter is on exploring how the implementation of a curriculum focused on learning through research at all levels of education, which connects students with external audiences through real-world outputs, has many benefits. Engaging students with research involving real-world objects not only motivates students, it offers an introduction to valuable and desirable research skills, instils a variety of skills highly attractive to employers, provides students with the ability to apply their subject knowledge to real-world scenarios and generates impact outside of university. We will explore a number of examples of how students tasked with a project have produced an output with real-world impact. We also hear from Rachel McCrindle, Professor of Human and Computer Interaction at the University of Reading, to whom I spoke during an R=T Masterclass.

2. Links to the UCL Connected Curriculum

The central dimension considered is Dimension 3 of the UCL Connected Curriculum, ‘Students make connections across subjects and out to the world’, which pertains to connecting with external audiences and creating an impact in the real world. This is in line with ‘UCL’s commitment to making an impact for good in the world and explore concepts of global citizenship’ (UCL 2016). Furthermore, students gain a multidisciplinary approach to their research.

Another aspect discussed in this chapter includes Dimension 5, ‘Students learn to produce outputs/assessments focused at an audience’,
which focuses on the production of outputs through a programme and the connection with external audiences. In learning through research and enquiry, students develop skills and generate an impact further afield than the lecture theatre. Finally, we consider Dimension 4, ‘Students connect academic learning with workplace learning’, in which programmes allow students to further connect with external audiences through workplace exchange or placements during the course of study. Through this connection, students gain a number of skills that may not be acquired through a more traditional university education. These skills include project management and business acumen.

3. Personal perspective

During my undergraduate degree, in medical laboratory techniques, a majority of the course work was taught through lectures and laboratory demonstrations. These activities focused on performing the tests employed in medical sciences laboratories. However, they were taught as bite-sized chunks focusing on a particular test and often lacked any connection between them. Moreover, the understanding of the tasks was taught at first principles and did not reflect the real-world environment. This ‘first-principles’ approach allowed a solid understanding of the technique: comprehending how each test worked and the steps involved in performing it. This may seem the ideal way to gain the knowledge to understand, and therefore perform, the test in the real world. However, when I first stepped into a medical sciences laboratory, knowledge of the theoretical aspects was there but application in the real world was lacking. Test kits, reagents and protocols differed and many methods were automated. Although I understood the principles of the test, I needed further training to perform each test in the real-world environment. I was fortunate enough to work in a laboratory during my study and having that real-world experience was invaluable to understanding the subject matter. It may be ideal to consider involving the employers of graduates in curriculum design. For example, many of my graduating peers went to work in medical science laboratories. By approaching these employers and working with them to understand the skills they look for in their future employees, we could design a curriculum that provides students with these skills. By establishing interactions with employers, we also initiate and foster that connection with the real world.
4. Real-world outputs with real-world impact

If students are tasked with undertaking a research project and therefore learn through enquiry, they will inevitably produce an assessable output. Most student outputs are only observed and assessed by a small number of people and therefore possess limited impact. If these outputs were aimed at a wider, external, audience this impact has the potential to be amplified. The production of real-world outputs allows students to connect with peers, industry and the end user. Focusing on one, or more, real-world outputs also teaches the students a number of desirable skills and the ability to apply the knowledge learnt to real-world scenarios. Professor McCrindle stated that we could consider real-world outputs as ‘anything which has any impact and adds value outside of the classroom’.

Other examples of outputs may include the publication of articles in peer-reviewed journals, oral and poster presentations at conferences.

Case study 1 Chlorine, an element of controversy

An extraordinary example of students producing real-world output occurred within the Department of Science and Technology Studies at UCL between 2000 and 2005, and eventually led to a fascinating real-world output. Chemistry historian Dr Hasok Chang devised an innovative educational experiment: ‘Students usually write essays with standard answers to standard questions. I thought it would be more interesting to have them do some original research, but we wanted to produce something that was publishable and wouldn’t just gather dust in a pile. That’s when we came up with this idea of inheritance.’ Dr Chang set his class the task of producing a dissertation on the history of a single chemical element, chlorine, from its discovery in the 1770s to the present day. Subsequent students were provided with the works compiled from the previous students’ work, and were tasked with advancing and improving the works. Following five cohorts of undergraduate students, the compilation of the works resulted in a monograph, published in 2007 by the British Society for the History of Science.

Science and Technology Studies, UCL
and exhibitions or public events, as well as the dissemination of content online in the form of blogs or videos. Furthermore, the value of the role of social media in the dissemination of information should not be underestimated. It could be envisaged that these outputs could change policy and evidence-based practice or even change our understanding. As PhD students and academics, we are likely to be encouraged or we are expected to produce these types of outputs (see, e.g., Nature 2015) and therefore it seems logical that undergraduate students should experience these activities at an early stage in their academic career. Additionally, many employers outside of an academic career require these types of activities as an obligation of the post. Other outputs may include the design, development and production of a product, such as the games created during one of Professor McCrindle’s software engineering modules. In these, software engineering students develop games that not only teach the participants about software engineering but also allow the students to learn through the process of creating the games (see Case study 2). Professor McCrindle has developed an innovative software engineering module for approximately 200 first-year students at the School of Systems Engineering. The students are from a wide range of disciplines, including computer science, information technology, cybernetics and robotics. The software engineering module is compulsory for students as it is an integral skill in whichever field they pursue.

To further motivate her students, each year Professor McCrindle holds the Software Engineering Brilliance Awards, or SEBAs. In addition to more formal assessments, the students present their work to real-world partners and academics, competing for awards in various categories. ‘When the students win one of the awards, it is considered rather prestigious and the students add it straight to their CV as it shows that they were the best in class’, Professor McCrindle explained. Another example of real-world outputs include those produced by her human–computer interaction students who work in conjunction with a global web development company to experience how web development projects are undertaken in the real world: from initial conception of an idea, through marketing and design, to a fully implemented and documented solution. A number of her final-year students have also developed a variety of medical devices, which are designed and produced to improve the lives of patients suffering from debilitating conditions and therefore have real-world impact.
Case study 2  Do you want to make a game?

Rachel McCrindle, Professor of Human and Computer Interaction at the University of Reading, discusses the use of gamification in her software engineering module. As part of the module, students are tasked with producing a game in which they learn about software engineering. This learning could be embedded in the game ‘board’, in other objects associated with the gameplay (such as question cards) or in the ethos or mechanics of the game. In designing the game, the students learn about the software engineering process: planning, designing, developing, testing, adjusting and re-testing. But why teach software engineering in this manner? ‘Software engineering is a real chicken-and-egg situation for the students’, Professor McCrindle said. The students need to know the underpinning concepts, theories, knowledge and tools before they use them on a project. However, they often do not appreciate the true value of them until they have used them on a project, and ultimately on a real-world project or placement. Through working on a project, students become more engaged as they ‘take ownership’ of the project. This is increased by working as part of a team. Along with the knowledge and application learnt through the gamification process, the students also acquire a number of other useful and desirable skills, including working as part of a team, project management skills, research skills and ‘soft’ skills such as communication skills, problem-solving, decision-making and creativity. Students also have to be able to react when things go wrong and have the ability to adapt to changes during the process. Because students are more prepared for the real-world environment, they often obtain placements. ‘When students return from their placements or other projects, the students state that they found the knowledge and the ability to apply it really useful,’ said Professor McCrindle. Therefore, through implementing a pedagogy based on real-world outputs, the students have an impact outside the lecture theatre. In subsequent years, students take the project further by applying the knowledge and skills learnt to other projects and in some instances producing and marketing systems as well as interacting with industrial partners. The external partners work with the university staff to lecture the students and set assessments which reflect real-world scenarios. This interaction creates a collaborative and sometimes multidisciplinary approach with a focus on ‘real-world outputs’ that breeds ‘real-world skills’.

Software Engineering, University of Reading
5. Research = Teaching = Real-world-ready students

I’m sure that at one time during your schooling you asked the teacher, ‘Yes, but when am I ever going to use this in real life?’ Through implementing a research-based education, this question may become a thing of the past as the students are able to see the application of the knowledge they are learning. By establishing an environment where students learn through research and inquiry, students are more enthusiastic. They take ownership of their project and develop a vested interest in obtaining the knowledge required to push the project forward and apply their skills to improve the project and, eventually, the final output. This ownership is often seen in Masters research and PhD projects. It would be highly attractive for undergraduates to follow a similar path. The students are also able to see that the outputs they are producing have real-world impact.

The term ‘research’ can be widely different depending on the field of study. However, the act of research is the basis of progress in every field. To this end, each and every field will have outputs relevant to the real world. Some may be generic across all disciplines, for example the publication of articles, books and online content such as blogs and vlogs (video blogs). More specifically, research in the sciences may influence evidence-based practice in fields such as medicine and engineering, while outputs in law and political science could impact policy makers. Through research, students also have to reflect on many of the factors experienced in the real world. These may include working as part of a team, working under time or budget constraints and the ability to produce outputs and communicate the work to a variety of audiences from diverse backgrounds.

By engaging students in learning through research, with a focus on real-world output and interactions with real-world partners, the students gain a variety of skills that prepare them for life after their degree. Taking the project from conception through design, production, implementation and testing to the final output requires creativity and adaptability. Whether remaining in academia or in the wider workforce, the skills that students gain are desirable and attractive to employers.

6.1 Technical skills

By undertaking a research project and producing real-world outputs, students will acquire valuable technical skills. To have the ability to produce
such an output, students must understand the knowledge and processes required to complete the task and communicate the results.

### 6.2 Communication

Through real-world outputs, students demonstrate that they are able to communicate the findings and outcomes of their research. They must also learn how to adapt the communication of their research to a varied audience. For example, audiences in industry may be more interested in commercial aspects while academic audiences may be more focused on learning outcomes. Working as part of a team also requires the ability to communicate effectively in a clear, concise way through verbal and written interaction, as well as the ability to listen to team members. These interactions may require students to negotiate with and persuade others.

### 6.3 Teamwork

One of the most important skills sought by employers is the ability to work as part of a team. During my discussion with Professor McCrindle, she stated that she could not emphasise this enough and that, increasingly, employers are looking for people who can work in diverse and international teams. Working as part of a team provides students with a number of desirable skills. To be an effective team member, students must be able to communicate effectively. Within the team environment, working on a project together, students must be able to compromise and speak up to have their voice heard. For the project to succeed, students must share effort and credit, and this may throw up issues when it comes to assessment of the project. Traditionally, assessment is focused on the individual, whether in examinations or performance in practicals. Working as an individual is counterproductive in the real-world environment where most jobs involve teamwork. Prior to assessment, Professor McCrindle asks her students to sign a groupwork contribution sheet, stating whether each member of the team has contributed equally. If so, the project as a whole is assessed and each member of the team receives the same grade. If not, the assessment and mark is adjusted accordingly. Other skills that students gain through teamwork, and which employers find desirable, include the ability to manage a project and delegate tasks, build positive working relationships, take responsibility for actions, work to a deadline and manage time and budget constraints.
6.4 Leadership

To complete the task at hand, students within a team need to keep themselves and others motivated, requiring good leadership skills and the ability to communicate effectively. These skills are desirable in almost every job. Being able to contribute to a group discussion requires the self-confidence to speak up, sometimes in potentially confrontational situations and, if only recently employed, as the least experienced person in the room.

6.5 Project management

During any project, students acquire the ability to manage a dynamic project. Therefore, they must remain organised, keep the team motivated and task-focused, and work under constraints. These may include time pressures – such as how much time each member has to contribute, working to deadlines and hitting key targets in a timely manner – as well as budget constraints. The ability to understand risk management and cope with and learn from negative outcomes are also highly desirable skills for employers.

6.6 Business acumen

By interacting with industrial partners, students gain an alternative perspective, thinking about the business aspects of their output, how their industrial partner operates and how they compete within a dynamic marketplace.

7. Designing the curriculum

Applications of theoretical material in real-life scenarios make content easier to understand, and the relevance of content is demonstrated by real-life application. When I teach my students about microbiology, I design the practical sessions to reflect the real-world experience as much as possible. This may include the collection, handling and processing of real specimens in a real-world environment. The students work in small groups and much of the work is self-directed. Through research and enquiry, the students are able to gain knowledge and technical skills. When students make mistakes, they are also able to observe and
understand the consequences, both to the results and, inevitably, the patient. This real-world process increases engagement and improves laboratory skills, core knowledge and the application of that knowledge. The feedback I have received has reflected this. When designing the curriculum based upon the acquisition and application of knowledge and the production of ‘real-world outputs’, the focus should initially be on assessment. Moreover, the assessment, or an aspect of the assessment, should be focused towards ‘real-world scenarios’. It is important to consider whether assessment is to be undertaken individually or as part of a group. Individual assessment appears to be the current preferred method. However, working individually seems counterintuitive when considering life outside of university. The majority of professions require employees to work within a team.

Professor McCrindle’s advice to those considering implementing a curriculum focused on real-world outputs was to start small and not be too ambitious. She said that these things often grow, and grow at a fast rate. For example, blogging often starts with an audience of just a class of students and spreads further afield. Further advice includes grasping the opportunities that come along, but if it is not what you want to do, don’t do it. More opportunities will come along. And finally, value networking and collaboration: real-world partners are an important aspect of the real-world experience.

8. Problem-based learning

Problem-based learning is a student-centred learning experience (Barrows 1996). Being student-centred in nature, the focus of instruction is shifted from the lecturer to the student. Problem-based learning was initially utilised in medical schools, but its use is now more widespread. In traditional learning, students are taught the content they need to know to pass the course, they memorise that content and then a question or problem is set to check whether this knowledge has been retained. In problem-based learning, the focus is instead on solving an open-ended problem. Students work in small teams. To start the process, the students define current knowledge, identify areas where current knowledge is lacking and plan how and where to find the information needed. Therefore, it is the students who drive the learning process. The facilitator, referred to as the tutor, supervises, directs and provides support during the process.
Using problem-based learning, students gain flexible knowledge of the subject, problem-solving and effective collaboration skills, self-directed learning, and intrinsic motivation (Hmelo-Silver 2004). Problem-based learning and working in a team requires innovation, creativity and collaboration to find the best path. One of the benefits of problem-based learning is the ability to expose the students to complex thinking. In the real world it is often less about getting to the desired conclusion, and more about getting there by the optimum path.

9. Challenges and barriers

There are a number of challenges and barriers to implementing teaching through research with real-world outputs. The major issue is in student management, especially where students have a variety of backgrounds and abilities. However, the level of student management required tends to diminish as students gain in experience, so it is more of an issue earlier in their studies. Students work in teams and, as such, assessment needs to be adapted to consider the dynamics within a team. Students also work closely with external stakeholders, which may include industrial partners or volunteers. In these cases, the students need to understand the professional aspects of working with these users.

10. Real-world partners – don’t go it alone

To gain a greater perspective of the real world, it is ideal to have industrial collaborators. In the sciences and engineering, industrial partners are often linked with research. This relationship should ultimately be synergistic in nature. Students work closely with industrial collaborators and must develop communication skills with these external partners in a professional manner. In partnership with the research councils, industrial partners take a leading role in the development of research projects as well as providing further funding, training and support. These include the UK’s CASE studentships (formerly known as collaborative awards in science and engineering), which are collaborative training grants that provide students with a first-rate, challenging research training experience. They allow graduates to undertake research, leading to a PhD, within the context of a mutually beneficial research collaboration between academic and partner organisations, such as research funding bodies. During CASE studentships, research students undergo
a placement with the industrial partner, developing real-world skills. They gain experience of an industrial research environment, as well as business-related training, for example in project management, business strategy and/or finance – expertise not provided in the academic environment. Students are also able to gain access to equipment and facilities that may not be available in their university, and develop a range of valuable skills that enhance their future employability. An important point to consider is how this pertains to less industry-intensive fields of study. The sciences and engineering have always been well connected with industry. But when you consider faculties such as law, political sciences or education, the terms ‘industry’ and ‘industrial partners’ probably do not fit. Perhaps a more favourable term is ‘real-world partners’.

11. Knowledge Transfer Partnerships

An important idea that Professor McCrindle discussed was Knowledge Transfer Partnerships (KTPs). She has been an advocate of such partnerships for over two decades, undertaking projects in collaboration with small and medium-sized enterprises, global corporations and charities/social enterprises across a wide range of markets and domains. The KTP programme is part-funded by the UK Government, and is one of the UK’s largest graduate recruitment programmes. It is designed to encourage collaboration between businesses and universities, allowing businesses to increase productivity, innovate and flourish. Each KTP consists of a business in the form of a private enterprise, public body or voluntary agency, a knowledge base in the form of a university, other higher education institution or research organisation and a recently qualified graduate, referred to as an associate. Initially, industry is connected with a university to solve a key strategic challenge identified by the company. The university and business then jointly submit a grant application to Innovate UK and if successful an associate is employed to work on a specific project. Many universities have a dedicated KTP contact or centre. The aims of each KTP programme are to facilitate the transfer of knowledge and technology and increase the spread of technical and business skills within the business, stimulate and enhance business-relevant research and training undertaken by the knowledge base, and enhance the business and specialist skills of a recently qualified graduate (Innovate UK 2015). As a part-government-funded programme, a business entering into a KTP programme contributes a considerable proportion of the project costs
(33–50 per cent), with the government contributing the remainder. Average annual project costs are approximately £60,000. This includes the associate’s salary, as well as a travel budget, personal development budget, academic input and expertise, and administrative support. In a KTP, the academic institution employs the associate who works with the industry partner. The graduate, in conjunction with their academic/industrial supervisors, brings new skills and knowledge to the business or develops them as part of the project. Following the completion of a project, approximately 60 per cent of graduates in a KTP are offered a permanent job with the industrial partner. Furthermore, it has been shown that businesses taking part in KTP increase their annual profit and create new positions. The academic partners are able to produce on average more than three new research projects and two research papers from each project.

12. Conclusion

Throughout this book we have been exposed to many examples of how we can improve teaching through encouraging students to undertake research. By involving students in research they acquire the subject knowledge, often in a self-directed manner. However, they also obtain the skills to conduct research, analyse data and manage projects. And by working in small groups, reflecting the mode of working in most real-world jobs, students also gain valuable leadership, negotiation and communication skills. These skills are, of course, highly desirable for a career after education. Embarking on research, meanwhile, can prepare graduates for a frequent requirement being asked of those in industry: that they disseminate their work to a wider audience. In academia, the term ‘publish or perish’ has been coined to reflect the pressure on academics to continually disseminate their research. The most considerable part of this process is peer review. In more traditional assessment, for example marking an essay, the only person likely to read the essay (apart from the student) is the assessor. By exposing output to the real world and therefore to a wider audience, the peer-review process opens up a dialogue between the author(s) and their peers and may require them to defend their findings. By encouraging students to undertake research as part of the learning process and produce output to a wider audience, we are able to produce students who not only know their subject area but who are capable of applying that knowledge in real-life scenarios.
References


