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Abstract

Disruption is an inevitable factor in business and society, while inability to mitigate and manage risk can cause irreparable damage to business, the economy, and our ways of life. The COVID-19 pandemic has heightened interest in standards-based strategies for risk management and crisis preparedness to enhance organizational and societal resilience. University curricula that integrate national and international standards offer students a rich skill-set for effective performance in their careers. Moving forward, we must cultivate capable professionals who understand the challenges and risks facing society, and who grasp standards and systems for strategic planning, response, and recovery to promote organizational resilience and sustainable development. This paper focuses on the effectiveness of integrating risk management and continuity standards into university curricula, based on implementation at a large private university and regional community college in the Northeastern United States. We propose and evaluate a modular approach to introduce students to specific national and international standards, and teach them to identify and apply relevant standards based on the locally driven, whole community nature of disaster preparedness, response, and recovery. Education using standards-based curriculum and the competencies that result will be key to readiness for tomorrow's graduates.

Introduction

The COVID-19 global pandemic has served as a painful reminder that disruption is an inevitable factor in business and society. There is a clear need to be able to mitigate and manage risk, and the inability to do so can cause significant, potentially irreparable damage to business, the economy, and our ways of life (Van Der Vegt, 2015). Businesses have increasingly incorporated elements of continuity planning, particularly following natural disasters, cybersecurity breaches that compromised consumer and business information, and acts of terrorism, yet many were unprepared to meet challenges for continued operations during a global pandemic (Koonin, 2020).

The crisis has intensified private and public interest in standards-based, systematic strategies for risk management, crisis preparedness, and business continuity to enhance organizational and societal resilience and competitiveness. Such standards and strategies will shape how our society deals with vulnerability and disruption, and will in turn shape the standards of how the professional will create value for society. Those entering the public or private

workforce must understand not only the role of standards in general, but also the role that particular standards and their application can have upon professional practice. As we move forward, it is clear that we need to cultivate capable professionals who understand the challenges and risks facing organizations and society, and who grasp standards and systems for strategic planning, preparedness, response, and recovery to promote organizational continuity, resilience, and sustainable development. National and international documentary standards have an increasing presence in risk management, crisis preparedness, response, recovery and organizational continuity, and these domains are interwoven in health, safety, environmental, policy, business, and information technology disciplines. Operational standards in these domains provide an opportunity for the implementation of innovative systems and strategies that reduce organizational vulnerability, provide for efficient crisis response and recovery, and promote resilience. Curricula that incorporate and apply key standards used in the U.S. offer students a rich and valuable skill-set in preparation for effective performance as they begin their careers (Greenwood, Schneider, Hess & Abraham, 2022).

This paper describes and presents an evaluation of a modular approach for standards-based curricula on risk, disruption, and continuity for various degree programs in engineering technology, smart systems technologies, construction and environmental, health and safety management, and its impact on students entering the workforce in engineering and management disciplines. Our research involved integrating risk, disaster and continuity standards content into existing graduate and undergraduate courses and programs at two institutions of higher education in the Northeastern United States: a large private university, and a regional public institution. Curriculum was implemented in a range of courses at these institutions and validated by participating higher education partners at additional large private and regional public institutions, providing feedback across the arc of early college constituencies and later college and graduate education for professional practice. Our approach was designed to prepare students in their future roles to identify and apply a range of relevant national and international standards based on the locally driven, whole community nature of disaster preparedness, response, and recovery, and to integrate systems across several relevant standards for risk, disruption, and continuity. While the curriculum was piloted in environmental sustainability, health and safety, engineering technology, and smart systems technologies courses, it applies to a range of disciplines that incorporate risk, disaster science, business continuity, and critical systems resilience.

Background – Risk and Resilience

Risk is a common, yet complex term that lacks a clear, consensus definition (Xu, 2008). It is understood in different ways that range from neutral to adverse, and from objective to subjective connotations, depending on context as well as professional and scientific disciplines (Aven, 2012). For this work, we focus primarily on disruption risk, reflecting uncertainty and the potential for adverse outcomes such as harm or loss resulting from disruption. Resilience as a concept was described by Holling (1973) as the capacity of ecosystems to remain consistent despite external disruptions. Holling defined resilience as “a measure of the ability of ecological systems to absorb changes of state variables, driving variables, and parameters, and still persist” (1973, p. 18). The concept of resilience as persistence in the wake of external disruptions has since been applied to describe the adaptive capacities of individuals, human communities and larger societies (Abraham & Anumba, 2020;

Linnenluecke & Griffiths, 2010; Nelson, Adger & Brown, 2007; Norris et al., 2008). For this work, resilience is conceptualized as a characteristic of a system or an organization when considered as a whole. Previously, a system was considered “stable” when defined as strong, static and resistant to change (Manyena, 2006; McEntire et al., 2002). Currently, a system is understood to be stable when it is able to remain more or less the same within a range of conditions, is flexible and able to adjust to stress (Holling, 2001; Thompson et al., 2009). Such ability to identify vulnerabilities and adjust, adapt, and recover from disruption is critical as we navigate an ever-changing risk landscape that threatens the systems on which business and society depend (OECD, 2003).

Importance and Relevance of Standards for Risk and Resilience

The literature is replete with the call for organizational resilience, business continuity, disaster recovery, and risk management principles. Indeed, business and society are increasingly vulnerable to disruption in operations, supply chains, and our ways of life due to risk and uncertainty (OECD, 2003). These risks can be associated with a range of factors such as information security (Yao & Jong, 2010), terrorism (Coaffee, 2016), natural hazards (Kleindorfer & Saad, 2005), climate change and extreme weather events (Scott et al., 2020), aging infrastructure (Osei-Kyei et al., 2021), and global health threats (McInnes & Roemer-Mahler, 2017; OECD, 2003). National and international standards and guidelines for risk and disaster management offer structured frameworks and technical guidance that represent emerging consensus on best practice as firms seek to enhance organizational resilience (Tiernan et al., 2019). Tammineedi (2010) maintained that business continuity management in the absence of acceptable management standards involved varied and inconsistent approaches, often resulting in unreliable and ineffective continuity plans. Recent research by Alharthi and Khalifa (2019) demonstrated a positive and impactful influence on organizational crisis performance through formalized business continuity management, informed by standards. Such operational standards provide an opportunity for cross-disciplinary implementation of systems and strategies that reduce organizational vulnerability, provide for efficient crisis response and recovery, and promote resilience.

Risk and Resilience Standards in University Curriculum

As organizations recover from disruption of labor markets following the COVID-19 global epidemic, it is increasingly important to enhance standards literacy in young professionals. President and CEO of the American National Standards Institute (ANSI), S. Joe Bhatia (2011), maintained that standards education both at the university level and in the professional environment is vital because “standards and conformance play a critical role in the economy, impacting more than 80% of global commodity trade” (p.2). In the 2011 joint meeting of the APEC Project Advisory Group on Education and ANSI Committee on Education, Bhatia asserted the need to increase standards education programs significantly if we intend to remain competitive in global markets, stating that “effective utilization of standards and conformance promotes technological interoperability and drives the global competitiveness of businesses,” and “a new graduate or professional who is familiar with the standards relevant to their industry and how the standards system works is a strategic asset to their future employer” (2011 p. 2). Standards-based curriculum in higher education can thus equip students with vital competencies that build their capacity to enhance organizational resilience and competitiveness in their future roles.

In September 2020, our research team was awarded a grant from the National Institute of Standards and Technology (NIST) for curriculum development to support integration of standards-based content into university curricula, as a means to strengthen student education, learning, and literacy in standards and standardization. Faculty in engineering technology and smart systems technologies programs at two institutions of higher education developed a set of multi-disciplinary learning modules to introduce students to standards and standards development while incorporating and integrating specific content from key standards used in industry and society. Traditional educational research has focused on enhancing a student's ability to acquire knowledge. More recently, the National Research Council has addressed how students learn, with a focus on how they encode knowledge through study tasks (Greenwood, Schneider & Valentine, 2018b). Karpicke and Blunt (2011) maintained the importance of considering retrieval processes that are developed during learning, and Taylor and Kaza's (2011) work reinforced this notion by demonstrating how self-contained modules can successfully be embedded in introductory programming courses to increase students' information security awareness. With this in mind, we developed a set of self-contained yet transposable learning modules incorporating standards on risk, disruption, and continuity.

Methods

Project Educational Approach

The educational approach integrated multiple standards in graduate and undergraduate curricula through the design, testing and evaluation of portable learning modules with thematic elements that can be configured and implemented in various combinations appropriate to course learning outcomes. Compatible modules were developed to introduce students to standards and standardization while incorporating and integrating specific content used in U.S. industry and society in the following three domains:

1. Risk: risk and vulnerability assessment, mitigation, and management;
2. Disruption: disaster and emergency mitigation, preparedness, prevention, and response;
3. Continuity: proactive strategies for recovery, continuity, and organizational resilience.

Key national and international documentary standards used in the U.S. that offer specifications and guidelines for organizations in one or more of these domains were introduced and incorporated in the modules. These standards promote assessment, planning, preventive action and response to advance organizational and societal preparedness and resilience. While we introduced students to a core set of standards, our broader goal was to enable students to identify and apply the standards that are relevant and applicable for an organization's particular locality and context. Key standards included the following:

- ISO 31000 - Risk Management;
- ISO 22301 - Security and Resilience – Business Continuity Management Systems;
- ISO 22318 - Business Continuity Management Systems –Supply Chain Continuity;
- NIST SP-39 & SP-30 – Information Security Risk;
- FEMA National Response Framework and National Incident Management System;
- FEMA Pandemic Preparedness/Response Guidance; and
- NFPA 1600 - Continuity, Emergency and Crisis Management.

The project team partnered with faculty at other institutions, specifically engaging applied science- oriented programs that develop applied technical and professional capacities. Given the current and future challenges that face society, students must be knowledgeable and skilled in using management systems and strategies as well as applicable technical standards related to risk, disruption, and continuity to their professional advantage (Greenwood, Schneider, Hess & Abraham, 2022). The project was structured to meet a series of goals that not only supported integration but also encouraged adoption by a broad set of faculty, students and programs. This included (1) a curricular goal for developing and embedding a set of reusable and customizable course modules on risk, disruption and continuity that integrate relevant documentary standards; (2) a faculty goal for supporting cross-disciplinary faculty expertise development in risk, disruption, and continuity and related standards; and (3) an educational effectiveness goal for ensuring the effectiveness of the course modules via a cohesive and proven educational structure.

Module Design Methods

Krechmer’s (2007) research on teaching standards to engineers and technical experts suggests that standards-based curricular content should begin with a broad view of the standards and establish their value and relevance. Purcell and Kelly’s (2003) work echoes the need to put standards in context regarding relevance, connection to practice, and how they impact other areas, such as business decision-making. To ensure a consistent approach among module developers in creating instructional materials, a standards-based curriculum template was developed based on literature review, using the approach of Greenwood, Schneider and Valentine (2018a; 2018b), and consistent with Kretchmer (2007), Purcell and Kelly (2003) Taylor and Kaza’s (2011) philosophies on curricular design. Table 1 provides a summary of the literature review results on module structure and content.

Table 1. Course Module Design Literature Review Matrix (adapted from Greenwood, Schneider & Valentine, 2018b)

Source	Module						Module				
	Overview/Description			Educational Content			Assessment				
	Overview	Rationale	Module Use	Suggested	Lecture	Slides/ Links	Readings/ Questions	Discussion	Assignments	Evaluation	Module
Liu, et al. (2013a; 2013b)	X	X	X	X	X	X	X	X	X	X	X
Quality Matters (2014)	X	X			X	X			X		
Orleans (2014)	X	X	X		X	X	X	X	X		
Mesa Center (2020)	X	X			X	X			X		
Stewart & Kogan (2015)	X				X				X		
Koszalka & Ganesan (2004)	X	X			X	X	X	X	X		
Graham, et al. (2001)	X				X			X	X		
Johns Hopkins (n.d.)	X	X			X	X			X		
Fink (2003)	X	X	X		X	X	X	X	X		X

The resulting template provided for development of content in three areas: (1) a module overview providing a description of the module structure and rationale, intended learning outcomes, and summary of key standards, (2) educational content with lecture materials, resources, sample questions and exercises, and (3) module assignments and assessment tools that can be applied. The template was structured to ensure that module learning objectives were established at both the undergraduate and graduate levels, and provided a means to establish a connection to course learning outcomes and topics. Table 2 provides an overview of the curriculum template.

Table 2. Overview of Curriculum Template

Component	Description
Module Overview & Description	- Executive summary with introduction and overview of the module - Module learning outcomes, description, and rationale - Summary of key standards included in the module
Educational Content	- Slides and notes for lectures with guided activities and exercises - Supplementary resources, e.g., readings, links to materials and tools - Example discussion questions and exercises
Module Assessment	- Example assignments - Assessment tools and methods to measure module effectiveness

The module overview materials were designed to introduce faculty to the modules in subject matter and approach, and the educational content was structured in thematic elements to facilitate inclusion and integration of the content by faculty. Instructional designers incorporated online learning strategies in the development of module materials to ensure that the content could be developed with resources or approaches needed for online delivery and customized accordingly for classroom delivery.

Module Educational Content

Kretchmer (2007) and Purcell and Kelly's (2003) research on teaching standards and standardization suggests that standards are taught most effectively in modules within a subject-specific, technical course. Module content was thus divided into elements appropriate to each topic area considering overarching themes identified across the modules, reviewed against relevant curriculum, and mapped to specific content in nine courses. This included one introductory and two upper level courses in the undergraduate curriculum in environmental sustainability, health and safety; two online courses in the graduate curriculum in environmental, health and safety management; one online course in the graduate curriculum in civil engineering technology/construction management; and three introductory level courses in smart systems technologies.

Purcell and Kelly (2003) observed that standards education may be most impactful after students have some experience and exposure to business operations, to enhance students' connection with the material and establish its value. Content for the introductory and undergraduate levels focused on introducing key module concepts, standards and their significance, and leveraged case studies and field trips to provide exposure to operations. Content for graduate level courses built upon introductory content, adding specific technical content for themes

that supported implementation across complex systems and organizations. Table 3 provides an overview that shows correlation of module themes within the specific courses targeted for module implementation.

Table 3. Correlation between Module Themes and Curriculum

Theme Relevance for Existing Courses	Themes in Risk, Disruption & Continuity Standards								
	Leadership & Strategy	Infrastructure	Critical Operations & Analysis	Business Impact	Risk Assessment & Reduction	Crisis Communications	Training, Testing & Tabletops	Supply Chain	Crisis/Emergency Resources
Principles of Environmental Sustainability Health and Safety (IUG)	✓				✓		✓		✓
EHS Management (G)	✓	✓	✓	✓	✓			✓	
EHS Management System Design (G)		✓	✓	✓	✓	✓	✓	✓	
Professional Communication (UG)	✓					✓			✓
Accident Causation & Prevention* (UG)	✓			✓	✓		✓		
Principles of Construction Leadership & Management* (G)	✓	✓						✓	✓
Introduction to Careers in High-Tech Ecosystems (G)	✓			✓	✓			✓	
Smart Systems Technologies (IUG)	✓	✓			✓		✓	✓	✓
Cyberphysical Automation II (IUG)	✓	✓	✓	✓	✓	✓	✓	✓	✓

*In progress (IUG) = Introductory undergraduate level (UG) = undergraduate level (G) = graduate level

Loepp (1999) emphasized the importance of designing a relevant, standard-based curriculum while ensuring students are challenged to address real-world problems. Our educational content was thus designed for flexibility to enable faculty to situate learning in contexts relevant to their courses, and to facilitate internalization of knowledge and deliver the material with meaning through connection with real-world situations and challenges. The provided resources, sample questions, exercises, assignments, and assessment tools were designed to incorporate active learning and engage with students via three forms of interaction:

- Participant-instructor interaction through classroom presentation and in-class exercises;
- Participant-content interaction through lectures, homework assignments, and examination questions; and
- Participant-participant interaction through in-class group exercises, class discussion or online discussion boards, and group homework assignments or projects.

Module Assessment Methods

Module assessment occurred at multiple levels, including internal and external content review as well as evaluation of student learning (Bharvad, 2010). Internal faculty evaluators from the two primary institutions reviewed content for evidence that the materials reflected different cognitive learning levels, provided a connection to real world contexts and situations, and connected back to the learning objectives. External content

review was provided from faculty at two secondary partnering higher education institutions as a means of content validation, and constructive feedback from internal and external review was applied to refine and improve module content. Following completion of module implementation in courses, faculty evaluated student learning based on results achieved on assignments, exercises, projects, and examinations.

Results

To date, we have engaged 148 students in seven courses with our modules, working with seven instructors at four higher education institutions. Our assessment metric for module effectiveness in student learning was based on percent of students achieving a grade of B or better on related course artifacts, with a goal for at least 80 percent of students to achieve an 80 percent or higher. In all courses in which modules have been implemented with graded assignments, we have met our goal for student success. Overall, 91 percent of students achieved a B or better on module-related assignments across the seven courses, based on the sum of the number of students achieving at least an 80 percent on each graded assignment, divided by the sum of the number of students completing each graded assignment. Effectiveness was also evaluated qualitatively through internal and external faculty feedback, which is addressed in the discussion section of the paper. Table 4 indicates the modules implemented in each course and summative module assessment results.

Table 4. Module Effectiveness Assessment

Course	Module	No. of Students	Assessment Method	% B or Better
Principles of ESHS	Risk Disruption	44	Based on student application of module concepts and content in relation to an off campus field trip, including assessment, treatment, and review.	Assignment A: 100% Assignment B: 94%
EHS Management	Risk	21	Based on application of module concepts and content within two unit assignments and a comprehensive case-based term project. Students were responsible for defining and assessing EHS and business risk.	Unit A: 95% Unit B: 86% Term project: 100%
EHS System Design	Continuity	12	Based on discussion and extra credit assignments to (1) relate critical resources to developing controls for major EHS issues and activities; and (2) enhance students' understanding of emergency management, in connection to business continuity.	Qualitative assessment

Course	Module	No. of Students	Assessment Method	% B or Better
Professional Communication	Risk	21	Based on class observation and student feedback on an in-class group exercise, where students represented stakeholders in disaster preparedness and response communication case study.	Class exercise: 80%
Intro to Careers in High-tech Ecosystems/Smart Systems Technologies (SST)	Risk Disruption Resilience	10	Based on class discussions and an essay assignment. Assignments in the SST course relate to the Intro course in which students visited over a dozen high-tech businesses.	Essay assignment: 80%
Cyberphysical Automation II	Risk Disruption Resilience	10	Based on an assigned paper where students addressed risk and resilience in the context of an individual automation project.	Paper: 80%

Discussion

Feedback from instructors has been positive overall, as well as constructive. At the graduate level, one instructor observed that students appeared to “grasp concepts well and were able to successfully apply them to the project and answer the related assignment questions,” and noted that the use of a group project allowed participant-participant collaboration to reinforce the concepts and advance students’ learning. At the undergraduate level, two instructors noted that students really engaged with the content and case study/scenario-based assignment, and that this helped to “make content more relatable.” Consistent with Loepp (1999) and Brame (2016), the case study approach promoted active learning and helped students to engage more deeply with the module content.

Conversely, a new instructor in environmental sustainability, health and safety who was just introduced to the content noted that a few students “were confused by exposure to frameworks from disciplines outside of the ESHS realm” and that it was a challenge to present some of the content that fell outside of the instructor’s disciplinary expertise. Going forward, the instructor intends to dig deeper into the module resources, and adapt and integrate our content further to target the specific focus of the course, which is consistent with the aim of our module structure and approach. Another instructor chose not to integrate the standards-based content in the semester for which it was planned due to lack of confidence with the material, lack of understanding of how and where to integrate the content in their course, and lack of time to review the resources provided with the instructional technology or to work with the instructional designers to address gaps.

Abu Karsh (2018) described the challenges associated with faculty adoption of new instructional technology and

resources when they are provided, based on individual faculty barriers and anxiety levels for using the technology. The author's survey of business faculty indicated that instructors experienced moderate barriers with the availability of support to use instructional technology effectively in the teaching and learning process, as well as with having time to develop lessons that use the technology (2018). The study suggests that instructors may benefit from training on integration of instructional technology for teaching and learning, as well as systematic technical and professional support. Bergeson and Beschorner's (2020) study of pre-service teachers employed a technology integration planning framework to help instructors purposefully apply instructional technology to support literacy goals for their subject matter. The authors' work suggests that instructors can benefit from support and scaffolding from standards module developers, as well as consideration of the barriers they face for use of instructional technology and the opportunity for reflection and collaboration with peers to overcome them. Burch and Mohammed's (2019) literature review on faculty perceptions of active learning technology integration in the classroom concluded that bringing faculty into the integration process can help to overcome instructor reluctance to adopt new instructional technology, and better supports student learning through the adopted active learning techniques. While these studies focused heavily on the use of digital media, their findings can apply to a range of instructional technologies consistent with Gagne's (2013) conceptualization, as "practical techniques of instructional delivery that systematically aim for effective learning, whether or not they involve the use of media."

We intend to further implement our modules in two additional courses in the current semester: one in environmental sustainability, health and safety and the other in construction management. While the instructor for the environmental sustainability course has had limited interaction with module developers, the instructor for the course in construction management was involved in developing the risk module and worked with other module developers early on to expand and adapt the content to suit the curriculum. The literature suggests that we may find better faculty and student engagement with module content in the latter case. In addition to integration in existing courses, we plan to offer a new, stand-alone undergraduate general education course that incorporates standards-based content from all three modules, taking lessons learned from the results of our research into account.

Conclusion

This research addressed methods, practices and results for integration of risk management, disruption, and continuity standards into curricula in higher education. Our experience and assessment indicate that a modular, active learning approach to standards-based curriculum development is successful for advancing standards literacy. The modules were effective for a wide range of audiences from undergraduate to the graduate level. The assessments of student learning indicated that the approach was effective in enabling students to engage in learning about standards that support organizational resilience, and to internalize, give meaning to, demonstrate, and apply this knowledge. By creating modular sets that organize standards content in smaller, thematic elements, the content can be used in and adapted to a variety of educational settings, with selection and customization of appropriate classroom activities and assessment tools. In addition, our faculty reviewers affirmed our view on the usefulness and applicability of the modules to a wide range of professional programs; however, introductory materials will likely merit scaling and adaptation by the individual instructor to provide the appropriate context

for their students and enhance engagement. Going forward, instructor adoption of our educational content may be facilitated by involving instructors earlier in the module development process.

Finally, the facets of what it means to be a professional continue to evolve. Standards-based, systematic strategies for risk management, crisis preparedness, and business continuity can enhance organizational and societal resilience and competitiveness in what may be referred to as the age of disruption. We maintain that such standards and strategies will shape how our society addresses vulnerability and prepares for and responds to disruption, and will in turn shape the standards of how the professional will create value for society. Standards-based curriculum and the skills and competencies that result will be key to preparing tomorrow's graduates for societal challenges that lie ahead.

Recommendations

While development of a faculty learning process was outside the scope of our initial project, our experience and feedback suggests that faculty with limited experience in implementation of risk, disruption and continuity standards may experience challenges with teaching about standards, may struggle to internalize the standards content themselves, and may lack confidence for instructor-participant delivery of the content. Further, while our work has focused on a specific implementation in higher education, young professionals who are not typically introduced to standards within their discipline in their academic career can benefit from structured and formalized instruction on standards and standardization. Faculty education and workforce development opportunities that use applied approaches based in their discipline would extend the impact of this effort. Programs targeting young professionals through professional societies or credentialing organizations would further enhance integration of standards and standards literacy among young professionals.

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