Kathryn MacCallum
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Industry Practices, Processes and Techniques Adopted in Education

Supporting Innovative Teaching and Learning Practice

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Preface

Introduction: The Motivation for This Book

In 2016, we had an idea about editing a book around agile and lean ideas being brought into education. We had seen the level of interest in this link between industry and education and believed there was value in providing a forum for researchers and practitioners in this area from around the world to share their work in an edited book. That book, *Agile and Lean Concepts for Teaching and Learning: Bringing Methodologies from Industry to the Classroom*, was published by Springer in 2019 and contained 19 chapters covering areas as diverse as agile approaches to grading, using Scrum in the school classroom, using agile games to teach software development, and applying Kaizen culture to education, among many other interesting and valuable approaches.

As we saw the high level of interest in that book in the first year or so after its publication, we began to discuss the possibility of a follow-up volume. We considered another book on the same topic, but felt that perhaps there would be insufficient new material so soon after the first book to ensure both the quantity and quality of submissions that would be required. As a result, we decided to cast our net somewhat wider within the same area of interest, namely ideas from industry that could be used effectively for teaching and learning. We were already aware of a number of educational practices, inspired in various ways from what goes on in the workplace that seemed to be effective in motivating, upskilling, and developing a wide range of competencies in students of all ages. These included ideas such as maker culture, design thinking, and school–industry partnerships. However, we were also curious about what other ideas might be out there that we were not aware of, so although we provided an indicative list of possible topic areas in our call for chapters, we were open to suggestions for submissions to the book.

The aim of this book was to explore the dynamic impact of "industry" on education—how it shapes what we teach and how we teach it. In this book, we are defining industry broadly as the destinations of our students as they exit education. Therefore, one focus of the book is how we are preparing our students for these roles and how knowledge and skills from industry are brought into their learning. Another focus

is how successful approaches to learning and creativity, individual or collaborative, which have been demonstrated in industry, can be applied within the context of formal education. Ideas from industry may be practices, processes, or techniques, and our focus is on exploring how these ideas can support innovative teaching and learning practice.

The book explores this focus from both an academic and practitioner perspective and includes chapters that describe a range of different approaches designed to explore practices, processes, and techniques from industry in different ways. Some of these chapters include empirical research, while others provide practitioner experience reports or practical guidance.

Rather than providing a comprehensive discussion of all possible practices, processes, and techniques, the intent of this book was to focus on those that were more innovative or adopted new ways of engaging with industry. The book is designed to cover a range of contexts, and each chapter is written to be read stand-alone. That said, there are some common themes among many of the chapters, and therefore, we have organized the work into a series of parts, bringing related chapters together.

The Selection Process

We originally put out the call for initial proposals for this publication at the end of 2020, with some preconceived ideas in mind about what kinds of submissions might arrive. In the event, we were both surprised and pleased by the sheer range of abstracts that were submitted in response. After an initial review process, we invited 25 full chapter submissions, which went through double-blind peer review, followed by an editorial review. From this rigorous selection process, 18 chapters have been chosen for publication. The international nature of our authors confirms that bringing industry concepts into teaching and learning has a global reach. Chapters have been contributed by authors from Australia, Canada, Columbia, France, Ireland, Mauritius, The Netherlands, New Zealand, Switzerland, and the UK. These contributors have helped us to provide a rich collection of expertise on how ideas from industry can be applied in teaching and learning at all levels of education. The breadth of topics in these chapters is surprising. Alongside the more mainstream studies of preparing students for the workplace with professional tools, and bringing industry concepts into institutional processes, there are many diverse explorations of the book's theme, from collaborative music production between professional musicians and students, to courses that reconceptualize the future of work, from professional broadcasting techniques brought into webinar design, to using design fictions to imagine the future of education.

Book Structure

We have organized the chapters in this book into several parts, beginning with chapters that provide some broad overviews of how industry-based ideas might be applied in education. We then include, in part two, chapters that look at how approaches from industry have been brought into the academy, in terms of specific concepts and practices that have been reinterpreted in the educational context. The third part includes chapters where there is a specific link between education and industry, with educators and practitioners working together on educational innovations. Part four looks at agile learning in the school classroom, followed by chapters in part five that address various aspects of bringing experiences and techniques from the creative industries into teaching and learning. In part six, we conclude with several chapters on industry-focused software engineering in the classroom.

This new book serves as a reference to a range of different ways that the authors of the various chapters have addressed the conceptual links between industry and education in their own contexts. There is an overlap of practices, processes, and techniques within the chapters, and this book was not designed to necessarily be read from cover to cover. Rather, the six parts identify the synergies across the chapters contained in each one. Each part highlights different ways that industry-based thinking is integrated into education within an overarching conceptual idea. The book chapters are written by different authors, with different contexts, emphases, and focus. Nevertheless, a range of common themes emerge, whether that be adoption, partnership, agility, creativity, or contemporary engineering practice. Each of the parts is outlined below.

Part One: Broad Themes From Industry in Education

Part one opens the book with chapters that introduce broad themes from industry that can have an impact on what goes on in the classroom. This part begins with the chapter "From the Workplace to the Classroom: How Ideas from Industry Can Inspire New Kinds of Learning", written by the editors, which is intended to provide an overview of various industry-based perspectives on teaching and learning as they have been explored so far in the literature. This chapter provides a broad and brief introduction to many aspects of this area and concludes with a summary of seven ideas from industry and some of the skills they bring into the classroom.

The second chapter is "Can Teaching the Future of Work Make the Future of Work Less Uncertain?" by Taurean Butler, Megan Rorich, Hayley Sparks, and Maheshi Wadasinghe from Tech Futures Lab in New Zealand. The focus of this chapter is a master's program in Technological Futures that provides students with the opportunity to rethink their own career paths in a rapidly changing world while also providing new opportunities for their communities through entrepreneurial and

disruptive projects. Central to the program is an andragogical approach that enables students to innovate independently within a supportive environment.

The first part closes with "From Industry to Academia: Case Studies of Innovative Learning Practices in a Digital Context" by Laurent Antonczak, Marion Neukam, and Sophie Bollinger from the Université de Strasbourg and Université de Lorraine, France. This chapter provides three examples of teaching and learning that are drawn from industry practice; learning-by-doing through workshops, project-based learning by means of case studies, and a heutagogical approach for the advertising and creative industries. The reference to heutagogy, where learners self-determine their own learning investment and actions based on their own motivation and abilities, links back to the andragogy approach referenced in the previous chapter, and indeed the authors discuss how learners can develop, in different contexts, along the pedagogy–andragogy–heutagogy continuum. The authors also indicate the importance of direct collaboration and shared experience between educators and industry, as introduced in chapter one and further explored in the chapters in part three.

Part Two: Bringing Industry Approaches Into the Academy

Following on from part one, which covers broad industry-related themes in education, this part contains chapters that have a more specific focus, where particular techniques have been brought from industry into the implementation of tasks within the academy.

The first of these is "Hybrid Project Management in Post-secondary Research and Education" by Gregory Skulmoski and Fabiola Brendolan from Bond University, Australia. This chapter is based on experiences of project management in both academia and industry. The authors define hybrid project management as combining project management elements from different project management methodologies, such as agile and lean, to achieve project goals. They share experience reports from both academia and industry, showing how insights gained in each context helped to inform practice improvement in the other. One illustrative example from the chapter describes how lean principles were applied to the updating of the university research ethics process.

The next chapter is "A Systems Engineering Approach for Blended Learning Design" by Alison McKay, Dan Trowsdale, Simon Carrie, Gerard Duff, and Celia Goodburn from the University of Leeds in the UK. This chapter focuses on the development of learning materials for blended learning delivery in the university context, using ideas taken from the systems engineering practices used to manage the design and development of products in industry. The chapter outlines how this approach involved multi-disciplinary teams of academics and learning technologists, a systematic approach to design, and the ability to accommodate multiple stakeholder requirements.

The third chapter in this part is "Ambidextrous Approaches to Postgraduate Programme Development in Higher Education" by Yvonne Hoggarth from the University of York, UK, which looks at how educational institutions need to

address the various forces at play in complex environments. To support this analysis, the chapter uses a framework of organizational ambidexterity based on March's concepts of exploitation and exploration. Exploration is outward-facing activities, while exploitation is inward facing. Both have their roles, and the chapter describes the interplay between them in the form of contextual ambidexterity. One implication of taking a more ambidextrous approach to academic program development is that it may mean negotiating more flexible teaching and learning frameworks when collaborating with external partners.

Part Three: Education and Industry Working Together

Perhaps the most obvious way in which ideas from industry come into education is where students work directly with industry stakeholders as part of their learning. This part comprises three chapters that describe how direct education/industry partnerships have been used to support student learning in very different ways.

The first of these is "The Agile Semester: How We Used Agile as an Engagement Mechanism" by Leigh Griffin and Brendan O'Farrell (Red Hat), and Colm Dunphy, Peter Windle, and Eamonn de Leastar (Waterford Institute of Technology—WIT), Waterford City, Ireland. The link with industry here is in preparing students for a specific professional pathway through a partnership between a software development organization (Red Hat) and an educational institution (WIT). Links between the two include guest lectures, participation in industry boards, and the establishment of a hiring pipeline where interns and graduates can find employment. The chapter explains the importance of an agile mindset at all levels of the relationship.

The second chapter in this part is "STUDIO602: A Model for Designing Real World Collaborations Between Higher Education and Industry" by Thomas Cochrane (University of Melbourne, Australia) and David Sinfield (Auckland University of Technology, New Zealand). This chapter explains how a student project was set up to work with a local district health board to develop designs for mobile applications that could directly help healthcare workers in their daily routines. The chapter discusses the application of several techniques used in industry, including design thinking, team management, stakeholder engagement, and rapid prototyping techniques. The pedagogical design principles outlined in the chapter facilitate authentic collaboration between student design teams and industry.

The next chapter is "Simulated Internships in Schools: Engaging Learners with the World of Work to Promote Collaborative Creativity" by Louis Major from the University of Manchester, and Alison Twiner and Rupert Wegerif from the University of Cambridge, UK. This chapter examines the potential of school-based virtual internships to support collaborative and creative learning and links to the workplace. These internships involve small groups of school students designing, modeling, or building a local solution to a global challenge presented virtually by engineers from two leading international telecommunications companies. The chapter outlines how virtual internships can successfully link schools and the world of work.

The final chapter in this part is "Bringing the Human Resource Management Experience to the Lecture Hall Through the Dramatic Arts" by Sinéad McCotter from the University of York, UK. Human Resource (HR) Management students may have very limited experience of the organizational setting in which HR activities take place. This chapter describes an innovative partnership whereby aspects of a performance appraisal review meeting are dramatized in the lecture hall, with the expert input of an HR manager. Students are able to interact with challenging professional scenarios in a supportive environment where they can propose solutions to the scenario, advised by both academic and professional experts. Although this chapter is placed in the part that addresses direct collaboration with industry, it might equally have been included in part five, "Bringing Experiences from the Creative Industries into Teaching and Learning", because of its use of the dramatic arts in teaching.

Part Four: Agile Learning in the School Classroom

This part of the book looks at how agile methods have been applied in the school classroom, with two chapters that describe how schools in different countries have been implementing agile approaches in different contexts. Interestingly, articles from these same schools were published in our previous volume on agile and lean concepts for teaching and learning, but these chapters are written with a combination of new co-authors, alongside Willy Wijnands (eduScrum), and Nicola Cosgrave and Paul Magnuson (Agile in the Alps).

The first of these chapters is "Experience the 'Flows' with eduScrum: About the Why, How, and What of the Empowerment of Students and Teachers" by Willy Wijnands and Kristina Fritsch of eduScrum. As the title suggests, one of the key issues addressed in the chapter is flow experience, including team flow, and how it can be fostered within the eduScrum learning experience. Various "learning chances" are outlined as examples. The martial arts concept of *Sangen* is discussed as a way of thinking about the interactions between learning scope, students, and student teams. The chapter concludes by presenting a learning value matrix that aligns a set of personal competencies to twenty-first-century skills via the activities and learning products within the eduScrum framework.

The second chapter from the school context is "Agile in the Alps: Stories of the Agile Classroom, from Teaching and Learning to Administration" by Nicola Cosgrove, Tom Cosgrove, Paul Magnuson, and Sarah Graham of the Leysin American School in Switzerland. The chapter reflects on a range of agile practices that have been adapted to suit the needs of the students and the school. The authors describe the challenges of applying new concepts such as "slack" in teaching and learning and aligning social and emotional competencies to an agile mindset. In addition to applying agile ideas in the classroom, these practices have transferred to other aspects of the school such as residential life, administrative work, and staff recruitment. The chapter begins with stories from the classroom and concludes with some examples from the administrative side of the school.

Part Five: Bringing Experiences From the Creative Industries Into Teaching and Learning

This part contains three chapters that in different ways bring in aspects of the creative industries to enhance the learning experience: broadcast media, music, and creative writing.

In chapter "Production of the 70:20:10 Webinar", Anthony Basiel and Michael Howarth bring their experience of UK broadcast media into the context of online learning. In their chapter, they outline the concepts of a 360° Socratic model for webinar design and a technique called 45° Learning. These concepts help the online educator to rethink the ways in which they interact with their students over digital media, taking into account factors such as camera angles, distances, and props. The 360° model is informed by prior research that suggests 70% of learning comes from challenging (informal) assignments, 20% is social through peer-to-peer interactions and feedback, and only 10% is formal learning. The chapter outlines how these principles can be brought into the design and delivery of the online learning experience.

The second chapter in this part is "Developing Music Production Expertise Through Virtual Collaboration" by Mark Thorley based in Coventry, UK. Increasingly, music production is becoming a collaborative process that leverages digital tools. Current versions of the ProTools music recording software, for example, are designed to support online collaboration. This chapter outlines three case studies where university music students were able to work with professional international musicians. The cases described cover a South African classical recording remix, a Jazz mix, and a remix of an acoustic singer-songwriter. In each case, the various successes and challenges are described, along with the feedback on student work from the professionals. These experiences provide unique opportunities for the students to learn from real-world collaboration.

This part concludes with the chapter "Educational Design Fictions: Imagining Learning Futures" by Samuel Mann, Richard Mitchell, Phoebe Eden-Mann, David Hursthouse, Mawera Karetai, Ray O'Brien, and Phil Osborne, from several different institutions in the Otago region of New Zealand. Building on the idea of design futures, from design theory and practice, this chapter includes a series of educational design fictions written by six of the contributors. These fictions provide a means for critically envisioning possible educational futures as creative provocations that raise questions about future directions, challenge understandings, and provide a lens on the present. The activity of creating design fictions is presented as a generative method for informing and promoting discussion about the future direction of education.

Part Six: Industry-Focused Software Engineering in the Classroom

The final part of the book comprises three chapters that look at different ways in which students can learn how to engineer digital products using an industry lens. The first of these chapters is "Connecting Industry and Academy Through Cyber-Physical Systems for Disruptive Education in Machine Automation" by Victor H. Grisales-Palacio, Ubaldo García-Zaragoza, and Heriberto Forero-Correa from the Universidad Nacional de Colombia. For students of engineering, it is important for them to address increasing digitalization in industry. One advantage of this technological change is that there are more tools available for simulating industrial processes. This chapter describes a learning experience that employs cyber-physical systems to connect the manufacturing and pedagogical perspectives, where students use various industrial strength software tools to design and simulate a box labeling machine.

The next chapter in this part is "A Framework for Analyzing and Comparing Software Projects in Academia and Industry" by Pankaj Kamthan from Concordia University, Montreal, Canada. For students of software development, the transition from academia to industry requires them to have practical as well as theoretical knowledge of professional software engineering practice. Students therefore need to work on software projects as part of their studies, but, as this chapter explains, the contexts are very different and have to be considered by those who run such educational projects. The chapter therefore provides an understanding of software projects in academia, compares them to those in industry, highlighting essential similarities as well as differences. It presents a survey of undergraduate and graduate students' experience in software projects and provides recommendations in the direction of positive as well as negative learning for teachers and trainers involved in software projects.

The last chapter in this book is "FDD, Crystal, DSDM—An Educational Perspective" by Visham Hurbungs and Soulakshmee D. Nagowah from the University of Mauritius. The agile methods and techniques most widely adopted by software industries are Scrum, Lean, Kanban, XP, and test-driven development, among others. However, from an educational perspective, there can be value in studying some other, less commonly used, agile approaches, since each agile method has its own unique ways of approaching software projects. This chapter therefore focuses on three of these less familiar methodologies, FDD, Crystal, and DSDM, and highlights their application in a creative educational environment. The main objective is to better prepare students for an increasingly complex and dynamic global software industry.

We hope that this book will repeat the success of the first volume by bringing valuable new ideas into education that can ensure high levels of synergy between the learning space and the workplace. Successfully bringing methodologies from industry to the classroom is a challenge for educators, since it requires a deep understanding of which aspects of these methods can provide value to the learner largely unchanged and which may need to be extensively reinterpreted to ensure that they work within the classroom context. There is no doubt that many educators have found

inspiration from industry in developing powerful new ways to approach their professional practice, and we are pleased to have been able to capture some of their wisdom in this book. We very much hope that this publication will inspire other researchers and practitioners to further develop these innovative and inspirational approaches to teaching and learning.

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Introduction: Broad Themes From Industry in Education

From the Workplace to the Classroom: How Ideas from Industry Can Inspire New Kinds of Learning

David Parsons and Kathryn MacCallum

Abstract The relationships between education and industry are many and varied. These relationships can be very direct, for example where students do some of their learning in the workplace, or practitioners engage with schools and universities by bringing their knowledge of the workplace into the classroom. There are, however, many more creative relationships that involve concepts and ideas from industry being adopted and repurposed in new ways for the educational context. We begin this chapter with an overview of the more traditional relationships between education and industry, including areas such as internships and externships, before exploring a range of ideas that have come from repurposing ideas from industry for the very different context of the classroom. These include agile methods from the software industry, lean thinking from the motor industry, creative community spaces for product development, design thinking, crowdsourcing, entrepreneurship, and industry-based models of leading change. We outline several ways in which these ideas from industry can inspire new kinds of student learning, not just to prepare them for the contemporary workplace but to provide them with essential higher-level skills that can help them to prepare for an unpredictable future.

Keywords Agile methods · Lean thinking · Design thinking · Makerspaces · Crowdsourcing · Entrepreneurship · Leadership

1 Introduction

The aim of this chapter is to outline how various synergies exist between ideas that come from industry and how they can be used in education. Terms such as *didactic transposition* have been coined to understand how scholarly knowledge

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is transposed in such a way that this knowledge can be taught in the classroom (Bosch & Gascón, 2006). This scholarly knowledge, however, can draw from a wide range of sources, including industry. In this chapter, we explore the different ways that practices, processes, and techniques, that represent this knowledge, can be drawn from industry and interpreted in education practice in different ways. At one level, there are explicit and obvious links between education and industry. These tend to focus on students gaining learning experiences that are directly linked to specific industry contexts. This may be students or teachers directly experiencing a workplace, or representatives from industry bringing their experience, skills, and knowledge into the classroom. This is no doubt a valuable learning experience for many students and is discussed in the first part of this chapter.

There is, however, a much broader and more creative way in which ideas from industry can be brought into education. This is where concepts, practices, techniques, and ways of thinking (collectively referred to as "ideas" in this chapter) that have developed and evolved in industry contexts are rethought and reinterpreted for teaching and learning. This is the topic of the second part of this chapter. Although these areas are treated separately, there are undoubtedly overlaps between the two approaches. However, our key area of interest is identifying some specific examples of how ideas from industry have proved valuable in the classroom.

We have identified seven specific areas where we see this type of migration of ideas from industry to education, but there are certainly many more, and those covered in this chapter should be regarded as an indicative, rather than a comprehensive, list. The motivation for this chapter is to help educators become more aware of the many opportunities that are available for learning to be enhanced by bringing in new ideas from outside the classroom to inspire, challenge, and excite students. It is hoped that the examples introduced here will encourage educators to not only explore these ideas but also to seek out and employ other ways in which industry practice can inform education.

We are aware that educators in some specific domains will already be very familiar with using some of these approaches in their own practice. However, the intent of this chapter is to inform educators across many different disciplines about these ideas. By doing so, we hope to encourage them to adopt approaches that they may not necessarily associate with their own areas of practice, but that may bring new and fruitful teaching and learning experiences into their classrooms.

1.1 Factory or Classroom?

The relationship between education and industry is a complex one, shaped by multiple discourses and histories, and sometimes hindered by a lack of trust or misunderstandings around purpose (Cooper & Shepherd, 1997; Zopiatis & Constanti, 2007). The perception of bringing industry into the classroom can have potentially negative connotations with the "factory model" of education. Implying the industrialization of learning suggests that educational institutions follow outdated models of learning that

are reflective of how young people were trained for a past industrial era. As Watters (2015) points out, this view, which perhaps found its origins in Alvin Toffler's influential 1970 book "Future Shock", is both flawed and oversimplified. Looking at the industry-education relationship from a more positive perspective, it is clearly the case that one role of education is to provide young people with the skills and attitudes to be able to find fulfilling and rewarding employment as adults. This means that educators need to ensure the skills and competencies young people are gaining are valued in the employment market (Green & Schulze, 2019). Links between industry and education can therefore ensure a better understanding of industry needs, and support educators to understand and respond to those needs. While such links between industry and education can support the dual purpose of both helping students to be work ready and providing suitable workers for industry, they can also provide real-world connections and contexts for broader learning. Ideas from these contexts can be brought into the classroom to enable creative and innovative learning approaches.

1.2   Domains of Purpose and Twenty-First Century Skills

Even if the link between education and productivity is, in fact, "tenuous and complicated" (Chang, 2011, p. 189), education also has a broader role in supporting students' social and personal development. As Biesta (2015) defines it, education has three domains of purpose: qualification, socialisation, and subjectification. It may be considered that in fact social and personal development are becoming increasingly important in the contemporary workplace, for example, the development of emotional intelligence for effective leadership (Brittain et al., 2020; Goleman et al., 2013). Increasingly, students are said to be in need of preparation for an unknown future for, in the rather overused phrase, jobs that "haven't been invented yet" (Frey, 2014, p. 38). Equally, then, we are preparing students for *lives* that haven't been invented yet, where social and personal development may be increasingly valuable.

Alongside this there has been a focus on what are often called twenty-first century skills, which are typically explained as being higher-level, transferable skills. These may encompass commonly reflected skill sets such as the "4Cs" of creativity, critical thinking, collaboration, and communication (Schaffhauser, 2015), but equally are often expanded beyond these core competencies to be inclusive of a range of other more specialised skills. The World Economic Forum (2016) outlined no fewer than sixteen foundational literacies and character qualities that they asserted were essential for the twenty-first century learner, including social and emotional skills. There is, however, consensus about a consistent set of core skills relevant to the contemporary learner. An analysis of eight twenty-first century skills frameworks showed that collaboration, communication, digital literacy, citizenship, problem solving, critical thinking, creativity, and productivity are mentioned in most of the frameworks (Voogt & Roblin, 2012).

It is also important to note that while the names of most twenty-first century skills seem to reflect those skills that were equally important in a previous era, their

mediation through digital technologies changes them qualitatively, and links them to important contextual skills that relate to broader competencies that are required to take advantage of the core skills: Ethical awareness, cultural awareness, flexibility, self-direction, and lifelong learning (van Laar et al., 2017).

This emphasis on supporting students to develop relevant twenty-first century skills requires the adoption of new pedagogies (Kivunja, 2014). These new pedagogies focus on the learner building their own knowledge, typically through social, hands-on and experiential learning exercises (Obi et al., 2022). Experiential learning is developed from many other learning theories, in particular Dewey's work on experience (Beard & Wilson, 2013). The theory highlights that knowledge is created through the transformation of experience. Learning takes place through reflection on the activity and then bringing this new understanding to perform another activity (Kolb, 2003). Experiential learning recognises learning as an active process where learners develop their knowledge, transferable skills, and attitudes from direct experiences within or outside a classroom setting (Obi, et al., 2022). Therefore, it is this transfer of learning into other contexts that supports the development of a wider range of critical twenty-first century skills.

While learning is supported through the application of new knowledge, the building of this new knowledge can often be supported through collaborative and social approaches. Social constructivism emerged out of cognitivist theories and recognised that learning is a social experience rather than an individual one (Kivunja, 2014). Therefore, the development of twenty-first century skills generally underpins the ability for students to work together to solve problems, discuss ideas, or acquire new knowledge.

The ideas from industry outlined in this chapter can directly assist learners to effectively develop relevant twenty-first century skills and assist in their social and personal development by exposing them to new ideas, creative activities, empowering processes and cognitive challenges. Drawing on relevant pedagogical approaches based on learning theory will help integrate these skills into the contemporary classroom. In the next section, we start to explore the different pedagogical approaches that have started to be brought from industry into education.

2   Industry in Education—A Two Way Relationship

When we talk about the relationship between education and industry, then we are looking at two moving targets: Industry, which is rapidly evolving internationally through productive technologies and the search for new "blue ocean" innovations (Chan Kim, 2004), and an education system that is also embracing change, trying to meet the needs of new generations of students. Social commentators increasingly grapple with questions around whether each generation of students is, in fact, in some way significantly different to the one before. Whatever the claims of this debate, there does indeed seem to be evidence that student cohorts are evolving in higher

education, and that this means higher education institutions must adapt their offerings accordingly (Jones et al., 2010).

So, the simple question is, what can industry offer to students in today's classroom? Some answers to this question are straightforward, for example, partnerships between businesses and educational institutions. These are perhaps most seen in relationships between industry and universities where activities such as joint research and internships are important (Thune, 2011). Industry partners can also bring their experience into the classroom in partnership with faculty (Tenenberg, 2010) and provide students with complex, open-ended problems to solve that provide more challenge than typical in-class assignments (Konrad, 2018). By bringing industry projects into the classroom, learning can be contextualised and draw on real-world problems. At the school level, Career and Technical Education (CTE) includes pathways of both academic and technical study that integrate classroom and real-world work-based learning, organised around multiple sectors of industry (Hoachlander, 2008). There is also the concept of "externships", where teachers gain their own experiences from industry to bring back to the classroom. This can lead to some innovative teaching practices such as casting students as employees in inquiry-based research projects (Bowen & Shume, 2018).

There are also some less explicit relationships, where students may undertake industry-related learning in the classroom but there is no direct connection with industry partners. This learning may relate to specific industry-related skills in the context of projects in engineering or the sciences (e.g., Hofstein et al., 1999), but equally can address more generic skills, such as addressing the social and political experiences that will be encountered in the industrial world, challenges such as teamwork and customer relations—developing "corporate literacy" (Weinstein et al., 2001).

All these relationships (and more) provide different types of interaction between education and industry, as summarized in Fig. 1. In this figure, which is intended
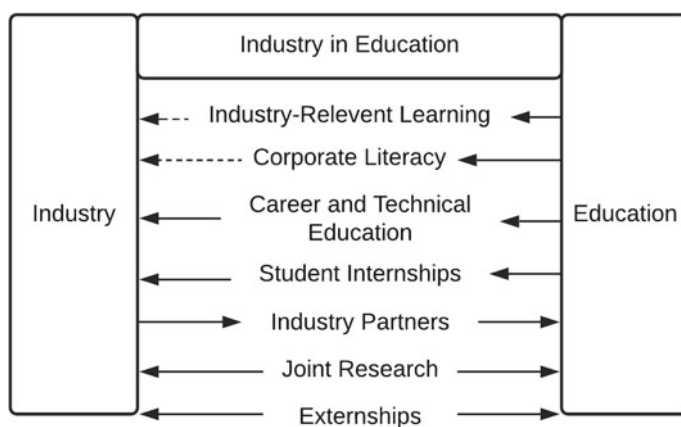

Fig. 1 Interactions between education and industry

to be indicative rather than exhaustive, relatively weaker relationships are indicated by the dotted lines, such as those where students do industry-relevant learning in the classroom or develop their corporate literacy, but there is no direct interaction with industry. Some other relationships are based on activities that do link directly from education to industry such as CTE and student internships. Some, like industry partners, have a relationship in the opposite direction, from industry to education, while other activities, such as joint research and externships, are highly interactive between both industry and education.

3   Ideas from Industry for Teaching and Learning

The previous section outlined some ways in which education and industry can work together to give students experiences that can better prepare them for their working lives. However, important as these are, the greater focus of this chapter is what industry-based ideas and techniques can offer educators at a conceptual level. We ask: What kinds of ideas around how contemporary organisations operate can be used as the basis for designing learning experiences for students at all levels of education? Such a question is by no means new. Dewey and Dewey (1915) described how a school in Gary, Chicago had students build gasoline engines and vacuum cleaners as part of their cross-curricular learning. In other words, engaging directly with the cutting-edge technology of the day (note that, despite the gendered language of the day, the context of this quote refers explicitly to "every child in Gary, boy and girl").

> When a pupil has completed a problem of this sort he has increased knowledge and power. He has tested the facts he learned and knows what they stand for in terms of the use the world makes of them; and he has made a useful thing in a way which develops his own sense of independent intelligent power. (Dewey & Dewey, 1915, p. 277)

This may seem to be the industry-relevant learning that was included in Fig. 1, but it is more than that. It is not about (in this case) preparing students to build engines and vacuum cleaners. Rather, it is about taking something that happens in industry and turning it into a valuable learning experience. Dewey was against the concept of vocational education as being too attuned to industry needs and not able to innovate. In contrast, he felt that the role of education was to facilitate student learning and growth through transformative teaching (Ralston, 2021).

So, what types of ideas from industry can we already see being brought into educational contexts as transformative learning experiences? As already discussed, there are many approaches that are related to making classroom experiences more akin to those in the workplace. However, beyond this we can see ideas that are not based on any explicit links between education and industry. After all, simply using the workplace as a metaphor for learning spaces neglects the unique qualities of the classroom (Marshall, 1988). As Dunlap and Grabinger (1996) point out, the learning environment does not have to try to replicate the work environment. Rather, it should provide a space to develop skills through anchored instruction, including authentic

problem solving. Koul and Nayar (2021) note that Education 4.0 should not be a copy of Industry 4.0 but provide new learning experiences that reflect the changing nature of work and technology. From this perspective, we find industry-inspired ideas being re-moulded and re-purposed to support teaching and learning. This less explicit link between industry-based ideas and their application in education has enabled educators to develop engaging, collaborative, and creative learning spaces, as well as better preparing their students for an increasingly complex and dynamic global environment.

3.1 Seven Ideas from Industry that Can Be Applied in Education

In this section we will briefly discuss seven industry-related ideas that have been transitioned into new contexts of teaching and learning. These examples cover lean thinking from the motor industry, agile methods from software development, design thinking from product development, hacker/makerspaces and Fab Labs from maker communities, crowdsourcing from business innovation, entrepreneurship and enterprise, and industry-based models of change and leadership. These examples are just an indicative selection from a broad field of research and practice.

3.1.1 Lean Thinking

If there is one technique from industry that appears to be focused on basing education on a factory model, then on the surface lean thinking may appear to be exactly that, derived as it is from the lean manufacturing processes developed in the Japanese car industry after the Second World War (Womack et al., 1990). It is certainly the case that some aspects of lean thinking focus very much on the efficient creation of products. However, there are also many ideas that translate well to other domains.

There are two general areas where lean thinking can make a valuable contribution to how education is delivered. One is the focus on the value stream, which involves identifying the key value to be delivered and focusing on removing all impediments to delivering that value. Within that value stream we endeavour to replace batch and queue with flow, to allow the learner to pull learning towards them as needed rather than having it pushed towards them, and allowing them to manage their own work in progress. Koul and Nayar (2021) refer to future learning environments where learners can autonomously dip into and out of continuous learning flows. The lean concept of the Kanban board can be used to manage these flows, allowing students to pull the learning when they are ready for it, managing their own WIP (work in progress) and taking responsibility for completing their own learning tasks.

The other important area is a focus on quality. There are two concepts of improvement in lean thinking. One is *kaizen*, which is a commitment to continuous improvement, while the other is *kaikaku* which is to make radical changes for improvement, and of course both are equally important, and each should be used when appropriate. The other key component of quality is to identify *muda* (waste). In education this may mean things such as not spending time on content that is not actually valuable to learners, avoiding wasting time waiting for feedback and, perhaps most important, avoiding the waste of human capital, ensuring that all learners gain maximum benefit from their educational experience.

Lean approaches to education have been explored in some detail in the university sector (e.g., Alves et al., 2016), perhaps less so in the school sector, but there are examples such as Flumerfelt and Green's (2013) study of a high school applying a lean approach to continuous improvement. In this context, a set of metrics were developed that monitored how much time students spent on specific types of learning activity (e.g., active versus passive, individualized versus standardized, etc.). As a result of this data, flipped learning was introduced, which led to improvements, particularly around individualized and differentiated instruction.

Lean thinking is therefore able to provide a framework within which educators and students alike can focus on what is most important to them in the learning process and look for ways to remove all impediments to that value.

3.1.2 Agile Methods

Agile methods emerged at the beginning of the twenty-first century as a way of developing software so that it better met customer needs and was more adaptive to changing requirements. Since then, it has enjoyed considerable success as a method of education (Parsons & MacCallum, 2019). Agile and lean concepts have much in common and have both been applied to software development. What agile thinking and approaches can offer to education is a focus on short delivery cycles, where outcomes of learning are planned based on need and priority and are seen to be delivering regular outcomes.

Building learning around an agile process has several benefits. It gives students agency in prioritising their own learning, working at a sustainable pace, and meeting their own goals. It encourages collaborative teamwork and independent learning. Student teams can manage their own task boards, estimating and organising their own classroom activities. The various ceremonies of agile methods such as Scrum ensure that there is sufficient reflective practice embedded in the process enabling, for example, metacognition to take place in retrospective meetings (Vogelzang et al., 2020). It is particularly powerful where students are learning in teams but can still be used to manage individual learning.

There are some schools that have built their learning process entirely on top of an agile approach. For example, in eduScrum schools in The Netherlands, students work together in teams in an active, effective, and efficient way. It is claimed that students are more engaged, more productive and achieve better learning outcomes,

while being able to discover who they are and what their abilities are (Wijnands & Stolze, 2019). The Leysin American School in Switzerland has also adopted an agile, Scrum-based approach to learning that emphasises the value of the agile mindset of *explore, adapt, redo and grow*. Students have effectively become able to run their own classes without teachers (Magnuson et al., 2019).

Although a complete transformation to an agile process might seem challenging to educators, specific agile practices such as iterative learning cycles, task boards and explicitly identifying when an element of learning has been completed can all be integrated into existing teaching contexts.

3.1.3   Design Thinking

To say that design thinking is a method from industry that has been adopted in education is perhaps not entirely true. Design thinking began as an academic concept, which then found its way into industry and has since been readopted back into education by many practitioners. John E. Clancey first used the term in his writings at Stanford University in the late 1950s (Arnold, 2016), and the link with Stanford has been sustained by the Stanford d school that addresses many aspects of design. However, design thinking became industry focused with the establishment of IDEO in the 1990s and is now widely recognized as being a valuable design technique in industry across all kinds of organizations, not just creative industries (Brown & Katz, 2019).

Design thinking focuses on producing something of value by engaging openly and empathising with customers. It encourages ideation—the generation of many ideas—followed by a focusing down on the best solution through a prototyping process in collaboration with stakeholders. Design thinking can be used by educators to ensure that what they are delivering in their practice is meeting the needs of their students and can also be used by students in project work. When used in educational practice it provides an iterative framework for constructivist learning that encourages metacognition, learning through experience, and complex problem solving (Scheer et al., 2012).

An example of design thinking being used in a middle school classroom was described by Carroll et al. (2010). In this activity, students used design thinking to learn about systems in the context of geography. They were asked to search for examples of systems in and around the school site (e.g., cafeteria, parking, etc.), capturing these in a map. They then went through a design thinking process to identify problems with these systems and ideated and prototyped solutions. This experience fostered the students' imagination and creative confidence.

Another example from higher education saw students taking a course in entrepreneurship using design thinking to redesign their own classes to increase their engagement and motivation (Ching, 2014). The resulting prototypes included a redesign of the classroom layout, a charity contest as part of the assessment, and taking classes with outside experts.