



**Project<sup>1</sup> Number:** 747069

**Project Acronym:** DesignEng

**Project title:** Designing Engineers: Harnessing the Power of Design

Projects to Spur Cognitive and Epistemological Development of STEM Students

## **Periodic Technical Report**

### **Part B**

**Period covered by the report:** from 01/01/2018 to 31/12/2019

**Periodic report:** 1<sup>st</sup>

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<sup>1</sup> The term ‘project’ used in this template equates to an ‘action’ in certain other Horizon 2020 documentation

## **1. Explanation of the work carried out by the beneficiaries and Overview of the progress**

This MSC Action is titled “Designing Engineers: Harnessing the Power of Design Projects to Spur Cognitive and Epistemological Development of STEM Students.” This project looks at: (1) how engineering and architecture students learn, and (2) how both design projects and teamwork affect their thinking and their overall personal development. The MSCA Research Fellow conducting this research is particularly interested in how students learn to design and how their thinking changes over time with regard to what knowledge is, where it comes from, and how it gets validated. Their views on this constitute their epistemologies.

These topics are important for society because the world needs more engineers, and more graduates from STEM (science, technology, engineering, and mathematics) in general, yet too few students are interested in studying these at the third level and too few pursue STEM careers. Moreover, problems have been identified in graduate engineers’ ability to think holistically—today’s graduates do not seem prepared to identify and address global challenges in the comprehensive way society needs.

Engineering is often perceived as a dry, technical subject but there is actually great room for creativity. Looking at architecture programs around the world, we see highly engaged students who are enthusiastic about learning and about defining their own design projects. In engineering, there has been a move to address these problems by teaching in a more active, hands-on, and project-based way. Increasingly, team-based design projects are used to motivate students and to get them thinking in context and about complex relationships. Engineering classrooms look increasingly like architecture design studios. This project explored relationships between engineering and architecture, particularly related to “design thinking,” how students learn to design, and how they perceive or understand what it means “to design.”

It is important to note that while engineering can learn from architecture’s historic success in engaging and teaching students to design, the field of engineering education—and even more specifically, the field of engineering education research (EER)—has placed more focus than the field of architecture has on understanding how students learn. EER spends time assessing the well-being of individual students and considering how to help teams work together in health and effective ways. As such, the fields of engineering and architecture education have much they can learn from each other.

### **1.1 Objectives**

Formal objectives of this Marie Skłodowska Curie Action (MSCA) have been to (a) develop and promote better ways to teach and support STEM students; (b) help transform engineering into a more diverse and creative field; and (c) investigate questions surrounding the theme, *To what extents do design projects influence the cognitive and epistemological development of undergraduates in engineering and architecture?* Another goal of the MSCA Individual Fellowship is to foster the development of the individual researcher. In this project, the objectives and goals have been addressed via six specific work packages: (1) qualitative research projects; (2) research on using multiple methods to evaluate engineering education; (3) development of special-focus journal issues; (4) outreach activities including public engagement and communication of findings; (5) researcher training and transfer-of-knowledge; and (6) project management activities. The goals and objectives of the MSCA IF proposal have been fully met.

### **1.2 Explanation of the work carried per WP**

Work performed during this fellowship was ascribed to six specific work packages. This section summarizes the results and outputs of each work package (WP). The MSCA Research Fellow worked at University College London (UCL) in the Centre for Engineering Education (CEE) worked under the day-to-day supervision of Professor John Mitchell with periodic input from her primary supervisor, Professor Nick Tyler. During the fellowship, she maintained collaborations and professional ties with her home institution, Technological University Dublin (TU Dublin, formerly DIT) and its CREATE research group. The achievements identified in this report reflect the positive learning environment at the host institution (UCL) and ongoing positive relationships with the home institution (TU Dublin).

### 1.2.1 Work Package 1

#### ***Qualitative Research***

The intention of WP1 was to use qualitative research methods to study how engineering and architecture students learn and how they conceptualize design creation and knowledge generation. The following deliverables were listed in the fellowship application: submission of one conference paper and one journal manuscript. The list of items produced is provided below and exceeds the stated expectations. Under WP1, the Fellow has delivered four conference publications and one journal publication to date. She has an additional three conference publications and two journal manuscripts underway. Details on all these are provided below.

The first journal paper published under WP1 was an editorial overview of epistemological development and identity development among students published in *IEEE Transactions on Education*. The academic citation for it is:

CHANCE, S., Williams, B., Goldfinch, T., Adams, R. S., & Fleming, L. N. (Eds.). (August 2019). Guest Editorial Statement for the Special Issue on Using Enquiry- and Design-Based Learning to Spur Epistemological and Identity Development of Engineering Students. *IEEE Transactions on Education*, (62)3, 157-164. DOI 10.1109/TE.2019.2923043.

The next set of manuscripts investigated the development of civil engineers. The fellow conducted nine interviews with civil engineers practicing in London to explore how they think about ethics and also how they integrate global responsibility (e.g., environmental and social sustainability) into their work. This yielded two conference papers:

CHANCE, S. M., Direito, I., Lawlor, R., Cresswell-Maynard, K., Pritchard, J., Tyler, N., & Mitchell, J. (2019, July). Background and design of a qualitative study on globally responsible decision-making in civil engineering. In *Proceedings of the 8th Research in Engineering Education Symposium, REES 2019-Making Connections* (Vol. 8, pp. 211-220). REEN (Research in Engineering Education Network) and SASEE (South African Society for Engineering Education). <https://www.sasee.org.za/wp-content/uploads/REES-2019-proceedings.pdf>

CHANCE, S. M., Direito, I., & Mitchell, J. (forthcoming). *To what degree do graduate civil engineers working in London enact Global Responsibility and support UN Sustainable Development Goals?* Engineering Education for Sustainable Development (EESD 2020) conference in Cork, Ireland.

The same UK-based engineering study will yield a number of journal articles. The conference paper on Sustainable Development Goals, listed above, was produced for the Engineering Education for Sustainable Development (EESD 2020) conference and is being expanded into a journal article. Moreover, the two following manuscripts have been drafted and are currently being reviewed and refined:

CHANCE, S. M., Mitchell, J., Direito, I., & Creswell-Maynard, K. (accepted for development). Limited by scope and client request: Challenges faced by early-career civil engineers enacting global responsibility in the UK workplace. *European Journal of Engineering Education* Special Issue: Early Career Engineers and the Development of Engineering Expertise.

CHANCE, S. M., Lawlor, R., Direito, I., Creswell-Maynard, K., & Mitchell, J. (under development). Ethical empowerment: A proposal for following past success to support sustainable behavior among civil engineers. *Australasian Journal of Engineering Education*. Special Issue: Ethics in Engineering Education and Practice.

Closely related to this UK engineering study is work the Fellow has done with the PhD student she has been supervising. The student's doctoral thesis investigates how creativity is manifest in engineering design and production. The two following papers have been published and presented at conferences—they helped apply the student's research on engineering organizations to higher education organizations—and many more journal papers are under development by the same team, to be submitted to various journals.

Empson, T., CHANCE, S. M., & Patel, S. (2019). *A critical analysis of the contextual pressures sustainable development presents HE researchers and evaluators*. Society for Research on Higher Education (SRHE) 2019 conference in Cardiff, UK.

Empson, T., CHANCE, S. M., & Patel, S. (2019, September). A critical analysis of 'creativity' in sustainable production and design. In *21st International Conference on Engineering and Product Design Education*. Glasgow, UK.  
<https://openresearch.lsbu.ac.uk/download/558f3416017710213fe7545d26ae7bc7e9c77ebcb138cc333363942cc7b01d3b/304990/Empson%20Chance%20Patel%202019-EPDE%202019%20paper.pdf>

All the projects listed above were helping build the Fellow's skills to conduct the headline project of this Work Package. For this headline project, the Fellow conducted in-depth interviews with 26 architecture and civil engineering students in the United Kingdom, Ireland, and the USA. This yielded a paper for the American Society for Engineering Education (ASEE), one of the world's most prominent conferences on engineering education:

CHANCE, S., Mimirinis, M., Direito, I., Mitchell, J., & Tilley, E. (2019, June). How architecture and engineering students conceptualize design creation: Report of a pilot study. In *American Society for Engineering Education* (Vol. 126). American Society for Engineering Education (ASEE). Tampa, Florida.  
<https://discovery.ucl.ac.uk/10077183/1/Chance%20et%20al-ASEE%202019-ArchEng%2024926.pdf>

Two manuscripts are now under development using the data collected. These will make a major contribution to the knowledge base related to design education:

CHANCE, S. M., Miminiris, M., & Direito, I. (under development). How architecture and engineering students conceptualize design creation. Targeting the *Journal of Engineering Education* or similar.

CHANCE, S. M., Miminiris, M., & Direito, I. (under development). How architecture and engineering students conceptualize the generation of new knowledge. Targeting *Design Studies* or similar.

By attending a May 2018 workshop at the Society for Research on Higher Education (SRHE), the fellow discovered phenomenography would be the optimal methodology for studying the issue defined in her MSCA grant application. As a result, UCL brought in the teacher of the SRHE workshop, Dr. Mike Miminiris, and employed him as a consultant to help the Fellow and her colleagues learn this highly structured research methodology. Dr. Miminiris provided a seminar for UCL staff and has guided the Fellow, and other researchers from UCL's Centre for Engineering Education, through the phenomenographical analysis process.

#### 1.2.2 Work package 2

##### ***Multiple Methods in Research***

Many researchers use a single methodology, or a highly focused set of similar methodologies, to answer their questions. Thus, they tend to ask questions that can be answered with the methodologies they know. As this particular MSCA Fellow aims to conduct research projects that address a wide array of research questions, she needs to develop mastery of many different methods. This way, she can use the most appropriate research method for answering each type of question when it arises. Therefore, the intention of WP2 was to build the Fellow's skills in new methodologies, and also to help build the skills of the larger engineering education research (EER) community by infusing knowledge about these methodologies.

In the MSCA grant application, the following deliverables were promised under WP2: submission of one conference paper and one journal manuscript. Under WP2, however, the Fellow has already delivered five conference presentations, three published journal articles, four conference presentations, and one encyclopedia entry. In addition, the Fellow has two conference manuscripts underway. Details are provided below.

The first major project under WP2 had two focus points: (1) comparing two different methodologies and applying these methodologies to (2) study engineering teachers' experiences implementing design- and problem-based learning. A major publication resulted:

CHANCE, S. M., Duffy, G., & Bowe, B. (2019). Comparing grounded theory and phenomenology as methods to understand lived experience of engineering educators implementing Problem-Based Learning. *European Journal of Engineering Education*, DOI: 10.1080/03043797.2019.1607826.

The content was also delivered at a leading conference:

CHANCE, S. M. & Duffy, G. (2018). *A model for spurring organizational change based on faculty experiences working together to implement Problem-Based Learning*. American

Society for Engineering Education (ASEE) conference in Salt Lake City, Utah.  
[https://discovery.ucl.ac.uk/id/eprint/10059261/1/Published%20ASEE\\_2018-A\\_model\\_for\\_implementing\\_change-v17-submitted.pdf](https://discovery.ucl.ac.uk/id/eprint/10059261/1/Published%20ASEE_2018-A_model_for_implementing_change-v17-submitted.pdf)

The above publications are part of a larger effort by this Fellow to support diverse students. As a result of this MSCA, the Fellow has emerged as a highly visible member and leader of the EER community globally. As part of this community, she is trying to develop better teaching practices (androgies, or pedagogies for adults). To support this effort, the Fellow co-authored an overview on socio-cultural diversity in engineering education that was published in a leading journal:

CHANCE, S., Bottomly, L., Panetta, K., & Williams, B. (Eds.). (November 2018). Guest Editorial Statement for the Special Issue on Increasing the Socio-Cultural Diversity of Electrical and Computer Engineering and Related Fields. *IEEE Transactions on Education*, (61)4, 261-264. DOI 10.1109/TE.2018.2871656.

Work conducted via WP2 also helped inform an encyclopedia entry authored by the Fellow:

CHANCE, S. M. (2020). Problem-Based Learning: Use in Engineering Disciplines. In Amey, M. J. & David, M. E. (Eds.). *The SAGE Encyclopedia of Higher Education*, 5v. Thousand Oaks, CA: Sage.

Under WP2, the Fellow also interviewed 20 women studying engineering in Ireland. This added to the set of interviews the Fellow had previously conducted, and it is allowing her to produce longitudinal studies on women's experiences learning engineering and working in engineering teams. Data analyzed to date focus on the experiences of: (a) a single mother studying engineering and overcoming challenges and (b) Middle Eastern women studying engineering in Ireland. In the future, journal articles will be prepared, related to both topics. Already-published work on this project includes one conference publication on the single mother:

Williams, B., CHANCE, S. M., & Direito, I. (2019). *No one really minded a female barmaid, but I don't know they'd "not mind" a female engineer: One student's journey*. UK-Ireland Engineering Education Research Network 2019 conference in Coventry, UK.

Already-published work on this project also includes multiple conference papers about Middle Eastern students' experiences:

CHANCE, S. M., & Williams, B. (forthcoming). *Here you have to be mixing: Collaborative learning on an engineering program in Ireland as experienced by a group of Middle Eastern young women*. EDUCON2020 – IEEE Global Engineering Education Conference in Porto, Portugal.

CHANCE, S. M. & Williams, W. (2018). *Preliminary findings of a phenomenological study of Middle Eastern women's experiences studying engineering in Ireland*. American Society for Engineering Education (ASEE) conference in Salt Lake City, Utah.  
[https://discovery.ucl.ac.uk/10059260/1/Published%20ASEE\\_2018-Middle\\_Eastern\\_women\\_abroad-final\\_draft-v14-submitted.pdf](https://discovery.ucl.ac.uk/10059260/1/Published%20ASEE_2018-Middle_Eastern_women_abroad-final_draft-v14-submitted.pdf)

An additional report of the Middle Eastern students' experiences was also presented at the following conference but was inadvertently omitted from the proceedings:

CHANCE, S. M. & Williams, W. (2018). *Middle Eastern Women's Experiences of Collaborative Learning in Engineering in Ireland*. International Conference on Interactive Collaborative Learning (ICL) in Kos Island, Greece.

In a similar vein to the study on Middle Eastern women studying in Ireland, an additional conference paper has been drafted that relates to people studying engineering abroad:

Direito, I., Williams, W., & CHANCE, S. M. (under development). Brexit impact: Perspectives of Portuguese students and staff in the UK. The 4th International Conference of the Portuguese Society for Engineering Education (CISPÉE 2020) in Lisbon, Portugal.

At the start of this MSCA, the Fellow and her colleague at UCL decided they also wanted to learn to conduct systematic literature reviews. They published individual studies using this methodology at the Societe Europeenne pour la Formation des Ingenieurs (SEFI) conference in 2018, and they joined with a third colleague they met there to later conduct workshops on the topic and publish a journal article collaboratively. The citation below is for the Fellow's initial conference paper:

CHANCE, S., & Direito, I. (2018, October). Identification and preliminary review of doctoral theses in engineering education that have used phenomenological methods. In *Proceedings of the 46th SEFI Annual Conference 2018. Creativity, innovation and entrepreneurship for engineering education excellence*. Societe Europeenne pour la Formation des Ingenieurs (SEFI). Copenhagen, Denmark.  
[http://discovery.ucl.ac.uk/10062437/1/Chance\\_SEFI%202018-ShannonChance-final%20paper-submitted.pdf](http://discovery.ucl.ac.uk/10062437/1/Chance_SEFI%202018-ShannonChance-final%20paper-submitted.pdf)

After joining together, the team selected one of the initial conference papers and developed it into a journal article on the construct of grit and how it has been studied in engineering education.

Direito, I., CHANCE, S. M., & Malik, M. (2019). The study of grit in engineering education research: A systematic literature review. *European Journal of Engineering Education*. DOI: 10.1080/03043797.2019.1688256.

An outgrowth of that article has been a study reported at an additional conference:

Direito, I., CHANCE, S., Tilley, E., & Mitchell, J. (2019, July). Assessing the grit and mindset of incoming engineering students with an emphasis on gender. In *Proceedings of the 8th Research in Engineering Education Symposium (REES 2019)* (Vol. 8, pp. 253-261). REEN (Research in Engineering Education Network) and SASEE (South African Society for Engineering Education). <https://www.sasee.org.za/wp-content/uploads/REES-2019-proceedings.pdf>

### 1.2.3 Work package 3

#### ***Special-Focus Journal Issues***

The intention of WP3 was for the Fellow to learn EER publication skills. The deliverable promised in the MSCA application was to deliver a publication-ready document to a publishing house by month 24, the end of the grant. The Fellow was able to exceed expectations by spearheading development of two different special focus journal issues that were already published and are currently informing the EER community. At this point, the

Fellow is leading the development of a third special focus issue and extending her reach farther across the globe.

The special focus issues spearheaded by the Fellow are cited as follows:

CHANCE, S., Williams, B., Goldfinch, T., Adams, R. S., & Fleming, L. N. (Eds.). (August 2019). Special Issue on Using Enquiry- and Design-Based Learning to Spur Epistemological and Identity Development of Engineering Students. *IEEE Transactions on Education*, (62)3. DOI 10.1109/TE.2019.2923043.

CHANCE, S., Bottomly, L., Panetta, K., & Williams, B. (Eds.). (November 2018). Special-focus issue on gender in engineering in the *IEEE Transactions on Education*, (61)4.

The third special focus issue, now under development by the Fellow is:

CHANCE, S., Strobel, J., Mazzurco, A., Hattingh, T., & Villas-Boas, V. (Eds.). (forthcoming May 2020). *Special Issue on Ethics in Engineering Education and Practice*. Australasian Journal of Engineering Education (AJEE).

An intention for this new issue is for the two lead editors (Chance and Strobel) to help mentor the three other guest editors through the proses to enable them to lead development of future special focus issues in EER.

#### 1.2.4 Work package 4

##### ***Outreach Activities***

The intention of WP4 was to provide public engagement and communication of findings. The MSCA application promised to deliver a total of 19 events. Under WP4, the Fellow ultimately delivered the following outreach to the General Public.

##### *Outreach to kids*

- 2 STEM activities book for kids published (the Fellow served as expert advisor for Usbourn publisher on one published book and one book that is currently in press)
- 4 RoboSlam (computer programming and robot building) workshops
- 2 RoboSlam (computer programming and robot building) educational exhibition booths

##### *Outreach via social media*

- 3 educational websites (IrelandByChance.com, RoboSlam.com, Chance Reflections.com)
- 1 LinkedIn Discussion Board moderated (for the Research in Engineering Education Network, REEN)
- 2 Facebook pages featuring grant activities (one public page and one private page)
- 1 Twitter feed of engineering education activities

### *Outreach to adults*

- 1 public presentation in Dublin on gender aspects of research
- 1 data source provided to UNESCO for a global engineering report
- 1 sub-section evaluated for UNESCO for a global engineering report
- 1 encyclopedia entry on the application of PBL in engineering education
- 1 interviewed for the UK Podcast “Engineering Matters” on ethics (to be aired March 2020)

Details on these items are provided below:

The Fellow conducted four robotics and electrical engineering workshops for kids in Ireland with colleagues from her home institution (TU Dublin). Having co-founded the RoboSlam robotics outreach team in 2013, she continued to be active in RoboSlam during her MSCA fellowship, as one of the four main coordinators of events. In 2018, she was part of a team that ran a number of robotics and electrical engineering workshops for kids in Ireland over the month of August with the Wexford library service. She assisted in running two workshops in Bunclody (17th August) and two in Enniscorthy (18th August). The workshops were attended by approximately 120 children in 8-12 years old. The children built an electronics arcade game that they brought home afterward. The intention of the workshops was to encourage an interest in electronics and programming. Feedback and pictures are available here: <https://www.dropbox.com/home/DIT%20Bread%20Board%20Games>. Technical resources used (instructions, and code) at those workshops can be found here: <https://ioprog.com/bbg>.

The Fellow also provided advising/support for the Engineering Your Future Week summer school for Transition Year students, sponsored by Enterprise Ireland. In 2018 the week focused on Robot Building and Biomedical Engineering.

The Fellow helped operate educational booths on electrical engineering, at Dublin Maker 2018 and 2019 in Ireland, with colleagues from her home institution. A large team of volunteers (staff and students) from the school participated in Dublin Maker. The theme of the 2018 stand was "paper programming" and the 2019 theme was “arcade games through the ages”.

The Fellow hosted and created content for an educational blog on being a “researcher on the move.” The blog has 209 followers who receive direct emails of every post. In 2018 had 3732 visitors and 13,106 views (discrete clicks indicating engagement) and, in 2019, had 4316 visitors and 9887 views. The Fellow promoted the blog posts using social media, including LinkedIn, Twitter, and two Facebook accounts.

- CHANCE, S. (2012-present). *Ireland by Chance: Research Adventures in Ireland and the UK*. [www.IrelandByChance.com](http://www.IrelandByChance.com) showcasing research and fellowship activities.

On the LinkedIn platform alone, her most recent 2020 blog re-post has garnered an additional 1520 views and 46 reactions.

The Fellow also provides content for a blog on robotics that she collaboratively manages with colleagues from her host institution. In 2018, this site had 3299 visitors and 6505 views. In 2019, it had 2437 visitors and 5642 views.

- Burke, T., CHANCE, S., Berry, D., & Duignan, F. (2012-present). *RoboSlam: Robot-building for Beginners*. Roboslam.com

### 1.2.5 Work package 5

#### ***Researcher Training and Transfer-of-Knowledge***

The intention of WP5 was to increase the Fellow's research skills and encourage her to share her own knowledge and skills with others (i.e., transfer her knowledge to them). The MSCA application listed the following deliverables for this work package: 26 Training and Transfer-of-Knowledge sessions completed by the end of the grant period. A list of 70 completed research training workshops and conferences is provided further down. Yet, it is important to note that the most important training and knowledge transfer actually resulted from the Fellow providing leadership in EER. As a result of having a Marie Curie research fellowship at UCL, many doors were open to her and she was able to learn from the wealth of opportunities that emerged. Via this MSCA grant, the Fellow has provided: (1) leadership in publishing and (2) leadership in research events. These are summarized directly below. Under that, a list of the completed researcher training session is provided. Finally, in this section, is a list of outreach activities the Fellow has conducted to support educators and researchers, including workshops she conducted and supervision and mentorship she provided to early career researchers.

As part of her training, she also earned a new teaching qualification in the UK while serving as an MSCA fellow:

- Senior Fellow of the Higher Education Teaching Academy (SFHEA)

Earning this credential helped her build proficiency on the vocabulary used in educational research in the UK, which differs somewhat from the USA. Earning it will also help her demonstrate the skills needed to teach at third level in the UK and Ireland. Since earning SFHEA, the Fellow has subsequently applied for the highest available credential in this program (Principal Fellow of the Higher Education Teaching Academy/PFHEA) and she now awaits results.

#### ***Research Supervision/Mentoring Skills***

The Fellow has been advising a full-time PhD student at London South Bank University (LSBU) since the start of her MSCA fellowship. The student's viva is scheduled, and on track, for August 2020. The Fellow has also mentoring 5-6 early career researchers. Her activities in this realm include:

- Mentoring a physics researcher through TU Dublin's researcher mentoring program
- Serving as PI for a new MSCA IF application in engineering education submitted September 2019 (which was not funded in 2019 but will be enhanced and resubmitted)

- Mentor for peer reviewers with the *Journal of Engineering Education* (appointed in 2018)
- Expert/external reviewer for applications to Fulbright Ireland (2018, 2019)

### ***Leadership in Publishing***

In the realm of journal production, the Fellow was appointed and has served as:

- Associate Editor, *IEEE Transactions on Education* (2018-present)
- Editorial Board, *European Journal of Engineering Education* (2018-present)

The Fellow serves as a peer reviewer for an academic journal in her field:

- *Australasian Journal of Engineering Education* (2019-present)
- *IEEE Transactions on Education* (2017-present)
- *European Journal of Engineering Education* (2016-present)
- *Journal of Engineering Education* (2013-present)

As noted above, she has also provided expert advice to the publisher of two children's books:

- *Scribble Architecture*, STEM activity book by Usborne Publishing Ltd. (in press)
- *Scribble Engineering*, STEM activity book by Usborne Publishing Ltd. (2018)

### ***Leadership in Research Networks***

Opportunities to provide leadership that emerged as a result of this MSCA include:

- Chair, Research on Engineering Education Network (January 2020-present)
- Vice-Chair, Research on Engineering Education Network (2019-2020)
- Governing Board, Research on Engineering Education Network (2018-present) and member of sub-committees including recruitment and selection of upcoming conference hosts
- Nathu Puri Institute at the London South Bank University (2018-present), serving on, for example, an interview panel for new director of the Institute (2018) and a member of the Institute's think tank.
- Marie Curie Alumni Association, Ireland chapter organizing committee (2018-present)

### ***Leadership in Funded Projects***

Providing grant-writing leadership, the Fellow advised Dr. Carlos Mora in securing **€56,000** in funding from the Cabildo of Tenerife in Spain to conduct education projects under a project

titled “INGENIA” or “Ingenuity” to support sustainability education (she is listed as the co-PI on this grant). The Fellow also secured a **£11,200** donation to UCL CEE from the UK’s Royal Academy of Engineers via Engineers without Borders UK (the funds will support her ongoing work with UCL’s CEE).

This MSCA is intended to broaden career prospects, and it definitely has. Even though the Fellow chose to return to her home university at the completion of the fellowship, she brought with her a contract valued at **€237,727** allowing her to provide curriculum development services to the University College London Contracts (UCLC) over the three-year period following her MSCA fellowship (2020-2023).

In 2019, the Fellow also served as an **expert evaluator** for the European Commission (COFUND fellowship program).

### ***Researcher Training sessions completed***

1. UCL online training module and certificate earned in *Safety*
2. UCL online training module and certificate earned in *Green Awareness*
3. UCL online training module and certificate earned as *Green Champion*
4. UCL day-long Researcher Development Workshop, *Finding Your Voice as an Academic Writer*
5. UCL day-long Researcher Development Workshop, *An Introduction to Research Student Supervision at UCL*
6. Researcher information session organized by the Irish Research Council, *Opportunities to collaborate with UK-based researchers*
7. UCL day-long Researcher Development Workshop, *Creative Approach to Problem Solving and Decision Taking for Researchers*
8. Informational workshop on MSCA programs held at DIT
9. UCL Arena Guidance Sessions: *Initial Guidance*
10. UCL day-long Researcher Development Workshop, *Leading Collaborative Projects*
11. UCL’s Centre for Engineering Education’s event, *In Conversation With... Angela Saini and Louise Archer*
12. UCL Astrea Voices workshop: *Choosing your journey*
13. UCL day-long Researcher Development Workshop, *Writing Books and Book Chapters*
14. UCL day-long Researcher Development Workshop, *Managing Your Reputation*
15. UCL Arena Senior Fellow Guidance Session: *Developing your application*
16. UCL day-long Education Conference 2018 at the UCL Institute of Education

17. Nathu Puri Institute Thought Leadership discussion and dinner in April
18. SRHE day-long workshop, *Migration and academic acculturation*
19. SRHE day-long workshop, *Developing curriculum, learning and pedagogies in STEM subjects: the case of Engineering*
20. SRHE day-long workshop, *Phenomenography: An approach to qualitative research in higher education*
21. UCL LLAKES Seminar by Louise Archer *Why can't we solve the science participation 'crisis'? Understanding young people's (non)participation in post-16 science*
22. Attended a UCL "Town Hall" to better understand the administrative structure of this research-intensive university, *Finding a new place in society for universities*
23. UCL day-long Researcher Development Workshop *Publish or Perish: Getting Collaborative Social Science Published*
24. One-day Inaugural Spring Colloquium of the UK-Ireland Engineering Education Research Network, held in Newcastle
25. UCL day-long Researcher Development Workshop, *The Superior Performer: How to Work to Your Strengths*
26. SRHE day-long workshop, *Publishing Academic Articles: A way through the maze*
27. UCL Researcher Development Workshop, *Induction for New UCL Research Staff*
28. Attended a half-day of UCL conference on *Impacts of Gender Discourse on Polish Politics, Society & Culture Comparative Perspectives reservation*
29. UCL workshop, *Provost's Welcome to New Staff*
30. UCL day-long Researcher Development Workshop, *Writing and Publishing Research Papers*
31. UCL day-long Researcher Development Workshop, *Increasing Impact - Gaining Positive Media Coverage*
32. Attended two-day *Inspirefest* celebrating women in technology, held in Dublin
33. Attended four-day conference of the American Society for Engineering Education (ASEE) in Salt Lake City
34. Attended one-day symposium at the Royal Society sponsored by the RAEng and UCL CEE, *Inclusive Engineering Education Symposium*

35. Second Nathu Puri Institute Thought Leadership Event at 6-9 Carlton House Terrace, London SW1Y 5AG
36. Attended two-day 7th International Symposium of Engineering Education (ISEE 2018), hosted by UCL
37. UCL day-long Researcher Development Workshop, *Storytelling Skills for Teachers and Presenters*
38. UCL Arena training for fellowship applicants at principal level, *PFHEA Lunch session*
39. Attended five-day conference of the European Society for Engineering Education (SEFI 2018) in Copenhagen
40. Attended three-day International Conference on Interactive Collaborative Learning (ICL 2018) plus events of the International Conference on Engineering Pedagogy (IGIP 2018) in Kos Island, Greece
41. UCL online training module and certificate earned in GDPR
42. SRHE day-long workshop, *IS THERE (STILL) ROOM FOR EDUCATION IN THE CONTEMPORARY UNIVERSITY? Exploring policy, research and practice through the lens of professional education. Seminar 3*
43. Lecture organized by the Irish Fulbright Commission, *Creative Minds: In Conversation with a NASA Astronaut*
44. TU Dublin (formerly DIT) online training module and certificate earned in GDPR
45. TU Dublin 2.5-hour workshop by Dr. Bill Williams, *Getting published in engineering education research journals*
46. Attended half-day *IEP Research Away (Half) Day*
47. UCL full-day workshop, *Building Research Leaders*
48. UCL Career Centre workshop, *Effective Academic Interviews*
49. UCL workshop, *Providing learning experiences that enable students to acquire the right mix of knowledge, skills and competences*
50. UCL two-hour workshop, *Using and understanding bibliometrics*
51. UCL full-day workshop, *Influencing and Negotiating*
52. UCL two-hour workshop, *Copyright for Research Staff*
53. UCL Arena *Principal Fellow Guidance Session: Developing your application*
54. Expert evaluator training briefing for the European Commission

55. Attended two-day spring symposium, EERN 2018 (UK & Ireland Engineering Education Research Network) in Newcastle upon Tyne, UK
56. Attended two-day Inspirefest (women in tech) in Dublin
57. Attended two-day engineering education conference, ISEE 2018 (7th International Symposium of Engineering Education) at UCL
58. Attended four-day engineering education conference, ASEE 2018 in Salt Lake City
59. Attended five-day engineering education conference, SEFI 2018 in Copenhagen
60. Attended three-day engineering education conference, ICL/IGIP 2018 in Kos
61. Attended three-day higher education conference, SRHE 2018 (Society for Research in Higher Education) in Newport, Wales
62. Attended three-day annual conference, MSCA General Assembly 2019 in Vienna
63. Attended two-day spring symposium, EERN 2019 (UK & Ireland Engineering Education Research Network) in Dublin
64. Attended four-day engineering education conference, ASEE 2019 in Tampa
65. Attended two-day MSCA IF monitoring event, education sector, in Brussels, June 2019
66. Attended three-day engineering education conference, REES 2019 in Cape Town
67. Attended four-day engineering education conference, SEFI 2019 in Budapest
68. Attended one-day conference of UK Engineering Professors Council and the Institution of Engineering and Technology, New approaches in practice, 2020
69. Attended two-day annual conference, EERN 2018 (UK & Ireland Engineering Education Research Network) in Coventry, UK
70. Attended 14 lectures at UCL Bartlett School of Architecture's International Lecture Series (2018, 2019) and at least 7 other lectures in the Faculty of Engineering.

***Outreach to Support Educators and Researchers (Workshops and Invited Presentations Delivered)***

The Fellow provided workshops on research techniques for Early Stage Researchers as well as experienced researchers. She also provided workshops on teaching (learning theories and innovative teaching techniques) for educators. These are presented alphabetically by country:

*Denmark*

Edström, K., Bernhard, J., van den Bogaard, M., Benson, L., Finelli, C., CHANCE, S. M., & Lyng, R. (2018). *Reviewers, reviewers, reviewers!* Workshop at the European Society for Engineering Education (SEFI) 2018 annual conference in Copenhagen, Denmark.

Edström, K., Bernhard, J., De Laet, T., CHANCE, S. M., (2018). *Doctoral Symposium*. One-day pre-conference workshop at the European Society for Engineering Education (SEFI) 2018 annual conference in Copenhagen, Denmark.

De Laet, T., Williams, B., CHANCE, S. M., & others (2018). Engineering Education Research. Workshop by EER Working Group at the European Society for Engineering Education (SEFI) 2018 annual conference in Copenhagen, Denmark.

### *Hungry*

Edström, K., Benson, L., Mitchell, J., Bernhard, J., van den Bogaard, M., Carberry, A., & CHANCE, S. (2019). *Writing Helpful Reviews for Engineering Education Journals*. Workshop at the European Society for Engineering Education (SEFI) 2019 annual conference in Budapest, Hungary.

Hannon, P. K., Berry, D., CHANCE, S., Core, M., & Duignan, F. (2019). *Physical computing: A low-cost project-based approach to engineering education*. Workshop at the European Society for Engineering Education (SEFI) 2019 annual conference in Budapest, Hungary.

Mimiris, M., CHANCE, S. M., & Direto, I. (2019). *Recognising and understanding qualitatively different experiences of learning in engineering: Variation as a learning tool*. Workshop at the European Society for Engineering Education (SEFI) 2019 annual conference in Budapest, Hungary.

### *Ireland*

CHANCE, S. M. (2018). *Gender Equality in STEM Education*. Presentation delivered at Irish Marie Curie Alumni Association's Gender Equality Workshop Programme on 3<sup>rd</sup> December 2018 in Dublin, Ireland.

CHANCE, S. M. (2018). MSCA fellowship experiences. Presentation delivered for Dublin Institute of Technology's EPA & IUA MSCA Research Information Workshop Programme.

### *South Africa*

Govender, S., CHANCE, S., & Direto, I. (2019). *Fostering Inclusivity in Engineering Education in the South African Context*. Two-day Master class conducted for the University of Cape Town's Engineering Education Existing Staff Capacity Enhancement Programme.

Akinmolayan, F. & CHANCE, S. M. (2018). *Facilitating group & Problem-Based Learning in the context of engineering education*. Two-day Master class conducted for the

University of Cape Town's Engineering Education Existing Staff Capacity Enhancement Programme.

#### *United Kingdom*

CHANCE, S. M. (2020). *Becoming Civil: Outcomes of a Marie Curie Fellowship with CEGE and CEE*. Lunch seminar for UCL's Centre for Engineering Education in London.

Bathmaker, A., CHANCE, S. M., & Wheelahan, L. (2019). Understanding and conceptualizing knowledge in professional and vocationally-oriented higher education: Beyond time management and interpersonal skills. Workshop provided Thursday 16 May 2019 for the Society for Research on Higher Education in London, UK.

CHANCE, S. M. (2019). *Learning theories in engineering: A US perspective on student development*. A class session for UCL's new MSc in Engineering and Education.

CHANCE, S. M. (2018). *Summary of National STEM Educational Policies in Relation to Girls' Experiences in Physics in Europe and into the Engineering Pipeline*. Society for Research in Higher Education conference 2018 in Newcastle, UK.

Direto, I., Malik, M., & CHANCE, S. M. (2018). *Conducting Systematic Literature Reviews in Engineering Education Research*. Workshop to the UK & Ireland Engineering Education Research Network (EERN) annual conference 2018 in Portsmouth.

Leão, C. P., Soares, F., Williams, B., & CHANCE, S. (2018). *Challenges, experiences and advantages in being a female engineering student: voices in the first person*. Presentation at the UK & Ireland Engineering Education Research Network (EERN) annual conference 2018 in Portsmouth.

CHANCE, S. M. (2018). *Implications for Irish policy of women's experiences in STEM education in Ireland, Poland, and Portugal*. UK & Ireland EERN Spring Colloquium 2018 in Newcastle-upon-Tyne.

CHANCE, S. M. (2018). *Supporting diverse students: Findings from a longitudinal study of female engineering students in three countries*. Lunch seminar for UCL's Centre for Engineering Education in London.

#### 1.2.6 Work package 6

##### ***Project Management***

The intention of WP6 was to provide essential information to the European Commission regarding the progress of the grant. This WP listed the following deliverables: a Career Development Plan (CDP), a mid-project report, and a final report. The CDP was developed and uploaded to the Participant Portal in the required timeframe. A mid-project report was developed by the Fellow but, as there was no portal available for uploading it on the EU reporting platform, the Fellow posted the mid-term report to her blog and sent a link to her

program officer (<https://shannonchance.net/2019/01/18/marie-curie-fellowship-interim-report/>). This is the final report, as required.

### **1.3 Impact**

Impacts anticipated from the MSCA are increased and improved: focus by engineering educators on developmental patterns shared among engineering students; student retention as a result of improved support; diversity as techniques to support minority students are increasingly employed; overall teaching in engineering education as a result increasingly credible and useful research; focus on ethics and sustainability in engineering education; and production of tools and models to help engineering educators foster creativity and engineering firms contribute to realizing the UN's SDGs. A final overarching impact is enhanced public perception of engineering as a fun and creative field.

### **2. Update of the plan for exploitation and dissemination of result (if applicable)**

The plan for dissemination and exploitation of results has been fully realized and exceeded.

### **3. Update of the data management plan (if applicable)**

The Fellow followed University College London data management guidelines. The projects involved were identified as "low risk" and data were managed based on current GDPR standards.

### **4. Follow-up of recommendations and comments from previous review(s) (if applicable)**

The Fellow participated in a monitoring session in Brussels, for projects involving education and learning sciences, one of the first sessions of its kind. Feedback was positive and no major alterations to the project(s) were necessary.

### **5. Deviations from Annex 1 and Annex 2 (if applicable)**

There were no deviations from Deviations from Annex 1 and Annex 2. However, there were minor deviations from the work plan proposed in the Fellow's MSCA application. These alterations did not alter the intent of the work or of the individual work packages.

The Fellow had proposed to work across sectors with the UK's Creative Industries Foundation, but ultimately worked instead with UNESCO, Engineers without Borders UK (EWBUK) and the UK's Royal Academy of Engineering.

The Fellow envisioned collecting data from participants in Ireland, Portugal, Poland and the United Kingdom. Ultimately, data were collected in Ireland, Portugal, the United States and the United Kingdom.

The Fellow honed the specific research questions, developing upon the originally envisioned themes of each work package. She made the sub-questions more precise within the major theme, while maintaining the intent to investigate:

- Gender (supporting diversity)
- Epistemic cognition
- Outcomes of design-based learning pedagogies

The Fellow also shifted the intention of WP2 slightly, focusing it on “multiple methodologies” in engineering education research rather than solely “mixed methods” as originally proposed. This shift in definition allowed her to learn a wider range of research techniques (see above, under Work Package 2). Changes to WP2 allowed study of the psychological construct of grit. The Fellow and her colleagues were able to study and critically evaluate how grit has been researched and reported in engineering education and formulate recommendations to guide others reporting work on grit in EER. This was one of the studies where the Fellow and her colleagues were practicing the research methodology known as “systematic literature review” which lead to multiple conference papers and a journal article. Learning to work collaboratively as part of a highly effective research team was a major outcome of this fellowship. Another shift in WP2 was that, while the Fellow originally anticipated developing and conducting her own survey to extend WP1, she was able to learn more by working with psychologist Dr. Inês Direito to design and implement a quantitative survey for use at UCL. That study was presented/published via the Research in Engineering Education Symposium (REES) in Cape Town in July 2019.

### **5.1 Tasks**

All critical objectives proposed in the Fellow’s MSCA application have been fully achieved. The list of deliverables far exceeds promises, and many additional manuscripts that are currently under development using data collected during this fellowship will continue to achieve impact in coming years.