



Volume 4

INNOVATIONS IN  
HIGHER EDUCATION  
TEACHING  
AND LEARNING

# Inquiry-Based Learning for Science, Technology, Engineering, and Math (STEM) Programs

A Conceptual and Practical  
Resource for Educators

EDITED BY **Patrick Blessinger** *and* **John M Carfora**

Volume 4 | INNOVATIONS IN  
**HIGHER EDUCATION  
TEACHING  
AND LEARNING**

Inquiry-based learning (IBL) is a learner-centered active learning environment where deep learning is cultivated by a process of inquiry owned by the learner. It has roots in a constructivist educational philosophy and is oriented around three components: 1) exploration and discovery (e.g. problem-based learning, open meaning-making), 2) authentic investigations using contextualized learning (e.g. field studies, case studies), and 3) research-based approach (e.g. research-based learning, project-based learning).

IBL begins with an authentic and contextualized problem scenario where learners identify their own issues and questions and the teacher serves as guide in the learning process. It encourages self-regulated learning because the responsibility is on learners to determine issues and research questions and the resources they need to address them. This way learning occurs across all learning domains.

This volume covers many issues and concepts of how IBL can be applied to STEM programs. It serves as a conceptual and practical resource and guide for educators, offering practical examples of IBL in action and diverse strategies on how to implement IBL in different contexts.



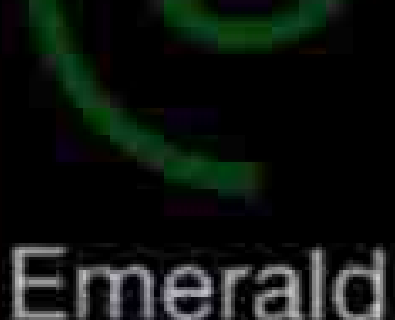
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# Inquiry-Based Learning for Science, Technology, Engineering, and Math (STEM) Programs

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SCIENCE, TECHNOLOGY,  
ENGINEERING, AND MATH (STEM)  
PROGRAMS: A CONCEPTUAL AND  
PRACTICAL RESOURCE FOR  
EDUCATORS**

EDITED BY

**PATRICK BLESSINGER**

*International HETL Association, New York, NY, USA*

**JOHN M. CARFORA**

*Loyola Marymount University, Los Angeles, CA, USA*

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INVESTOR IN PEOPLE

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PROGRAMS: A CONCEPTUAL AND  
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# INNOVATIONS IN HIGHER EDUCATION TEACHING AND LEARNING

Series Editor: Patrick Blessinger

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- Volume 3: Inquiry-Based Learning for Multidisciplinary Programs: A Conceptual and Practical Resource for Educators – Edited by Patrick Blessinger and John M. Carfora

## LIST OF CONTRIBUTORS

<i>Amelia J. Ahern-Rindell</i>	University of Portland, Portland, OR, USA
<i>Teresa Bettencourt</i>	University of Aveiro, Aveiro, Portugal
<i>Patrick Blessinger</i>	International HETL Association, New York, NY, USA
<i>Barb Bloemhof</i>	McMaster University, Hamilton, Ontario, Canada
<i>Jacqueline Broerse</i>	VU University, Amsterdam, The Netherlands
<i>Mindy Capaldi</i>	Valparaiso University, Valparaiso, IN, USA
<i>John M. Carfora</i>	Loyola Marymount University, Los Angeles, CA, USA
<i>Lorraine Carter</i>	Nipissing University, North Bay, Ontario, Canada
<i>Fabio Dovigo</i>	University of Bergamo, Bergamo, Italy
<i>Richard R. Hake</i>	Indiana University, Bloomington, IN, USA
<i>Philip Hawes</i>	Whitireia Community Polytechnic, Porirua, New Zealand
<i>Henk Huijser</i>	Batchelor Institute of Indigenous Tertiary Education, Batchelor, Australia
<i>Megan Y. C. A. Kek</i>	University of Southern Queensland, Toowoomba, Australia
<i>Les Kirkup</i>	University of Technology, Sydney, New South Wales, Australia
<i>Wanda S. Konijn</i>	VU University, Amsterdam, The Netherlands



<i>Natalie Kuldell</i>	Massachusetts Institute of Technology, Cambridge, MA, USA
<i>Jeroen Maas</i>	VU University, Amsterdam, The Netherlands
<i>Gina J. Mariano</i>	Troy University, Troy, AL, USA
<i>William F. McComas</i>	University of Arkansas, Fayetteville, AR, USA
<i>Rudolph Mitchell</i>	Massachusetts Institute of Technology, Cambridge, MA, USA
<i>Vanessa R. Pitts Bannister</i>	Florida A&M University, Tallahassee, FL, USA
<i>Vincenza Rocco</i>	University of Bergamo, Bergamo, Italy
<i>Richard E. Shope</i>	Loyola Marymount University, Los Angeles, CA, USA
<i>Susana Silva</i>	University of Coimbra, Coimbra, Portugal
<i>Lorraine Stefani</i>	University of Auckland, Auckland, New Zealand
<i>Ana Cristina Tavares</i>	University of Coimbra, Coimbra, Portugal
<i>Ruth Terwijn</i>	University of Southern Queensland, Toowoomba, Australia
<i>Wendy Trimmer</i>	Whitireia Community Polytechnic, Porirua, New Zealand
<i>Dylan Powell Williams</i>	University of Leicester, Leicester, UK
<i>Baiba Zarins</i>	Nipissing University, North Bay, Ontario, Canada
<i>Marjolein B. M. Zweekhorst</i>	VU University, Amsterdam, The Netherlands

## **SERIES EDITOR'S INTRODUCTION**

The purpose of this series is to publish current research and scholarship on innovative teaching and learning practices in higher education. The series is developed around the premise that teaching and learning is more effective when instructors and students are actively and meaningfully engaged in the teaching-learning process.

The main objectives of this series are to:

1. present how innovative teaching and learning practices are being used in higher education institutions around the world across a wide variety of disciplines and countries,
2. present the latest models, theories, concepts, paradigms, and frameworks that educators should consider when adopting, implementing, assessing, and evaluating innovative teaching and learning practices, and
3. consider the implications of theory and practice on policy, strategy, and leadership.

This series will appeal to anyone in higher education who is involved in the teaching and learning process from any discipline, institutional type, or nationality. The volumes in this series will focus on a variety of authentic case studies and other empirical research that illustrates how educators from around the world are using innovative approaches to create more effective and meaningful learning environments.

Innovation teaching and learning is any approach, strategy, method, practice, or means that has been shown to improve, enhance, or transform the teaching-learning environment. Innovation involves doing things differently or in a novel way in order to improve outcomes. In short, innovation is positive change. With respect to teaching and learning, innovation is the implementation of new or improved educational practices that result in improved educational and learning outcomes. This innovation can be any positive change related to teaching, curriculum, assessment, technology, or other tools, programs, policies, or processes that leads to improved educational and learning outcomes. Innovation can occur in institutional development, program development, professional development, or learning development.

The volumes in this series will not only highlight the benefits and theoretical frameworks of such innovations through authentic case studies and other empirical research but also look at the challenges and contexts associated with implementing and assessing innovative teaching and learning practices. The volumes represent all disciplines from a wide range of national, cultural, and organizational contexts. The volumes in this series will explore a wide variety of teaching and learning topics such as active learning, integrative learning, transformative learning, inquiry-based learning, problem-based learning, meaningful learning, blended learning, creative learning, experiential learning, lifelong and lifewide learning, global learning, learning assessment and analytics, student research, faculty and student learning communities, as well as other topics.

This series brings together distinguished scholars and educational practitioners from around the world to disseminate the latest knowledge on innovative teaching and learning scholarship and practices. The authors offer a range of disciplinary perspectives from different cultural contexts. This series provides a unique and valuable resource for instructors, administrators, and anyone interested in improving and transforming teaching and learning.

Patrick Blessinger  
*Founder and Executive Director,*  
*International HETL Association*

## FOREWORD

In the United States in particular, millions of dollars have been poured into improving undergraduate education in science, technology, engineering and mathematics (STEM) education. This is in response to mounting concern about a lack of scientists, engineers and mathematicians to keep the United States in the forefront of research, innovation and technology. As the chapters in this book demonstrate this focus on STEM education has resulted in research into, and implementation of, a range of different classroom practices, the development of curricula designed for authentic STEM learning experiences and shifts in pedagogical models and frameworks. A prominent development has been that of inquiry-based learning (IBL) as applied to STEM education. Interestingly in Australia and the United Kingdom the terms IBL and problem-based learning (PBL) are used almost interchangeably albeit there are potential philosophical and conceptual differences between definitions of the terms.

There is a school of thought suggesting that PBL is one of the most innovative, instructional methods conceived in the history of education. As a pedagogical approach, PBL first came to prominence in response to the widespread criticism that traditional teaching and learning methods fail to prepare medical students for solving problems in clinical settings. This is not a dissimilar reason for IBL coming to the forefront in STEM education. The significant commonalities between PBL and IBL are that they are pedagogies which have their origins in the work of the American philosopher and educator John Dewey (1859–1952), father of the experiential learning movement. Dewey's view of learning essentially assigns a major role to what can be best described as a creative intelligence in the discovery of new ideas in the disciplines. At its best, IBL is a student-centred active learning approach, focusing on questioning, critical thinking and problem solving.

What makes IBL as applied to STEM education intriguing is the idea of STEM as a meta-discipline, that is, the creation of a discipline based on the integration of other disciplinary knowledge into a new 'whole'. STEM education is an inter-disciplinary, some might say trans-disciplinary approach where rigorous academic concepts are coupled with authentic real-world learning as students apply science, technology, engineering and mathematics

learning that can help to make connections between formal learning, community learning and work-based situations. It is in no way an easy task to achieve a meta-disciplinary approach in learning and teaching and it would be wrong to suggest that we have completed this journey with respect to integrative STEM education. However, by applying IBL within the STEM subject areas, we are by definition: facilitating student learning rather than pushing students through a content-driven curriculum (guide on the side rather than sage on the stage); supporting the development of self-directed learning skills (inquiring, questioning, researching – all of which are likely to encourage boundary crossing between disciplines); supporting co-creation of new knowledge (empowering students to create knowledge rather than having all knowledge imposed).

Clearly, the effective use of new technologies in the classroom greatly enhances the potential of IBL in STEM education. Learning is no longer confined to official classroom hours or the availability of textbooks. Most students in the 21st century carry with them their own personal digital environments; they communicate constantly using social media and they are consummate consumers of information instantly available to them. The real trick for meaningful learning lies in strategies that enhance their information literacy skills. Although IBL predates the technologies we have available to us today, new technologies might be said to be ‘made to measure’ for IBL and IBL as applied to STEM in particular. Digital technologies support a range of learning styles and strategies and their huge advantage lies in the potential for connectivity and creativity as well as access to increasingly sophisticated software and experimentation in learning.

The chapters in this book will inspire and motivate all STEM teachers and facilitators of learning to take the ideas into their own classrooms, to provide authentic learning experiences for learners and to increase engagement for STEM students.

Lorraine Stefani  
Professor of Higher Education Strategic Engagement  
Faculty of Education, University of Auckland

A handwritten signature in black ink, reading 'Lorraine Stefani'. The signature is stylized with a large, sweeping initial 'L' and 'S'.

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