

# HOW TO PUT TOGETHER A CUMULATIVE THESIS

*Waltenegus Dargie, TU Dresden, Germany*

When you opt to submit your dissertation in the form of a cumulative thesis, you may have thought that the onerous burden of writing a complete thesis is off of your shoulders. You may be right. But do not underestimate the task. Submitting a cumulative thesis can be as challenging, if not, indeed, more challenging. But if you understand how you should organise your published papers ahead of time and publish accordingly, then, yes, submitting a cumulative thesis is not only easier, but also the most reasonable thing to do.

One of the most challenging tasks of putting together a cumulative thesis is to have an interesting, unified, and well-connected story from the beginning to the end. You can divide this story into five sections and organise your papers accordingly; but remember, this is your story and you can organise and tell it in any way you like, as long as you tell an interesting story.

## The Motivation (Introduction)

Your thesis is a product you wish to sell. At the time you write your first paper, the product may not be formed yet. It may not even be conceived in your mind yet. You may have only the ambition to produce it and a vague idea thereof. All the same, you have to start thinking how to sell it, like all other products people sell. You may think the Introduction Section to be an advertisement or a quest to entice an investor to invest in your product. You need to have an appealing story to tell. It is a challenging task, particularly, when the product is not there yet.

Now publishing an introductory paper is really challenging. So, you need to find a modest venue where work-in-progress or a poster paper can be accepted. But if you are clever, you can write a paper that shows the limitations of some existing approaches, “a hole in the bucket”, so to say, and with that you can sell your idea.

Be sure that the papers coming in this section are short and highly motivating.

If you have no way to publish a motivation paper, do not worry; you can use this section to write an introductory chapter, introducing the papers which make up your thesis.

## Related Work

Every researcher should publish a survey paper to their own expressed advantage. You can save two birds at once with it. If you are a self-respecting researcher, you should know your area very well. You have a comprehensive understanding of the state-of-the-art. The closer you study works similar to yours, the more interesting aspects you discover. Interesting does not necessarily mean appealing, though. You will discover what works and what does not work in a proposed approach; what is a reasonable assumption and what is not. Such insights you can share with the research community by publishing a survey paper. It is your duty. But survey papers are also widely cited. Having said it, writing a survey paper is quite

exhausting and competitive. But it is doable, especially, if you have a committed supervisor and a motivating and cooperative team.

## The Concept

The concept is really your contribution. It has to be solid and it has to stand out and stand alone. Ideally, this is the idea that makes you famous. If your peers hear someone mentioning the idea or ideas related or similar to it, your name should flash in their mind. You should put it on the table and regard it objectively from all sides. Have the members of your team regard it honestly and objectively before you bring it to market. If the idea were the look of your child, would you be pleased with it? And in some ways, it is your child, your brain child.

Concept papers, like motivation papers, are difficult to publish. So often, it may be published with the “motivation” and the “implementation” sections together. At this time it is worth distinguishing between “motivation” papers from “concept” papers. In a “motivation” paper, you present (deliberately) a bigger picture where your concept finds a place. But you have to demonstrate how your “concept” is connected with other concepts to produce a big, appealing picture. In a concept paper, however, your singular focus is on your concept, detailing with all its organs, sinews, tendons, and muscles. A concept paper is watertight. You can present it in the form of an architecture, an algorithm, a mathematical model, etc.

## The Implementation

Here, you realise a concept, or as Aristotle would put it, create matter to a form. This is relatively easy for engineering students to accomplish. You have a prototype and it enables you to collect lots of data with it to draw graphs or carry out statistical analysis. Make sure you have a set of quantitative metrics to characterise the prototype. Ideally, the metrics affirm the concept and magnify it.

## Comparison

No scientific work is complete without objective and quantitative comparison with competitive work. Einstein’s GR was first verified by the eclipse results of 1919. The model enabled him to predict by what angle background starlight is bent as it passes the Sun. The model’s prediction was compared with the results obtained by Newtonian inertial laws. Some researchers compare results of different models they have not developed to bypass comparing their work with those dealing with similar issues. Typical examples are the use of learning models such as K-means clustering, SVM, CNN, LSTM. This, however, is not a comparison work. Choose three to five competitive approaches and make objective comparisons. You have a wide degree of freedom for comparison of both functional and non-functional aspects: Plausibility of assumptions or operating conditions, system complexity, system performance, volume of data, range of applications, flexibility of use, etc.

## Conclusion

Fortunately, you do not need to publish any paper for this section. It suffices if you compose a short summary of your work. That said, this section is your chance to refresh the reader's memory of your story and how it was well-connected and rounded; to highlight the most salient features of your concept and the results you obtained. It is also where you show your human side, by telling your reader the difficulties you faced during your journey and how you overcome them. Candidly write about the aspects you fail to realise or implement and mention the reasons behind it. Admit the limitations of your approach. Discuss the plausibility of the assumptions you made at the outset and how close they brought the prototype you have developed to the real world. Finally, someone has to start where you stopped, the next doctoral researcher, not necessarily in your team or at your institution. highlight the open issues and indicate the direction to which the future research should head.