On introductions

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1. Introduction: What is an introduction?

The main point of an introduction is to tell the reader the focus, or the emphasis, of the paper one is writing. It contains certain themes (such as 1. to 9. below) designed to provide certain kind of information. What you talk about in the introduction is what is then supposed to be elaborated upon in detail in the rest of the paper. If the main focus specified in the introduction isn't picked up then the paper is missing the point or the introduction has the wrong focus. The introduction should therefore not mislead the reader by emphasising one theme and then (accidentally) going off on a tangent and developing another theme in the main body of the text.

So, some examples of themes include the following. Note that introductions do not contain all these themes, just some of them. Some of the themes might be seen as compulsory, such at 1. and 8. Other themes will be seen as down to the author's choice depending upon what the author wishes to emphasise or develop in the main body of his/her paper:

1. Giving general background information about the area of study (this can include literature review);
2. Establish the importance of a topic;
3. Highlighting a problem or controversy; Highlighting gaps or inadequacies in previous research;
4. Stating the significance and/or limitation of your work;
5. Stating the aim, purpose or focus of the essay;
6. Outlining the structure and content of your essay;
7. Stating the thesis, thesis statement or research question.

When writing an introduction we can ask the question,

What makes a text a/an { "giving background information" / "establishing the importance of a topic" / "highlighting a problem or controversy" / "highlighting gaps or inadequacies in previous research" / "stating the aim, purpose or focus of the essay" / "outlining alternative solutions to a problem" / "stating the significance and/or limitation of your work" / "outlining the structure and content of your essay" } type of text?

The following examples taken from the literature should illustrate this point.

2. Examples from the literature

1.1. Example 1: Giving general background information

Consider the following text (Zhang et al., 2013).

> "Since its debut in 2004, graphene has attracted enormous interest because of its unique properties. Chemical vapor deposition (CVD) has emerged as an important method for the preparation and production of graphene for various applications since the method was first reported in 2008/2009. In this Account, we review graphene CVD on various metal substrates with an emphasis on Ni and Cu. In addition, we discuss important and representative applications of graphene formed by CVD, including as flexible transparent conductors for organic photovoltaic cells and in field effect transistors.
>
> […]
>
> CVD graphene has electronic properties that are potentially valuable in a number of applications. For example, few-layer Graphene grown on Ni can function as flexible transparent conductive electrodes for organic photovoltaic cells. In addition, because we can synthesize large-grain graphene on Cu foil, such large-grain graphene has electronic properties suitable for use in field effect transistors."

Analysis

To be done during the lesson.

Note also that lines 4-8 act as that to state the aim, purpose or focus of the essay. We will return to this theme in another section.

1.2. Example 2: On establishing the importance of a topic

Consider the following text (Di Bucchianico et al., 2019, p120).

> "The role of mathematics [in big data analytics] is easy to overlook and not fully recognized because technological advances are much more visible than mathematical advances, even though the latter often have more effect. […]
> In this essay, we present several explicit real–life examples of the mathematics behind big data, highlighting the role and importance of specific areas of mathematics in these contexts. We show a wide variety of examples: search engines, virtual prototyping in manufacturing, data assimilation, web data analytics, health care, recommendation systems, genomics and other *omics* sciences, and precision farming."

Analysing the text

- The first sentence over lines 1-3 acts as topic sentence for the paragraph. Topic sentences are written in a generalistic form, and this one is no exception. To see this one could rewrite the topic sentence as follows without altering the focus or emphasis in any way:

  "*In general*, the role of mathematics [in big data analytics] is easy to overlook. Mathematics [in big data analytics] is *usually* not fully recognized because technological advances are *typically* much more visible than mathematical advances, …"

- The second sentence of lines 4-6 signposts that some examples will be presented, as well as the fact that these examples will demonstrate importance, without actually mentioning the specific example themselves nor how they illustrate importance. Such an approach to writing is indeed a generalistic form of writing. This is seen by the phrasing "several … examples", and "highlighting the … importance of specific areas of mathematics"

- The third sentence of lines 6-8 then gives examples of the areas where mathematics is used in big data analytics, but again not the specific examples themselves. Although the listing of the areas where mathematics is more specific than the writing of lines 4-6, the grammatical use of plurals acts as a generlaistic form of writing.
- As such, we might expect the rest of the paper to answer questions such as:
    1. What *specific* mathematical examples are presented?
    2. How do these specific examples illustrate the importance of mathematics in big data analytics?

It is for the authors to decide which questions to raise and answer in their paper. It may be the case that items 2. and 3. are not addressed at all, but such question seems sensible based on their introductory comments.

1.3. Example 3: Highlighting a problem or controversy

Consider the following text (Foster, 2014).

> "[…] I think the arguments given are often rather dubious. For example, teachers often say that the mean is 'unduly' influenced by outliers, but is this right? Surely outliers influence the mean to a precisely proportionate degree? If the outlier is a mistake, and we don't want it to influence our conclusions, we should remove it from our data. If we leave it in, because it is real, then we should expect and want it to have its due influence on our results. An outlier may be the most important piece of data."

<u>Analysing the text</u>

- The first sentence on line 1 suggests a possible problem, as the author sees it. The key word which highlights this is "dubious".
- The second sentence of lines 1-2 also suggests a possible problem, via the phrasing "but is this right?". Notice that without this phrase, the sentence is simply a statement: "For example, teachers often say that the mean is 'unduly' influenced by outliers"
- Note that the third sentences over lines 2-3 could be removed without affecting the technical meaning of the paragraph. However, there would be a minor disjoint in cohesiveness of language. Can you see this? If so, how would you improve the cohesiveness between the second sentence and the third sentence?

- In the fourth sentence (over lines 3-6) can be interpreted as an example and counter-example: “remove outlier or leave it in”. This is one specific way of using language to signpost that you are referring to a problem or controversy.
- The text of lines 3-6 then answers the example and counter-example issue. These answers can themselves be considered generalistic in their phrasing. To see why this is so, questions requiring much more detail can be asked:
    - Under what conditions would we remove or keep the outlier?
    - Can specific mathematical criteria be developed in order to determine whether or not to keep/remove an outlier? Or is such a decision down to the experience of the researcher?

Notice that in order to ask questions of such specificity you have to know the subject!

1.4. Example 4: Highlighting gaps, limitations or inadequacies

Consider the following text (Lamoureux and Chaves-Carballo, 2024). Note that this text also has elements of highlighting a problem:

> “Hydrogen bonds or hydrogen bridges (we use H-bridges in this article) are important in all fields of chemistry and materials science, but the teaching of this concept with antiquated information leaves students at all levels with many misconceptions (Lamoureux, Chaves-Carballo, & Arias-Alvarez, 2021). Perhaps the most unfortunate heuristic that persists in the twenty-first century is that H-bridges only form among the elements of fluorine, oxygen and nitrogen (FON). […]
> We noted in a previous article the limitations of using only these three elements and have proposed a new system to organize the H-bridge interactions in grids (Lamoureux et al., 2021). Students need practical assistance in visualizing the H-bridge interactions; grids are useful to organize these many interactions using structures of the complexes. […]
> In this article, we propose that textbook authors and lecturers should be cognizant of the 2011 IUPAC definition and the use of grids to represent better these H-bridges. The first step is to communicate that the (F,O,N) heuristic lacks utility, which this article concludes.”

Analysis

Notice that in this text the authors first highlight a problem in the teaching of chemistry lines 1-6), and then go on to highlighting limitations line 7 onwards).

- Lines 1-4: The first sentence is a topic sentence which states that there is a problem in the teaching of hydrogen bonds or hydrogen bridges. This is seen by the phrasing of lines 2-4 starting "but the teaching of …". The use of the words "but", "antiquated", and "misconception" linguistically emphasise this a "highlighting a problem" language.
  Note that although, in line 2, there is the phrasing "are important in all fields of chemistry" the main thrust of this introduction text as a whole is not about establishing the importance of the topic.

- Lines 4-6: This sentence continues the theme of highlighting the problem. This is seen by the phrasing "Perhaps the most unfortunate". Without this phrasing we would have the sentence "the heuristic that persists in the twenty-first century is that H-bridges only form among the elements of fluorine, oxygen and nitrogen (FON)" which, as it stands linguistically, does not infer any problem or limitation.

- Lines 7-9: In this sentence we now see the authors discussing the limitation of using the concept that "H-bridges only form among the elements of fluorine, oxygen and nitrogen". This is seen by the wording "the limitations of …".
  Then note line 8. The authors propose a solution to this: "organize the H-bridge interactions in grids". *If you are going to highlight a gap, limitation or inadequacy in research then you should also propose a solution.*

- Lines 9-11: This sentence elaborates on why the authors' solution solves the limitations of the current way of teaching about H-bridges. This can be seen by the wording "grids are useful to" where the authors then explain the actual usefulness of their approach.

- Lines 12-15: These two sentences actually states the aim of the paper. See the next example (example 5) for a more detailed version of this type of content to an introduction.

Note that other words such as "effects", "constraints", "drawbacks", "flaws", or other similar words can also act to address limitations, provided these words are properly used in context.

1.5. Example 5: Stating purpose, aim or focus

Consider the following text (Garcia and Ross, 2017)

> We hope to initiate a discussion about various methods for introducing Cauchy's Theorem. Although Cauchy's Theorem is the fundamental theorem upon which complex analysis is based, there is no “standard approach." The appropriate choice depends upon the prerequisites for the course and the level of rigor intended. Common methods include homotopy theory, Green's Theorem, or Goursat's lemma, each of which has its positives and negatives.[…]
>
> One side of the debate argues that technical details are what makes mathematics so beautiful, concise, and complete. It all fits together so beautifully. […] Another side of the debate argues that the majority of our students do not go on to graduate school in pure mathematics. Focusing on the technical details is not needed nor appreciated by the majority of our students. Instead, teachers should emphasize the general ideas and the interconnections of these ideas.[…]
>
> In this paper, we focus on Cauchy’s Theorem, and look at both sides of this struggle. Since the reader is presumably a professional mathematician with experience in complex variables, we will assume a working knowledge of the field. We do not attempt to work through the details of the proofs and techniques discussed below. We focus instead on several standard approaches to Cauchy’s Theorem, and weigh the pros and cons of each [from a pedagogical perspective].

<u>Analysing the text</u>

- Lines 1-3: The first sentence is a topic sentence. This then leads on to the second sentence which might be thought of as a highlighting a problem, issue or limitation, due to the phrasing “there is no “standard approach".
- Lines 3-6: The sentence in lines 3-6 then list the many alternatives which reflect the lack of standard approach mentioned in line 3.
- Lines 7-12: This paragraph focuses on reasons as to why alternative approaches can be adopted. Lines 7-8 address one perspective on how Cauchy’s theorem should be presented, and lines 8-12 address another perspective on how Cauchy’s theorem should be presented.

- Lines 13-18: The previous two paragraphs effectively act to set up the third paragraph. Then, this third paragraph states the focus of the paper (the use of Cauchy's theorem) and the aim of the paper ("look at both sides of this struggle"). This aim and focus is again repeated in lines 17-18.

Other phrasing which refers to "Stating the purpose, aim or focus" include:

- "The main objective of this work is to investigate methods for improving …"
- "We are specifically interested in the aspects of … as they relate to …"
- "In this paper we investigate … with specific reference to …"
- "In terms of … this work concentrates on …"
- "In order to address the questions outlined above, we report here …"

1.6. Example 7: Stating significant aspects of the research

In this subsection we will look at two examples.

Example i): Consider the following text (Wang et al., 2024).

> As the automotive industry advances and the need for energy efficiency and emissions reduction increases, higher standards are being set for light-weight automobiles. 1,2 As aluminum alloys have the characteristics of lightweight, high strength, and good plasticity, the use of aluminum instead of traditional steel for automotive manufacturing has a significant effect on lightweight, so the mass application of aluminum alloys is a crucial way to realize the light-weight of automobiles.

Example ii): Consider the following text (Marc et al., 2015).

> "We compiled time series of landslide inventories in the epicentral areas of four intermediate and large earthquakes with similar mechanisms and source depths. These inventories span periods before, during, and after the earthquakes and can be compared with matching records of precipitation and background seismicity. Normalizing for meteorological forcing, we demonstrate that landslide rates were significantly elevated for periods of 0.7–4.5 yr after these earthquakes, and that order-of-magnitude increases in landslide rate decreased exponentially to background values over this interval. "

Analysis

Both texts are identical in the way they address significant aspects of research, hence they can be analysed at the same time.

- In the Wang et al. (2024) text we see, on line 5, the phrasing "the use of aluminum instead of traditional steel for automotive manufacturing has a significant effect on" after which the authors go on to describe a consequence of the use of aluminium. This is indeed what any author should do, namely that *if s/he specifies the significance of something they then need to explain why it is significant.*

  Note that the authors consistently misuse the words "light weight". In line 3 they write "As aluminum alloys have the characteristics of lightweight" when they should write "As aluminum alloys have the characteristics of light weight", and in line 5 they write "has a significant effect on lightweight" when they should write "has a significant effect on light weight". Ditto for line 6.

- In the Marc et al. (2015) text we see, in lines 5-6, the phrasing "we demonstrate that landslide rates were significantly elevated", the "proof" of which will come in the rest of their paper. Note that this text comes from the introduction section of the authors' paper, so they will not provide proof of significantly elevated landslide rates here. *However, by the use of the wording "we demonstrate that" they do signpost that they will explain or justify why their results are significant.*

Note that other words such as "noteworthy", "substantial", "considerable", or other similar words can also act to describe significant aspect of research work, provided these words are properly used in context.

Also, be careful how you use the word "significant". Consider the text below (Burch et al., 2019) where the word is used correctly but where "significance" is not defined or explained. Can you see this to be the case? What is the difference between the use of the word "significant" in the text below compared to its use in the two texts above?

> "The purpose of this study was to analyze the electron measurements of MMS in regions near the X-line of two magnetotail reconnection events to characterize the interactions leading to UH and both parallel and perpendicular beam-mode wave growth. It is found that crescent-shaped distributions with significant positive df/dv_{perp} produce UH wave growth …"

1.7. Example 8: Outlining the structure or content of a paper

Consider the following text (adapted from Hernandez, 1989).

> "This paper draws attention to certain principles governing the application of mathematics to engineering and the physical sciences. Broadly speaking, these applications require
>
> *(a)* producing mathematical descriptions of physical phenomena *(modelling),* and
>
> *(b)* drawing conclusions about those and related phenomena with the help of such models *(simulation).*
>
> Not surprisingly considering its stated goals, this paper is concerned with both modelling and simulation. […]
>
> In the last resort, however, all modelling and simulation work depends upon the expertise and good sense of the modeller; any systematic theory should be aimed at supplementing rather than replacing the modeller's craft. This being said, the reader must be warned that far less ambitious goals are aimed at in most of the paper. For instance, sections 4 and 8 deal with setting up and solving differential equations, respectively. The choice of modelling methodology adopted in section 4 owes a great deal to treatments now classical in the chemical engineering literature, such as [7] and [8]. As to section 8, it is a brief review of numerical methods for differential equations, ordinary and partial. […]
>
> The differential equations are ordinary when time is continuous and space is discrete; in all remaining cases there result partial differential equations. To keep matters within bounds, the main ideas developed in both sections 3 and 7 are illustrated in terms of the differential equation models developed in the elementary examples of section 2. Section 7 is concerned with model validation criteria, and relies heavily upon concepts-describing empirical work. It is seen therein that confrontation with experiment may be critical, and require a careful re-examination of the fundamental assumptions underlying the given model."

The analysis of the text is left as an exercise. What language or phrasing suggests that the author is talking about the structure or content of the paper?

1.8. Example 9: Stating a thesis, thesis statement or research question

We have already studied aspects of thesis and thesis statement in a previous lesson. Refer back to those notes if necessary.

3. Some comments about introductions

1.9. Similarities and differences between topic sentences and introductions

Note the different between a topic sentence (studied in a previous lesson) and an introduction:

- the topic sentence is the introduction to a paragraph, whilst the introduction sentence is the introduction to the essay/paper as a whole;
- the detail of the topic sentence is described in the paragraph for that topic sentence, whereas the detail of the introduction section is described in the rest of the essay/paper.
- a question asked in a topic sentence is usually answered in the paragraph of that topic sentence;
- questions asked in the introduction section of an essay/paper are usually not answered in the introduction but later on in the essay/paper. If any questions are answered they will almost certainly be answered in a general or vague manner (implying they will be answered in detail in the rest of the essay/paragraph).

So both the topic sentence and the introduction to the essay act as introductions, but with different degrees of generality or specificity, and also at different levels of text (i.e. introductions are written for the paper as a whole whilst topic sentences are written for individual paragraphs).

1.10. The introduction to the introduction

Note that the introduction section of a paper or essay also has its own introductory part. This "introduction to the introduction" usually outlines some general information to justify the substance of the introduction.

For example, we have the following (Garcia and Ross, 2017):

> "For those of us who regularly teach an undergraduate course in complex variables, there are always the looming concerns about the appropriate level of technical detail and rigor to include. […] One side of the debate argues that

> technical details are what makes mathematics so beautiful, concise, and complete. […] Another side of the debate argues that the majority of our students do not go on to graduate school in pure mathematics. Focusing on the technical details is not needed, […] Since the two of us frequently teach undergraduate complex analysis, we often struggle with "detail" versus "not enough detail," with "plodding proofs" versus "deus ex machina proofs. […] In this paper, we focus on Cauchy's Theorem, and look at both sides of this struggle."

This last sentence falls under the category of "Stating the purpose, aim or focus of the essay", but the authors introduce their aim by preceding it with some background information about the general state of affairs relating to the difficulties in teaching complex analysis course. This general background acts as an introduction to their introduction. The same can be seen in the text of example 6. above. It is only in the middle of the second paragraph, and then in the third paragraph, that we see the author describing the structure and content of his paper.

As another example, consider the text below adapted from "Inferential Statistics as Descriptive Statistics: There Is No Replication Crisis if We Don't Expect Replication" by V. Amrhein, D. Trafimow & S. Greenland (*The American Statistician*, 73:sup1, 262-270)

> The "crisis of unreplicable research" is not only about alleged replication failures. It is also about perceived nonreplication of scientific results being interpreted as a sign of bad science (Baker 2016). Yes, there is an epidemic of misinterpretation of statistics and what amounts to scientific misconduct, even though it is common practice (such as selectively reporting studies that "worked" or that were "significant"; Martinson, Anderson, and de Vries 2005; John, Loewenstein, and Prelec 2012). But all results are uncertain and highly variable, even those from the most rigorous studies. […]
>
> In the following, we argue that the crisis of unreplicable research is mainly a crisis of overconfidence in statistical results. We recommend that we should use, communicate, and teach inferential statistical methods as describing logical relations between assumptions and data (as detailed in the Appendix), rather than as providing generalizable inferences about universal populations."

Here the last paragraph falls under the category of “Stating the purpose, aim or focus of the essay” and also “Highlighting a problem or controversy”. And, in order to be able to state the purpose of their essay, the authors have had use part of their introduction to give some introductory background relating to the problem in the use of inferential statistics.

Ultimately, from all of the examples we have seen we might say that

Introduction = A piece of text focusing on the general themes of a paper,
whose aim is to orient the reader’s attention towards the content of the paper,
all this using suitable language and phrasing having suitable degree of generality.

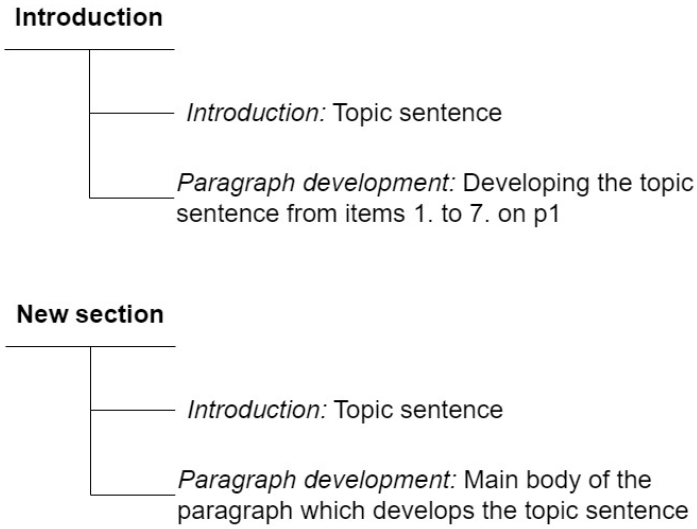
Note: It is important to note that you do not need to use (and probably cannot use) all of the themes listed in section 1 in your own introduction. These aforementioned themes are presented only for you to see the possibilities of how to frame an introduction. It is for you to decide what to include in your introduction (apart from item 1 and item 8 which are compulsory for your essay).

1.11. Transitioning between different themes in an introduction

Note that introductions contain several themes. For example, an introduction may contain general background information along with a literature review along with a statement about the importance of the work along with a thesis. As such we need to transition between these different themes. This brings up the issue of paragraph development. As such, and if necessary, revise all three parts of the topic of paragraph development: sentence structure, topic sentences, and cohesive and coherent development of ideas.

4. Levels of introduction

Recall that each new paragraph of a text generally has an introduction sentence, i.e. a topic sentence. And, we have seen that the introduction to an essay or paper usually has an introductory part to it. So, it appears that the idea of "introduction" occurs everywhere in a paper or essay, as illustrated in the diagram below.



The same can be said about the headings of each section of an essay or paper. Each heading can be seen as an introduction to the core theme of a section. For example,

- *Title*: We use this word as a "topic" word to orient the reader towards the key idea of the essay or paper.
- *Introduction*: We use this word as a "topic" word to orient the reader towards the fact that we will be giving background information about the topic as well as addressing one or more of the categories above;
- *Methodology*: We use this word as a "topic" word to orient the reader towards the methods that will be used to collect information, as well as the way in which these methods are used systematically;
- *Results and Analysis*: We use these words as "topic" words to orient the reader towards the fact that we will be presenting the results obtained from implementing our methodology, and the analyses of these results;
- *Discussion*: We use this word as a "topic" word to orient the reader towards the fact that we will be discussing the significance of the results along with any limitation and improvements which could be made;
- *Conclusion*: We use this word as a "topic" word to orient the reader towards the fact that we will be summarising the main points of the essay or paper.

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