Codifying Systematic Manuscript Preparation Checklists as a Training and Productivity Resource for Research Students

Paul Cuffe, *Member, IEEE*

***Abstract*—This papers aims to provide research students with a tool to make explicit and tangible the steps needed to efficiently produce a high-quality, polished research manuscript. The tool is implemented as a set of *checklist resources* to be completed by the research student at various stages of manuscript production. Fundamentally, humans are forgetful and are typically poor at consistently executing multi-part procedures in a systematic way. The simple technology of checklists overcome this weakness of human cognition. The checklists themselves function as a learning re-enforcement aide, ensuring that students methodically and repeatedly work through the prescribed workflow for manuscript production and proofreading. Interactive PDF documents were chosen as a suitable educational technology to implement these checklist resources. Such PDF documents contain fillable boxes that can be completed and saved by the user, avoiding the need to print, scan or manually edit such forms. Embedding quality control and proof-reading feedback in such digital documents promotes good record keeping and captures the progression of a manuscript though its different stages of drafting.**

I. Introduction

Learning research skills is essential for many engineering students: whether enrolled in a research masters, conducting a doctorate, or writing a dissertation as the capstone of a taught undergraduate programme. However, many research skills are tacit and illegible. For instance, how should a manuscript be structured, the literature reviewed [1] or a journal chosen? At the more granular level, what software tools for manuscript production should be used, and how? It can take students many years to become deft at the actual writing-up of research: a lot of the relevant tips and skills are tacit and undocumented. In this context, there is scope for improving the entire workflow [2] surrounding the build-out of a research manuscript. The preparation of research manuscripts is a central and time-consuming activity within academia, but the actual practicalities of this process are often overlooked.

The aim of the present paper is to create repeatable workflow procedures so that that research students can rapidly and painlessly create high quality papers. The specific focus for the present work is to design a checklist process for writing up and proofreading research. This workflow should effectively and dependably teach research students the tacit and often overlooked knowledge about how best to efficiently disseminate research. Furthermore, such resources may equip research students to more rapidly produce and disseminate high quality technical work.

P. Cuffe (paul.cuffe@ucd.ie) is with the School of Electrical and Electronic Engineering, University College Dublin.

The set of interactive checklists will allow the lead author of a manuscript to:

- perform systematic self-reflection on their own work [3]
- systematically gather meaningful criticism from peer proofreaders, each of whom will carefully examine just a particular part of the paper [4]
- avoid last minute problems with manuscript submission, by flagging publication page limits, deadlines, and abstract word counts
- document their compliance with their research team's quality control systems

A. Checklist based approach

Checklists are a powerful tool for quality control across many domains [5]. For instance, within the ambit of academic publishing, they have been proposed to enhance consistency and efficiency in peer review activities [6]. Work in [7] documents a structured checklist approach to manuscript preparation in the biomedical sciences, targetted at early stage researchers. Work in [8] describes a systematic workflow that enforce data transparency and replication standards for manuscripts.

More generally, checklists have been proposed to enhance undergraduate learning, facilitating self-assessment of work and streamlining feedback delivery [9]. Work in [10] documents the integration of a structured authoring workflow into an undergraduate technical writing course (the author of [11] argues that engineering classrooms systematically teach students sloppy writing habits) Work in [12] proposes a structured *'problem-solution-based writing model'* process to equip research students for whom English is an additional language to write effective introductory sections for research articles. Research in [13] used systematic principles of value engineering to analyse the five lifecycle stages of a research paper. Related research in [14] proposed the use of checklists as a procedural tool to enhance multidisciplinary research communication and academic writing and presentations. Even famous novelists have contributed systematic tips on writing quality scientific papers [15], offering injunctions such as *"limit each paragraph to a single message"* and *"avoid placing equations in the middle of sentences"*

The purpose of adopting a codified research workflow is multi-fold. Firstly, early stage research students often have similar challenges [16] and questions e.g *how should a literature review be structured; how can citations be handled; what software should be used to prepare a manuscript*? Rather than repeatedly answering these questions in an ad-hoc fashion, there seems to be scope to build up a set of relevant and credible resources that cover these points. Furthermore, a

defined research workflow resource based around checklists should better educate students in the full breadth of skills required to be a productive researcher. The goal is to produce a defined research workflow resource, similar to a rubric [17], that edifies students while simultaneously enhancing the quality of their published work. This defined workflow will make more tangible certain research skills, and will seek to embody the unstructured knowledge, tips, tricks, hacks and know-how that experienced researchers accumulate throughout their career. Operationalising this granular domain knowledge [18] within a defined workflow for research students will ensure that these skills are passed on in an apt, applicable and repeatable fashion.

II. Workflow Checklist Design

The goal is to design a set of checklist PDF documents that more rapidly equip research students with all the tacit skills needed for the rapid, efficient production of a high quality manuscript. These documents form part of a documented and repeatable workflow for writing up research, enhancing quality control of published outputs as part of a 'standard operating procedure' when preparing any manuscript for submission.

A. Precursor Resources and Tools

The proposed checklists are an extension of resources previously developed by the present author:

- A 'pre-flight' checklist document for final quality control and vetting of written material prior to publication [19]
- A specific checklist for proofing data visualisations [20], which including signposting of relevant educational resources on this topic
- A video piece which delineates how the production of data visualisations should be approached within the MATLAB environment [21]. This builds on more general visualisation advice in [22], [23]
- A standard project folder on the online colloborative writing platform Overleaf [24], containing a customised LaTeXtemplate of an IEEE manuscript [25], pre-populated with specific writing guidance from [26]. This project folder also contains templates for 'response to reviewers' documents. At the beginning of each new research paper, this standard workspace is forked, and this project folder than subsequently contain everything relevant to that manuscript over its lifetime (e.g versions at different stages of peer review, cover letters, etc.)
- An online 'research manifesto' [27], a live and regularly updated document containing various thoughts and outbound links on how to conduct academic research

B. Rationale for designing multiple checklists

The codified research workflow resource is composed of four interactive PDF documents. Each of these checklists forms is to be filled in digitally and submitted alongside the draft manuscript to the research supervisor. In this way, the supervisor is not only providing feedback on the as-written draft manuscript, but also has sight of the process that went into producing it. Furthermore, the completed PDF forms will then reside in the relevant project folder on the online colloborative writing platform, documenting the status of the manuscript at each particular stage of its evolution.

A crucial design choice is that the process of proofreading the draft manuscript is divided between three peers, separate to the lead author and the supervisor named on the manuscript. Giving each proofreader a smaller portion of the manuscript is intended to elicit a greater density of granular, comprehensive and actionable feedback. When an entire manuscript is given to a peer for proofreading, there is a tendency for the depth and rigour of the textual comments to thin out further into the manuscript as their attention-to-detail wanes. This design decision is intended to overcome this natural ebbing of focus: *"The intensity with which proofreading must be done precludes marathon sessions."* ([28], chapter 8)

Furthermore, the proofreading checklist forms are carefully written to overcome the default positivity that prevails when reading the work of a friend and a peer. Actual peer reviewers for journals tend to be notably less easy to please, so gaining actionable, constructive feedback at an early stage is more beneficial than receiving vague praise.

III. The Developed Checklists

A. Four checklists

The four developed workflow checklists are as follows, where forms B, C and D are completed by peers at the behest of the lead author. These interactive PDF documents are available on a persistent online repository under a permissive license at [29].

- **Form A**, covering the logistics of manuscript preparation. This form is to be completed by the student who is lead author on the draft manuscript in question. This form captures such information as the chosen publication venue, whether deadlines or page limits apply, and so forth. Reproduced in Fig. 1.
- **Form B**, which systematises the procedure for proofreading [30] the *narrative* and *framing* portions of the draft manuscript: typically the title, abstract, introduction and conclusion. This particular proofreader should emphasise the examination of the manuscript's narrative arc, impact, novelty and relationship to extant literature. Reproduced in Fig. 2.
- **Form C**, which systematises the procedure for proofreading the *methodology* portions of the draft manuscript. This proofreader will be guided to focus on the clarity of mathematical notation, pseudocode, flow-charts etc. Reproduced in Fig. 3.
- **Form D**, which systematises the procedure for proofreading the *results* portion of the draft manuscript. This checklist form systematises procedures for ensuring the quality of data visualisations, numerical tables and the explanation of the implications of the results obtained. Reproduced in Fig. 4.

1) Preamble text: The checklists B, C and D each commence with the following standard text, deliberately written in an encouraging and informal tone:

> You are being asked as a proofreader to read just these sections of the manuscript: this should allow you to really focus in and give ample, granular and constructive feedback. Don't feel that you must be

Pre-submission workflow checklist. Form A
Manuscript *logistics*

This document codifies the tasks to be completed before submitting a substantial draft of a paper to the supervisor. This is a fillable PDF form, so complete it in a suitable reader. It should typically be submitted alongside forms **B**, **C** and **D**, which will be completed by your chosen proofreaders.

Foresight:

Title of manuscript

Name of targeted journal/conference/special issue/other venue

Permitted page count

Permit word count of abstract

Submission deadline (if applicable)

Can reviewers be recommended? ☐

Have relevant data and scripts been uploaded to Figshare? ☐ If not, why not?

Proofing:

Has the UCD Writing Centre been visited? ☐ Date of visit?

Has the manuscript been run through Grammarly? ☐

How many total acronyms appear in the manuscript?

Proof-read of **Abstract**, **Introduction** & **Conclusion** sections (Emphasis on narrative, impact, novelty and relationship to extant literature) — Has **Form B** been completed? ☐ Name of proofreader

Proof-read of **Methodology** section(s). (Emphasis on clarity of notation, pseudocode, flow-charts etc.) — Has **Form C** been completed? ☐ Name of proofreader

Proof-read of **Results** section(s). (Emphasis on clear visualisations & tables and implications of results.) — Has **Form D** been completed? ☐ Name of proofreader

Name of submitter: Type your name Today's date:

Fig. 1. An adapted representation of the **Form A** logistics checklist

generally positive: *"nice paper!"* is not actionable advice. Instead, engage deeply to give specific proofing advice guided by this checklist. Reviewers can be fairly hostile: this exercise is meant to elicit those kinds of response in-house.

This is a fillable PDF form which should be completed and sent back to the lead author, in addition to a red-inked version of the manuscript you've been asked to look at.

The schema in [1] B. Mensh and K. Kording, "Ten simple rules for structuring papers," *PLOS Computational Biology*, vol. 13, no. 9, 2017 should guide the proofreading work

2) Form A: Manuscript logistics: This form, reproduced in Fig. 1, is to be completed by the lead author of the manuscript and submitted to the principal supervisor alongside the other checklists. The *'Foresight'* section is intended to flag in a timely way problematic issues that may be encountered just before manuscript submission. Potential problems here include exceeding page limits or abstract word counts. This section also documents whether the chosen venue allows reviewers to be suggested: if so, this early signposting creates the opportunity to compile a panel of potential names well in advance of submission.

The *'Proofing'* section of this form is intended to enforce standard procedure for comprehensive quality control of the manuscript. The availability of the institutional writing resource centre is flagged, as is access to automated proofreading software [31]. This form requires that the total number of acronyms in the manuscript be counted: ideally this will be a small amount [32]. This section also documents who the lead author has enlisted to complete the specific proofreading tasks in forms B, C and C.

3) Form B: Manuscript narrative: This form is to be completed by a proofreader; a peer selected by the lead author. This checklist guides this proofreader in implementing the schema for good technical papers given in [26] (which has the alias numbering of [1] in Fig. 2). This proofreader will focus on the narrative sections of the manuscript, those prose passages that bookend the work: typically the title, abstract &

Proofreading workflow checklist. Form B
Manuscript *narrative*

This document codifies the tasks a proofreader should complete when examining the *narrative sections* of a manuscript: typically the **Abstract**, **Introduction** and **Conclusions**.

Title and Abstract:

Did the paper's **Abstract** clearly explain why this paper matters and is relevant? (An effective abstract situates the work in its wider context, identifies specific problems that need to be solved, points towards the novel approaches that can be deployed, and summarises the results achieved)

☐ [× means yes]

"The abstract is, for most readers, the only part of the paper that will be read" [1]

After reading the T**itle** and **Abstract**, could you provide an "*elevator pitch*" summary of what the paper is about?

Try your best to write in a quick summary!

On a scale of 0 to 10, how would you rate the effectiveness of the **Title** of the manuscripts? (A good title should be memorable, include key words, should invite curiosity, and should prefigure the central findings)

☐

"*The title is the ultimate refinement of the paper's contribution*" [1]

Feel free to suggest an alternative title here

On a scale of 0 to 10, how would you rate the effectiveness of the **Abstract** of the manuscripts? (A good abstract should be self-contained, fun-to-read, and suitable for a general audience)

☐

"*the abstract must convey the entire message of the paper effectively*" [1]

Introduction section:

On a scale of 0 to 10, how would you rate the effectiveness of the **Introduction** of the manuscript? (An effective Introduction progresses from the general to the specific, summarises the relevant literature, and argues for the aptness and timeliness of the proposed methodology)

☐

"The vast majority of popular (i.e., memorable and re-tellable) stories have a structure with a discernible beginning, a well-defined body, and an end" [1]

On a scale of 0 to 10, how thorough would you rate the literature review? (Is it thorough, relevant, and uo-to-date?)

☐

Feel free to suggest any missing citations here

Imagine you are a distracted and faintly hostile peer reviewer: after having read the **Introduction**, would you be looking forward to reading the rest of the paper? Would you feel motivated to care about the proposed methodology?

Yes / No / Maybe?

Conclusions section:

On a scale of 0 to 10, how would you rate the effectiveness of the **Conclusions** of the manuscript? (Ideally, this section should be pithy, self-contained, and a fair summary of the paper's achievements)

☐

Is the terminology in the **Conclusions** section consistent with the Abstract and Introduction?

☐

Imagine you are a distracted and faintly hostile peer reviewer: does the **Conclusion** section convince you that the paper has documented a technical contribution of archival relevance? What letter grade would you give the overall paper narrative, what is your gut feel?

C+

Name of proofreader: Type your name Today's date:

Fig. 2. An adapted representation of the **Form B** manuscript narrative checklist

Proofreading workflow checklist. Form C
Manuscript *methodology*

This document codifies the tasks a proofreader should complete when examining the *methodology sections* of a manuscript: typically the **Methodology** itself and any **Appendices** that may be present.

Methodology section:

Did the paper's **Methodology** clearly explain the core technical techniques of the manuscript? How would you rate this section on a scale of 0 to 10?
(An effective methodology follows a logical train of thought, makes good use of headings and sub-headings, and is written in a general and abstract sense: numbers and specific should come later in the manuscript) ☐

Were there any particular components of the **Methodology** that you feel a hostile reviewer could attack? Are there any dubious assumptions that could be seen as a point of weakness? Mention any weak aspects here

Does the **Methodology** contain enough supplementary and graphical material to help explain how it all works together e.g diagrams, pseudocode, flowcharts? Needs more / less / just right

Did the **Methodology** make clear, even as a self-contained section, its inputs, outputs, and the broader importance of what it seeks to achieve? Provide a score out of 10 to gauge how effectively the **Methodology** fares as a standalone and self-explanatory piece.
(There should be some redundancy in a paper, and the Methodology can refresh the reader's memory by re-iterating importing framing points from the Introduction) ☐

Mathematical notation:

Did you carefully check the consistency of the mathematical notation used? ☐ [× means yes]

Has every mathematical symbol been given a clear prose definition including e.g its units? ☐

Is the same mathematical notation used to link with later presentation of outputs in a **Results** section? Is there consistency and integration between the **Methodology** and subsequent **Results**?
(It can be confusing when a Results table reads "Bus voltage" if the Methodology only refers to V_b) ☐ Comments

Name of proofreader: Type your name Today's date:

Fig. 3. An adapted representation of the **Form C** manuscript methodology checklist

introduction and the conclusion. They will return this completed form (it is a fillable PDF document) alongside their marked-up copy of the draft manuscript itself.

This form solicits numerical ratings for each section both to discourage overly positive, overly broad feedback and to indicate where revisions are most required. Particular attention is paid to the title and suggestions for alternatives are elicited here, due to its importance. The checklist concludes by soliciting an overall letter grade of the work, with an unspectacular score of **C+** populated in by default. This is intended to simulate a peer-reviewer who must ultimately communicate a final decision to the editor: all things considered, is the narrative of the work compelling?

4) Form C: Manuscript methodology: This checklist, reproduced in Fig. 3, focuses on the particularities of how the core technical aspects of the work are communicated. In the *'Methodology'* section of the form, the proofreader is guided to cast a skeptical eye on the elucidation of the technical techniques: is the description comprehensive and watertight? Even in isolation, are the context and relevance of the methodology relevant? Are there weak points or elisions that a reviewer could legitimately query?

On a more granular level, the *'Mathematical notation'* section of Form C invites the proofreader to perform a close reading of all notation used. Is it consistent? Have all symbols been defined? Is notation used in coherently throughout the manuscript, even beyond the methodology section itself?

5) Form D: Manuscript results: This checklist, reproduced in Fig. 4, implements some of the preceding quality control checks on the results portion of the manuscript. In addition, this checklist has a granular focus, with a number of binary questions posed about specific features of the data graphics and tables. Similar to [20] the intention here is to spot the specific mistakes and omissions that frequently hamper the quality of published graphics. There are a lot of problems that can arise when building intricate data visualisations or complex

Proofreading workflow checklist. Form D
Manuscript *results*

This document codifies the tasks a proofreader should complete when examining the *results sections* of a manuscript: typically the **Results** and **Discussion.**

Results section:

On a scale of 0 to 10, how would you rate the effectiveness of the **Results** section of the manuscripts? (A good set of results should be compelling, easy to follow, transparent, and honest)	☐	
Did the **Results** make clear, even as a self-contained section, its inputs, outputs, and the broader importance of the data it presents? Provide a score out of 10 to gauge how effectively the **Results** section fares as a standalone and self-explanatory piece. (There should be some redundancy in a paper, and the Results can refresh the reader's memory by re-iterating importing framing points from the Introduction and Methodology)	☐	Comments
Is the same mathematical notation used to link with earlier presentation of variables in the **Methodology** section? Is there consistency and integration between the **Methodology** and **Results**? (It can be confusing when a Results table reads "Bus voltage" if the Methodology only refers to V_b)		Yes / No / Maybe?

Data graphics:

Have you carefully checked that the text size in all figures is consistent?	☐	[× means yes]
Have you carefully checked that each figure is deliberately designed to fit the print dimensions / width of the column it resides in? (for instance, an IEEE column is 8.87 cm)	☐	
Are the graphics still readable when printed out in black and white?	☐	
Are colours used consistently between multiple figures and tables? (for instance, if 'voltage' uses a red trace in Fig. 5, this same colour should be used when portraying this quantity in subsequent figures and tables)	☐	
Look carefully at each figure and its accompanying caption: does each tell a reasonably self-contained story?	☐	
Look carefully at the axes: are logical tickmarks and units used?	☐	
Look carefully at the axis labels: they should be oriented to read left-to-right as normal text, should integrate unicode arrows →, and should use consistent terminology with the rest of the paper. Do they?	☐	
Overall, what is your rating out of 10 for the polish, professionalism and impact of the graphical figures that present the **Results** of this paper?	☐	Comments

Tables:

Do any of the tables include vertical lines?	☐	
Do all tables include units for each quantity represented?	☐	
Are quantities in tables represented with terminology and notation that is consistent with the rest of the manuscript?	☐	Comments
Overall, what is your rating out of 10 for the polish, professionalism and impact of the tables used to present the **Results** of this paper?	☐	Comments

Name of proofreader: Type your name Today's date:

Fig. 4. An adapted representation of the **Form D** manuscript results checklist

tables, and these checks are enforced to ensure that the final manuscripts showcases all numerical results in a transparent and impactful fashion.

IV. Future Ambitions

The four developed checklists are intended to form the core of an evolving set of workflows and resources to equip students with the skills to be efficient and productive researchers. Further ambitions for future interventions that systematise and enhance research workflows may include:

- A checklist for post-publication actions after the acceptance of a manuscript (e.g generating publicity on social media [33], [34], or directly and deliberately notifying authors of key works cited in the accepted manuscript)
- A data sharing checklist form, to ensure that principles of open science are upheld [35]
- A workflow to systematise and make routine the proactive running of a plagiarism detector [36] on manuscripts prior to submitting them. In a context where numerous people may be involved in the production of a manuscript, there always exists a risk that one co-author may behave dishonestly and could plagiarise some text without the knowledge of the other authors. Using software to routinely vet manuscripts for plagiarism prior to submission is a proactive form of reputation protection
- Adoption of special document formats and typefaces [37], [38] to produce manuscript versions specially typeset to be conducive to proofreading activities
- There is evidence that it can be advantageous to use the 'suggested reviewers' facility that some journals offer [39], [40]. Should a systematic procedure be followed to identify potentially suitable reviewers for submitted work?
- Can phrasebank resources [41], [42] be systematically integrated into writing workflows? These resources provide granular, specific language snippets to ease students over problem points in writing papers. Making verbiage like this more directly accessible should accelerate the writing process.

V. Conclusions

There is an encouraging evidence base in the extant literature which documents that checklists and repeatable workflows enhance quality control and productivity in many domains, and are also effective as teaching and self-assessment tools. The present intervention has sought to harness these capabilities to enhance the training of research students, while simultaneously improving the quality of the research manuscripts they produce.

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