

A Research Supervision Framework for Quality and Scalability

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Abstract: Academic staff provide research supervision based on the one on one approach or the apprenticeship model. Current student recruitment policies are enrolling larger numbers of students on taught master's programmes. The current research supervision approach is not sustainable with growing numbers of students and conducting research supervision that is scalable is a challenge. Increasing the number of supervisors leads to difficulties with the consistency in the quality of the supervision. This research proposes a research supervision framework that scales with increasing numbers of re-search students and ensures consistency in the quality of research supervision among faculty. The framework combines teaching practices, timetabled group supervision, co supervision, coaching and scaffolding. The research supervision framework was applied in timetabled group research supervision sessions in May to August 2020 with 15 students, September 2020 to January 2021 with 10 students and May to August 2021 with 12 students. Results demonstrate an increase in the quality of research as demonstrated by the publication of 4 book chapters, 3 peer reviewed international conference papers and 3 invention disclosures. These publications occur during a period of growth in student numbers by approximately 1000% from 2012 to 2020. This research is of interest to both Deans and faculty. Deans will gain insight in how to ensure quality of supervision with growing student numbers on taught master's programmes. Faculty will gain insight in how to effectively supervise students in order to increase their academic publications using alternative supervision approaches.


1 INTRODUCTION

Research supervision typically takes place on a face-to-face basis in individual sessions. Research supervision may take place at PhD level, Masters by Research or through a taught Masters programme. Although research is available on doctoral research supervision, a gap in the literature on master's research dissertation supervision has been highlighted by Macfadyen, et al., (2019), Cornelius & Nicol (2015) and Drennan & Clarke, (2009). At taught and research Masters level, both approaches have a research dissertation as a final task to obtain the qualification. A further difficulty is that a taught masters would have a lower period of time based on credits to spend on the research dissertation. The contribution of the research dissertation on a taught master's programme typically varies between 25-30 credits. The duration of the dissertation on a taught

masters is typically 3 months full-time or 6 months part-time in the last phase of the master's programme.

Taught Masters programmes characteristically have larger numbers of students studying on the program. As student numbers grow the traditional research supervision model known as the apprenticeship model with one on one supervision is not sustainable. The supervision of master's students is very difficult to define as there are many variables based on the programme discipline, duration and diversity (Pilcher, 2011). The aim of this research is to investigate to what extent a research supervision framework scales with increasing numbers of research students and ensures consistency in the quality of research supervision among faculty. The major contribution of this research is a framework that combines teaching practices, timetabled group supervision, co supervision, scaffolding and coaching. This research is of interest to both Deans and faculty. Deans will gain insight in how to ensure quality of supervision with growing student numbers

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on taught masters programmes. Faculty will gain insight in how to effectively supervise students in order to increase their academic publications using alternative supervision approaches.

2 RELATED WORK

This related work is organised around the apprenticeship model of supervision, group supervision, co-supervision, teaching practice and scaffolding. The role of the supervisor as an assessor is also re-viewed as this is a factor that has workload implications for master's supervision as applied to group supervision approaches.

The British single supervisor model uses an apprenticeship model of training whereby a student registers to study on an independent piece of original research under the supervision and guidance of an experienced academic researcher who advises them on the conduct and publication of their research. Higher education institutes are under increased pressure from growing national and international student numbers enrolling on postgraduate programmes (Bitzer & Albertyn, 2011; Engebretson, et al., 2008). As a result, there is increased pressure on the supervisor workload (Bitzer & Albertyn, 2011; Usher, 2002). The increasing workload of supervisors of postgraduate students threatens the quality of research (Deuchar, 2008). The apprenticeship model is seen as being inappropriate to meet the needs for supervising students and alternative supervision approaches involving combining supervision groups, student colloquia and individual supervision are proposed by Dysthe, Samara, & Westrheim, (2006).

Bitzer & Albertyn (2011) present alternative supervision approaches such as group supervision and the team/panel approach to relieve the burden of increased supervisor workload arising out of increased student numbers. Groups may be comprised of students with similar levels of experience in the research process or mixed supervisor-and-student groups (Samara, 2006). Group supervision has the benefit of students producing higher quality dissertations particularly when students interact with their peers and supervisor (Lovitts, 2008). The structure of the group supervision process reported in Malfroy (2005) included a one-to-one follow-up session with the supervisor after a group session to build on the intellectual discussion and to help set a new direction.

Supervisory Teams can involve a co-supervisor that participates occasionally (Nulty, Kiley, & Meyers, 2009) which can assist with the continuity of

supervision or they can bring additional expertise to strengthen the supervision. Team approaches provide a more holistic approach to problem solving, less interpersonal issues, and enhanced quality of research (Lee, 2009).

Dysthe, Samara, & Westrheim (2006) propose that a supervision approach should combine supervision groups, student peer groups and individual supervision to remove the dependency on one supervisor interaction and to manage the academic workload. Macfadyen et al. (2019) indicates that a supervision approach should prepare for growing numbers of master's students and be able to adapt to individual student's needs.

Marnewick (2020) proposed a supervision approach to support the learning process of master's students during research supervision. The structured approach includes self-learning, peer learning, individual supervision, and existing teaching practices. Teaching practices can be used by less experienced supervisors to structure students' supervision.

Manathunga (2005) indicates that experienced supervisors use scaffolding of activities through the research process. Dysthe, Samara, & Westrheim (2006) and Crossouard (2008) indicate the importance of having guidelines to ensure that the supervisory team fulfil their roles and responsibilities.

Another issue that affects research supervision is the role of the supervisor as the assessor of the research, with a second independent assessor (de Kleijn, Mainhard, Meijer, Pilot, & Brekelmans, 2012; Cornelius and Nicol 2015) or it is done by two independent assessors.

In conclusion, growing student numbers (Engebretson et al. 2008; Bitzer & Albertyn, 2011) and maintaining the quality of the research supervision (Deuchar, 2008) are challenges faced by institutes of higher education. Alternative forms of supervision such as group supervision and co-supervision, (Bitzer & Albertyn, 2011) and structured supervision that includes self-learning, peer learning, individual supervision, and existing teaching practices Marnewick (2020), are shown to reduce the supervisor's workload and lead to students producing higher quality dissertations (Lovitts, 2008). Scaffolding of activities and research supervision guidelines support inexperienced supervisors and assist the supervisory team with clear roles and responsibilities to create a supportive research environment for the students.

3 METHODOLOGY

This research investigates the challenges around growing student numbers and maintaining the quality of the research supervision.

The environment in which the framework was developed was in a School of Computing at an Irish institute of higher education. Students attended taught master's programmes in the area of Data Analytics. The students in full time were diverse and predominantly international. The taught masters programme consisted of taught modules and a research theme. The research theme consisted of a Research in Computing module of 5 credits in semester 2 and a Research Project of 25 credits in semester 3. The research theme represents 33% of the qualification. The students would typically engage in applied research. Supervision was based on the apprenticeship model involving one on one supervision. We developed the framework over several years from 2017 to date following an action research approach. Action research seeks transformative change through the simultaneous process of taking action and doing research, which are linked together by critical reflection (Lewin, 1946). The framework was applied to the research project in the MSc in Data Analytics. We applied the research supervision framework in timetabled group research supervision sessions in

- May-August 2020 to 15 students,
- September 2020-January 2021 to 10 students
- May – August 2021 to 12 students

Students first complete a research proposal that consists of an abstract, literature review and proposed methodology as part of research in computing in semester 2. The students are assigned to group supervision as part of the research project.

The delivery of the research project in full-time over a 12-week period is as follows: -

In week 0, I would get the students Research Project Proposal from Research in Computing and the research paper that most influences their work from the state of the art. I would provide detailed comments on Abstract, Introduction, Literature Review and Methodology in order to bring the sections up to a standard that is publishable. I would also ensure that the influential research paper has been published recently in a reputable journal or Scopus linked conference.

In week 1, I would go through the slides "Module Overview, Research Handbook, and slide decks on writing an Abstract, Introduction and literature review. I encourage the students to identify a quality

conference that they would like to publish in with a focus on Scopus linked international conferences.

In week 2, I go through slides on Methodology, Design and Implementation. On a weekly basis, I check the students' progress in terms of what they completed in the last week. I set goals with the students that they have to complete in the following week. Week 2 goals involve starting to scope out the aim of the experiments that they will complete. Where the first experiment is to replicate the state of the art from the paper that most influences their research. I also focus on the environment and implementation of experiment 1.

In week 3, I help the student to sharpen their research question in the problem domain and focus on goals around the implementation of experiment 1.

In week 4 I flesh out each experiment that will be documented in the results section with signposting around "The aim of this experiment is to ...".

In week 5, I go through slides on Results. I also focus on completing experiment 1 and updating the report on results.

In week 6 I go through the slides on Discussion and Conclusion. I focus on getting the students to update their conference style report with a discussion of experiment 1. I also focus on getting the students to implement experiment 2 based on making one change to experiment 1.

In week 7 the co-supervisor joins the meeting. The co-supervisor meets with each student and discusses progress.

In weeks 8, 9, 10 and 11 we focus on completing each experiment and making one change for the next experiment.

In week 12, we check that the conclusion restates the research question, objectives and the work done. We check how successful student has been in answering the research question and achieving the objectives, that the key findings are restated, and any proposals for future work or potential for commercialisation are identified.

After the examination of the master's research project, we work with the student to refine the research paper and submit to a Scopus linked international conference. If the research has commercial potential we submit an invention disclosure form.

The research output quality is evaluated based on publications and invention disclosures that are recognised at a National and International level. Publications are in the form of Book Chapters and Scopus linked conference papers.

4 RESEARCH SUPERVISION FRAMEWORK

The research supervision framework combines teaching practices in section 4.1, timetabled group supervision in section 4.2, co supervision in section 4.3, coaching in section 4.4 and scaffolding in section 4.5.

4.1 Teaching Practice

Teaching practices was applied to the research project by allocating 5 of the 30 credits into semester 2 as part of a module Research in Computing that consisted of 1-hour lecture and 2 hours tutorial. The Research in Computing module introduces students to the requirements of academic writing, including carrying out a review of the state of the art in their chosen domain, how to create a research proposal, the importance of reproducible research, scientific writing including citing and referencing, and the presentation of results. 25 credits are allocated to the Research Project module in semester 3. Students have to submit a portfolio that consists of a research paper style report, an artefact/product, a user configuration manual and a presentation to be defended in a viva. The traditional dissertation of 10,000 to 15,000 words is replaced with a research paper style report shall comprise up to 20 pages of between 4,000 to 6,000 words. The report describes the individual research and production of an ICT solution. The format of the paper follows a conference/journal style with abstract, introduction, related work, methodology, design, implementation, evaluation, conclusion and references. The motivation for this change was to reduce faculty workload in assisting students with publishing their dissertation in an international conference.

4.2 Timetabled Group Supervision

Timetabled group supervision is a structured activity based on assigning 10 to 12 students from the same thematic area to a scheduled class with a research supervisor. The class is scheduled in a block of 4 hours. The first hour is a group session where the supervisor goes through a slide deck on the research process covering aspects of the research paper style report in a timely fashion to the sections of the report that students are working on. The remaining three hours are based on a one-to-one follow-up session between the supervisor and students to build on the

intellectual discussion and to advise the student on the research.

4.3 Co-supervision

Co-supervision was applied to research groups to ensure continuity of the supervision during the summer holidays. The co-supervisor participates occasionally and provides very different but complementary support. They usually attend half way through the research process. The students have to give an update on their research progress, issues they are encountering and the next steps. Co-supervision is also applied to new full-time faculty as a form of direct coaching the goal of which is to go through the research supervision framework and create a publication in a peer reviewed Scopus indexed international conference/journal. This co-supervisor participates for the full supervision.

4.4 Coaching

Coaching is codified in the form of weekly supervisor guidelines that highlight the responsibilities that a supervisor has in a temporal form for example before meeting the student for the first time in the research project the supervisor should critique the research proposal from Research in Computing. The critique should align the proposal to the sign posting in the template and provide the student with comments on the abstract, introduction, literature review, and methodology.

4.5 Scaffolding

Scaffolding is in the form of a slide deck and a template with signposting of the research vernacular. The slide deck was created to provide consistent instruction to the students independent of supervisor experience. In addition, tips are provided to support students with writing sections of the research paper style report. The slide deck consisted of separate slides on the abstract, introduction, literature review, methodology, design, implementation, results and conclusion. The template is based on a published paper in an international peer reviewed Scopus indexed international conference. The template highlights signposting of the research vernacular and is based on Oluwatobi, Murphy, Pathak, & Stynes, (2021).

The template guides the student in creating a title around 3 aspects namely the novel contribution, classification of that contribution and the story. An example from the template where the contribution is

“An on-device Deep Learning”; the classification is a “Framework” and the story is “to Encourage the Recycling of Waste”.

The slides on the abstract discusses the structure of the abstract in terms of background, objectives, methodology, results and findings. The first sentence in the abstract of the template discusses the story from the title to provide context of the research. The second sentence emphasises wording such as use of “challenge” to bring out the research problem. The 3rd sentence articulates what the research is proposing and that it is aligned to the title of the research with phrasing such as “This research proposes an ... framework (or model and so on) to ...”. The fourth sentence further describes the classification of the research with phrasing around “The proposed framework (or model and so on) combines...”. The fifth sentence describes the methodology. The sixth sentence starts with wording “Results ...” to ensure the student describes the metrics applied and results achieved. The final sentence uses phrasing “This research shows promise for ...” to ensure the student describes the benefit of this research to a stakeholder that is interested in this research.

The slides on the introduction discuss the background to the research, the motivation for the research, the variables or factors that affect the outcome of the research, research question, and contribution. The template reinforces the slides with phrasing “The aim of this research is to ...” and “The major contribution of this research is a novel ...”.

The slides on the related work provide a guideline for writing a critique, writing style and referencing. There is a focus on identifying future work from a journal or Scopus linked conference paper in order to ensure that students work on a novel contribution that is publishable. If a research paper is important to their research that they will use or improve on, then they should describe it in a paragraph in the literature review. The paragraph should describe the purpose of the research paper, methods used, main results and strengths or limitations. Strengths are good practice and something the student should aim to emulate in their research. Limitations provide an opportunity for students to improve on or extend that work. The concluding paragraph of the literature review sums up the strengths and weaknesses of the related work and by assessing its contribution to the advancement of knowledge, theory, or practice. The template provides guidance in the first paragraph students should start with a sentence that is directly related to the title of their research. Phrasing for the concluding paragraph to ensure students focus on summing up the strengths

and weakness “In conclusion, the state of the art indicates ...”.

The slides on methodology emphasise that students experiment need to be verifiable by other researchers, so that they can review the results by replicating the experiment and guaranteeing the validity. The slides describe the sections of a methodology based on the steps followed in the research; describing the materials and equipment used in the research; explaining how the samples were gathered, any randomization techniques and how the samples were prepared such as cleaned and transformed; explaining how the measurements were made and what calculations were performed upon the raw data; and describing the statistical techniques used upon the data. The template provides phrasing such as “The research methodology consists of five steps namely ... as shown in Fig. 1.”, “The first step, ...”, “The second step, ...” and so on. Students must ensure the steps are labelled in the figure and they should name the step for example “The first step, Data Gathering involves combining six waste image datasets”.

The slides on design discuss presenting the techniques and/or architecture that underlie the implementation. The template provides phrasing where the students must discuss the name of their contribution from the title of their research paper and the main architectural components of their design in the following sentence “The ... framework (or model and so on) architecture ... as shown in Fig. 2.”. The design section is split into a description of each component. The second sentence in the template ensures the students discuss all components in the diagram starting with phrasing “The components of the ...”.

The slides on implementation describe the outputs produced such as transformed data, code written, models developed, questionnaires administered. The description should also include what tools and languages you used to produce the outputs. The first sentence in the template ensures students focus on implementation with phrasing “The ... framework (or model and so on) was implemented ...”. For publications a screen shot of the graphical user interface works well in this section.

For slides on results, discusses the presenting of only the most relevant results using visual techniques such as graphs, figures and tables. Presenting an in-depth and rigours analysis of the results and how they relate to answering the research question and the current state of the art. Students are requested to replicate the state-of-the-art as the first experiment. This is to ensure students really understand what a

research methodology is in terms of replicating a study and they really understand the state-of-the-art approach. In addition, this provides an opportunity for students to be able to discuss the results they get in further experiments as a comparison to the state of the art. The second experiment is based on making one change to the first experiment. This may involve implementing the future work identified in the state-of-the-art research paper. A rich discussion can take place in terms of the results of experiment 1 and how they relate to previous research from the state of the art. Experiment 2 may involve changing/optimising/enhancing the framework (or model and so on) and seeing if the results improve. By following this approach there is clear and systematic evidence of novelty and contribution to the state of the art which is publishable in a conference or journal. The template for the results starts each experiment to ensure students are clear on the experiment with phrasing “The aim of this experiment is to ...”. To ensure that students discuss the meaning of the results the template uses phrasing “This result indicates that ...”. The template emphasises that students should describe the diagrams and tables in detail. To make clear the most relevant results the template uses phrasing “The results show promise for ...”.

The slides on the conclusion discuss the conclusion in terms of restating the research question, your objectives and the work done; stating how successful the student has been in answering the research question and achieving the objectives; restating the key findings and finally describing any proposals for future work or potential for commercialisation. The template provides phrasing that reemphasises the discussion in the slides with phrasing “The aim of this research was to ...”. “This research proposes an ... framework (or model and so on) that ...”. “Results demonstrate that ...”. “This research can potentially enhance ...”. This work can be improved by ...”. “This research benefits ...”.

5 RESULTS

The research supervision framework was designed to scale the supervision based on handling the growing number of students registering on taught MSc programmes. In 2012, 69 students were enrolled. Enrolments reached a peak in 2019 with 814 students, representing a growth of approximately 1000% since 2012.

From 2012 to 2017 faculty provided one on one research supervision in the research project. An

observation was that there was a break in the continuity of supervision when faculty went on summer holidays. MSc surgery sessions were provided to ensure continuity of supervision. The MSc Surgery involved one academic checking all postgraduate students’ progress. Progress was reflected in the student’s blog, documenting the chapters they have updated, the academic answering research questions and identifying work that needs to be completed.

Table 1 shows the interventions that were made in creating the research supervision framework.

Table 1: Interventions in the Research Project.

Year	Intervention
2017 - 2018	Group Supervision (6 students) and One on One Supervision. MSc Surgery Session.
2018- 2019	Scaffolding in the form of a slide deck. Timetabled group research supervision (15 students) and Co-supervision.
2019- 2020	Scaffolding in the form of a Slide deck. Timetabled group research supervision (15 students) and Co-supervision.
2020- 2021	Coaching in the form of weekly supervisor guidelines. Scaffolding in the form of a Slide deck and template. Timetabled group research supervision (10-12 students) and Co-supervision.

Difficulties in recruitment of faculty to supervise based on one to one supervision indicated that this approach of scaling up research supervision was not sustainable. A model of group supervision of up to 6 students in a thematic area with an increased focus on Associate Faculty supervision was trialled to one group of data analytics students in September 2017. Associate faculty are part time faculty and would predominantly have a PhD. An observation was that student attendance during the research project was problematic. Timetabled group research supervision was implemented in 2018 in order to address the issue of attendance. Group supervision increased from 6 to 15 students in order to address growing student numbers. However, the supervisory model was that supervisors would have to examine their students and second mark an equal number of students over a two-week period. A supervisor would have 30 students to examine, comprising of 15 students that were supervised and 15 students that were 2nd marked. At 2 hours per examination this would take around 60 hours over a two-week period. As associate faculty are part time and may have a full-time job, this could add an additional 30 hours per week for two weeks leading to workload issues. The number of students

assigned to timetabled group supervision was reduced to 10 students in order to address the workload issue. Whilst 10 students in a timetabled group supervision is the right balance, this number could increase if supervisors are not part of marking or they did not have to complete second marking of other student's research style papers.

MSc Surgery sessions were poorly attended and as such co-supervision was introduced to replace the MSc surgery sessions.

We introduced scaffolding of activities around a slide deck, template and research supervision guidelines in order to create a supportive research environment for the students.

Table 2: MSc research output quality recognised at National and International level.

Date	Number of Students Supervised	Research Output
May-20 to Aug-20	15	2 Book Chapter - Lecture Notes in Computer Science Springer (Kumar, Pathak, & Stynes, 2020) and SciTePress (Palani, Stynes, & Pathak, 2021) 3 International Conference Papers (Wagh, Pathak, Stynes, & Nardin, 2020), (Kanhere, Sahni, Stynes, & Pathak, 2021), (Agughalam, Pathak, & Stynes, 2021) 1 Invention Disclosure
Sep-20 to Jan-21	10	1 Book Chapter - Lecture Notes in Computer Science Springer (Ekundayo, Murphy, Pathak, & Stynes, 2022) 2 Invention Disclosures
May-21 to Aug-21	12	1 Book Chapter – European Alliance for Innovation (EAI), European Union Digital Library (Padalkar, Pathak, & Stynes, 2021). Submitted - Awaiting Acceptance 1 Journal Submitted - Awaiting Acceptance 1 International Conference Paper In preparation 1 International Conference Papers

We applied the research supervision framework in 3 timetabled group research supervision sessions in May-August 2020 to 15 students, September 2020-January 2021 to 10 students and May – August 2021 to 12 students as described in Table 2. The 3 groups of students were supervised and co-supervised by the authors.

Results show promise with an increase in the quality of research as demonstrated by increased research publications and invention disclosures at National and International level. We supervised 37 students on a taught master's programme in timetabled group supervision with co-supervision.

The research output of this supervision consists of 2 book chapters as part of lecture notes in computer science with Springer, 1 book chapter with SciTePress, 1 book chapter as part of the European Alliance for Innovation and stored in the European Union Digital Library, 3 peer reviewed international conference papers and 4 invention disclosures. At the time of writing one paper has been submitted to a journal awaiting acceptance, one paper has been submitted to an international conference and 1 conference paper is in preparation. This quality research output as a result of the Research Supervision Framework occurs during a period of growth in student numbers by approximately 1000% from 2012 to 2020.

6 CONCLUSION

The aim of this research is to investigate to what extent a research supervision framework scales with increasing numbers of research students and ensures consistency in the quality of research supervision among faculty. The framework combines teaching practices, timetabled group supervision, co supervision, scaffolding and coaching.

Results demonstrate that students we supervised in a small group with co-supervision have been successful at a national and international level in writing 4 book chapters as part of lecture notes in computer science with springer and SciTePress and the European Alliance for Innovation, 3 peer reviewed international conference papers and 3 invention disclosures. The framework has scaled with growing student numbers during a period of growth of approximately 1000% from 2012 to 2020. Pass rates have also increased from 29% in 2012 to 88% in 2020.

Future work could investigate the effective use of student peer groups to reduce the work load of the supervisor. In addition, future work could explore the

role of a second independent assessor being an active second supervisor in order to increase the likelihood of publications at an international level.

REFERENCES

- Agughalam, D., Pathak, P., & Stynes, P. (2021). Bidirectional LSTM approach to image captioning with scene features. *Thirteenth International Conference on Digital Image Processing (ICDIP 2021)*, 11878, pp. 81–88. doi:10.1117/12.2600465
- Bitzer, E. M., & Albertyn, R. M. (2011). Alternative approaches to postgraduate supervision: A planning tool to facilitate supervisory processes. *South African Journal of Higher Education*, 25(5), 875-888. doi:10.33130/AJCT.2021v07 i01.019
- Cornelius, S., & Nicol, S. (2015). Understanding the Needs of Masters Dissertation Supervisors: Supporting Students in Professional Contexts. *Journal of Perspectives in Applied Academic Practice*, 4(1), 2-12. doi:10.14297/jpaap.v4i1.161
- Crossouard, B. (2008, March 1). Developing alternative models of doctoral supervision with online formative assessment. *Studies in Continuing Education*, 30(1), 51-67. doi:10.1080/01580370701841549
- de Kleijn, R. A., Mainhard, M. T., Meijer, P. C., Pilot, A., & Brekelmans, M. (2012, December 1). Master's thesis supervision: relations between perceptions of the supervisor–student relationship, final grade, perceived supervisor contribution to learning and student satisfaction. *Studies in Higher Education*, 37(8), 925-939. doi:10.1080/03075079.2011.556717
- Deuchar, R. (2008, August 1). Facilitator, director or critical friend?: contradiction and congruence in doctoral supervision styles. *Teaching in Higher Education*, 13(4), 489-500. doi:10.1080/13562510802193905
- Drennan, J., & Clarke, M. (2009, August 1). Coursework master's programmes: the student's experience of research and research supervision. *Studies in Higher Education*, 483-500. doi:10.1080/03075070802597150
- Dysthe, O., Samara, A., & Westrheim, K. (2006, June 1). Multivoiced supervision of Master's students: a case study of alternative supervision practices in higher education. *Studies in Higher Education*, 31(3), 299-318. doi:10.1080/03075070600680562
- Ekundayo, O., Murphy, L., Pathak, P., & Stynes, P. (2022). An On-Device Deep Learning Framework to Encourage the Recycling of Waste. In *Intelligent Systems and Applications, Lecture Notes in Networks and Systems* (pp. 405–417). Cham: Springer International Publishing, ISBN: 978-3-030-82199-9. doi:10.1007/978-3-030-82199-9_26
- Engebretson, K., Smith, K., McLaughlin, D., Seibold, C., Terrett, G., & Ryan, E. (2008, February 1). The changing reality of research education in Australia and implications for supervision: a review of the literature. *Teaching in Higher Education*, 13(1), 1-15. doi:10.1080/13562510701792112
- Kanhere, S., Sahni, A., Stynes, P., & Pathak, P. (2021). Clustering Based Approach to Enhance Association Rule Mining. *2021 28th Conference of Open Innovations Association (FRUCT)*, (pp. 142–150). doi:10.23919/FRUCT50888.2021.9347577
- Kumar, A., Pathak, P., & Stynes, P. (2020). A Transfer Learning Approach to Classify the Brain Age from MRI Images. In L. a. Bellatreche, *Big Data Analytics (Lecture Notes in Computer Science ed.)*, pp. 103–112. Cham: Springer International Publishing. doi:10.1007/978-3-030-66665-1_8
- Lee, A. (2009, July 1). Some implications of European initiatives for doctoral supervision. *Political Science*.
- Lewin, K. (1946). Action Research and Minority Problems. *Journal of Social Issues*, 2(4), 34-46. doi:10.1111/j.1540-4560.1946.tb02295.x
- Lovitts, B. E. (2008). The Transition to Independent Research: Who Makes It, Who Doesn't, and Why. *The Journal of Higher Education*, 79(3), 296-325. doi:10.1353/jhe.0.0006
- Macfadyen, A., English, C., Kelleher, M., Coates, M., Cameron, C., & Gibson, V. (2019, July 29). 'Am I doing it right?' Conceptualising the practice of supervising master's dissertation students. *Higher Education Research & Development*, 38(5), 985-1000. doi:10.1080/07294360.2019.1597024
- Malfroy, J. (2005, May). Doctoral supervision, workplace research and changing pedagogic practices. *Higher Education Research & Development*, 24(2), 165-178. doi:10.1080/07294360500062961
- Manathunga, C. (2005, May 1). The development of research supervision: "Turning the light on a private space". *International Journal for Academic Development*, 10(1), 17-30. doi:10.1080/13601440500099977
- Marnewick, A. J. (2020). A supervision approach to facilitate learning during the master's research journey. *Teaching in Higher Education*, 1-16. doi:10.1080/13562517.2020.1811223
- Nulty, D., Kiley, M., & Meyers, N. (2009, December 1). Promoting and recognising excellence in the supervision of research students: an evidence-based framework. *Assessment & Evaluation in Higher Education*, 34(6), 693-707. doi:10.1080/02602930802474193
- Oluwatobi, E., Murphy, L., Pathak, P., & Stynes, P. (2021). An On-Device Deep Learning Framework to Encourage the Recycling of Waste. In *Intelligent Systems and Applications - Proceedings of the 2021 Intelligent Systems Conference (IntelliSys) Volume 3* (Vol. 296, pp. 405-417). Springer Nature Switzerland AG. doi:978-3-030-82199-9
- Padalkar, A., Pathak, P., & Stynes, P. (2021). An Object Detection and Scaling Model for Plastic Waste Sorting. In M. Z. Philipp Wicke (Ed.), *Proceedings of the 1st International Conference on AI for People: Towards Sustainable AI, CAIP 2021*. Bologna, Italy: EAI, ISBN:

- 978-1-63190-326-7, ISSN 2593-7642 Series CORE.
doi:10.4108/eai.20-11-2021.2314204
- Palani, K., Stynes, P., & Pathak, P. (2021). Clustering Techniques to Identify Low-engagement Student Levels. In *Proceedings of the 13th International Conference on Computer Supported Education* (Vol. 2, pp. 248–257). CSEDU, ISBN 978-989-758-502-9; ISSN 2184-5026, SCITEPRESS.
doi:10.5220/0010456802480257
- Pilcher, N. (2011, February 1). The UK postgraduate Masters dissertation: an ‘elusive chameleon’? *Teaching in Higher Education*, 16(1), 29-40.
doi:10.1080/13562517.2011.530752
- Samara, A. (2006, May). Group Supervision in Graduate Education: A Process of Supervision Skill Development and Text Improvement. *Higher Education Research and Development*, 115-129.
- Usher, R. (2002, July 1). A Diversity Of Doctorates: Fitness for the knowledge economy? *Higher Education Research & Development*, 143-153.
doi:10.1080/07294360220144060
- Wagh, V. K., Pathak, P., Stynes, P., & Nardin, L. G. (2020). An Evacuation Route Model for Disaster Affected Areas. *AICS 2020*, (p. 12).

