# CONTENTS

*List of figures* *xi*
*List of tables* *xv*
*Foreword* *xvii*
*Preface* *xxi*
*Acknowledgment* *xxv*

**PART I**
**Introduction** **1**

1 Transformational learning with educational robotics 3
*1. Introduction 3*
*2. STEM and technology-enhanced learning environments 4*
*3. Educational robotics 8*
*4. Exhibiting the role of robots in supporting student learning 20*
*5. Conclusion 24*
*6. Key takeaways 25*

2 Applications of robots in educational settings 33
*1. Introduction 33*
*2. Constructionism and educational robotics 34*
*3. Educational robotics: Roles and settings 40*
*4. Examples of applications of robots as a learning tool in teaching and learning 44*

5. *Conclusion 49*
6. *Key takeaways 50*

3 Teaching STEM with robotics: Synopsis of a research-guided program 55
1. *Introduction 55*
2. *Need for authentic STEM learning experiences 56*
3. *Rationale for robotics in STEM education 57*
4. *Overview, theoretical background, and project design 58*
5. *Illustrative examples from implementation 66*
6. *Project outcomes and recommendations 70*
7. *Conclusion 72*
8. *Key takeaways 72*

**PART II**
**Theory, design, and implementation** 79

4 Design-based research for robotics-enhanced learning environments 81
1. *Introduction 81*
2. *Design-based research 82*
3. *Literature review exemplifying the use of design-based research in robotics-enabled learning 88*
4. *Design-based research implementation examples from robotics-enhanced learning environments 89*
5. *Implementation challenges of design-based research 107*
6. *Conclusion 110*
7. *Key takeaways 111*

5 Effective professional development for robotics-focused learning environments 115
1. *Introduction 115*
2. *Teacher professional development 116*
3. *Designing for effective professional development 119*
4. *Literature review on teacher professional development for robotics-based learning 122*
5. *Designing a robotics-based professional development program using situated learning 123*
6. *Creating a professional development program using the social capital theory 129*

7. *Challenges in planning effective professional development programs and incorporating their lessons 134*
8. *Conclusion 136*
9. *Key takeaways 137*

6 Applying TPACK to design for robotics-enhanced learning 141
1. *Introduction 141*
2. *Technological, pedagogical, and content knowledge 142*
3. *Literature review on teachers' TPACK development 148*
4. *Development of teacher TPACK through professional development aimed at using robotics as a learning tool 150*
5. *Development of TPACK-guided robotics-based STEM learning units 155*
6. *Conclusion 165*
7. *Key takeaways 166*

PART III
**Instructional perspectives and lesson designs 169**

7 Prerequisites, practices, and perceptions to design effective robotics-based lessons 171
1. *Introduction 171*
2. *Enabling effective integration of robotics in classrooms 172*
3. *Prerequisites for robotics-based STEM lessons 174*
4. *Instructional practices for effective robotics-based lessons 177*
5. *Factors that influence student perceptions of utilizing robots as educational tools 184*
6. *Conclusion 187*
7. *Key takeaways 188*

8 Applying cognitive domain of Bloom's taxonomy to robotics-based learning 192
1. *Introduction 192*
2. *Bloom's taxonomy 193*
3. *Literature review on applications of Bloom's taxonomy in robotics 198*
4. *Integrating cognitive domain of Bloom's taxonomy with educational robotics to promote higher-order thinking 199*
5. *Conclusion 207*
6. *Key takeaways 207*

9 Using the 5E instructional model to develop robotics-based science units 211
1. *Introduction 211*
2. *The 5E instructional model 212*
3. *Literature review on integrating the 5E model in robotics-based learning 216*
4. *Exemplar robotics-based science unit plans aligned with the 5E model and Next Generation Science Standards 218*
5. *Implementing the 5E instructional model 227*
6. *Conclusion 230*
7. *Key takeaways 230*

*Appendix A Related information from 'Teaching STEM with Robotics' project* 234
1. *A summary timeline for the 'Teaching STEM with Robotics' project 235*
2. *A comparison of design-based research with other research methodologies 236*
3. *Sample items from the TPACK self-efficacy and TPACK awareness surveys 237*
4. *Instructional practices for successful robotics lessons 238*
5. *A lesson planning template using Bloom's taxonomy 240*
6. *Characteristics of the 5E instructional model 241*
7. *A 5E lesson planning template 244*
8. *A learning unit on genetic mutations 245*
9. *A lesson plan on speed, distance, and time 248*

*Appendix B Online repository of robotics-based lessons* 253
1. *LEGO robotics-based lessons 253*
2. *NGSS-plus-5E robotics lessons 253*
3. *Additional robotics-based STEM lessons 253*

*Index* 258