


Bryan Edward Penprase

STEM Education for the 21st Century

 Springer

Contents

1	History of STEM in the USA	1
1.1	History of US Higher Education and Diversity in STEM	1
1.2	Attitudes About Higher Education and the American Dream	3
1.3	Development of Science Education in the United States	4
1.4	STEM Education in the Twentieth Century	7
1.5	STEM Education and Social Mobility Within US Higher Education	9
1.6	Diversity Within US Campuses and in STEM Fields	10
1.7	Conclusion—the Vital Need for Diversity, Equity and Inclusion	14
	References	14
2	Active and Peer-Based Learning	17
2.1	Students Constructing Knowledge	17
2.2	The Force Concept Inventory and Active Learning in Physics	19
2.3	Eric Mazur and the Development of Peer Instruction	20
2.4	Carl Wieman and Expert Thinking	22
2.5	The Carl Wieman Science Education Initiative	24
2.6	Gordon Conference on Discoveries and Physics Education	26
2.7	Active Learning in Biology	28
2.8	Creating Research-Based Environments in Biology Courses	29
2.9	Microbes to Molecules and Tiny Earth	31
	References	33
3	Theories of Teaching and Learning	35
3.1	A Review of Educational Research and SoTL	35
3.2	Scientific Teaching	37
3.3	Theories of Learning	39
3.4	Taxonomies of Learning	41

3.5	Constructive Alignment	43
3.6	Liminality and Threshold Concepts	45
3.7	Pedagogical Content Knowledge and Self-similarity	47
	References	49
4	Engineering Education Reconsidered	51
4.1	Yale Engineering and the CEID	52
4.2	Cal Poly San Luis Obispo and “Learn by Doing”	55
4.3	Olin College of Engineering	59
4.4	Liberal Arts Engineering	63
	References	67
5	Online Education in STEM	69
5.1	From MOOCs to Microcredentials	69
5.2	A Brief History of MOOCs and Online Learning	70
5.3	Coursera	73
5.4	Coursera HQ Visit in the Year of the MOOC	75
5.5	Stanford Online Education	78
5.6	Udacity	81
5.7	EdX and Open-Source MOOCs	84
5.8	HarvardX—Online Education Goes to Harvard	87
5.9	The Future of Online Learning and Colleges and Universities	88
	References	90
6	Interdisciplinary Science	93
6.1	Integrated Science, Multi and Interdisciplinary Curriculum	93
6.2	The Meaning of Interdisciplinary Science	95
6.3	Curricular Integration Within Interdisciplinary Programs	97
6.4	Overview of Global Interdisciplinary Science Curricula	99
6.5	Learning More—Interviews with Interdisciplinary Science Leaders	101
6.6	Case Studies of STEM Interdisciplinarity	101
6.7	Keck Science Department Claremont Colleges—AISS	103
6.8	University of Massachusetts, Amherst—iCons Program	105
6.9	Princeton University Integrated Science	106
6.10	Yale-NUS College (Singapore)—Integrated Science	107
6.11	National University of Singapore—Special Programme in Science	109
6.12	University of British Columbia, Science One	110
6.13	Yale-NUS College, Foundations of Science	111
6.14	University of Hong Kong, Fundamentals of Modern Science	113

6.15	McMaster University, iSci Program	113
6.16	Findings from Research into Interdisciplinary Science Teaching	114
	References	118
7	The Future of STEM Teaching and Learning	121
7.1	The Fourth Industrial Revolution and STEM Education	121
7.2	The First Two Industrial Revolutions and Education	122
7.3	Educational Responses to the Third Industrial Revolution	123
7.4	Emerging Realities from the Fourth Industrial Revolution	124
7.5	Artificial Intelligence.	125
7.6	Biotechnology	126
7.7	Nanotechnology and the Internet of Things	127
7.8	Future FIR STEM Curriculum	128
7.9	STEM and the Future Human Condition	129
7.10	New Sequencing of Education to Renew Skills	130
7.11	Conclusions	131
	References	132