Programming is Writing is Programming

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Abstract Writing and programming are often seen as different. Writing a creative profession, programming a technical one. Below the surface however, there is one large similarity. Both writing and programming are, ultimately, the translation of a high-level idea into low level sentences or statements. In this paper, we compare the activities of writing and programming, and indeed uncover similarities in the activities commonly described as part of the writing and programming workflow. However we also observe some differences, like the attention writers have for formatting and styling, and the opportunity for feedback programmers have by compiling and executing programs. We aim to explore differences and similarities, to understand each field better. Where are the procedures similar? Where can we learn from each other? Do we understand striking differences?

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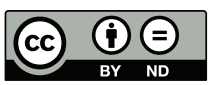

1 Introduction

Writing and programming might seem worlds apart: Writing is a creative activity, with goals ranging from entertaining to persuading, from structuring the writer's thoughts to passing a message to the reader. Programming, on the other hand, is a form of problem solving, in which the programmer starts with a problem, creates a design—a plan of how to solve problem—and then solves this by writing code that a machine can execute. But when one takes a look below the surface, there are also clear similarities to discover. Most strikingly, we can describe both writing and programming as the translation of a high-level idea into low level sentences or statements.

In this paper we explore the activities commonly performed in writing and programming and elaborate on similarities and differences. For example, in programming, formatting and style receive less focus while this could make code more readable. In programming, code is executed and tested early in the process, while text is often proofread when more finished.

We believe that both fields can learn from a detailed comparison of activities. What does formatting mean in the context of code? If it important? Can text writing be as iterative and test-driven as code. These are just a few of the questions raised by our side by side exploration. Does writing make you a better programmer? What skills underpin both?

2 What is writing and what is programming?

So, what is writing? Writing is a way in which humans communicate, using letters and symbols, forming words and sentences. It is used for various different reasons and purposes, including but not limited to storytelling, correspondence and reports of various kinds. The term 'writing' is broad, and can be used for activities varying from the motor skill of forming letters to formulating thoughts, feelings and opinions, and to be flawless in the spelling of words and use of grammar rules [15]. In this paper we focus on the activity of text composing, regardless the type or genre of the text.

And what is programming? Programming is commonly seen as the process by which a human formulates a problem in such a way that a computer can execute it. It involves understanding the problem, creating a design, writing the syntax of a program—sometimes referred to as coding—and performing maintenance on an existing program [24].

3 A high level plan executed in detail

One of the most striking similarities between writing and programming is the fact that in both, there are high-level plans. A murder mystery writer imagines a killer that stabs blond men with stiletto heels; while a programmer imagines an iPad app

to manage different bank accounts. Both of these can definitely be classified as a designing.

Something, but not always, writers create designs before they start. A programmer might draw a UML diagram or an architecture plan, and a writer can create a Table of Contents before the writing, or use character sheets and scene descriptions. Both these activities can be seen as designing activities.

In both activities, these high-level designs need to be translated into very low level constructs: sentences and words for the writers, and methods and lines of code for the programmers. How to approach this is a topic for many methodologies in both writing and programming. Is it better to draft broadly and then iterate, or to take one chapter or feature and make it perfect before adding others? In both fields, there are people on both sides of the argument. In writing, these two extremes even have terms: Pantsers and plotters.[1]

To help manage the complexity of the translation, in both fields, there are intermediate steps. A writer divides a story into chapters or an essay into sections. These in turn are divided into paragraphs and sentences. Likewise a programmer thinks of classes or objects to contain some parts of a program, which have methods and fields in them.

One aspect where the high-level idea into low-level implementation transformation manifests is when one makes changes. No text is perfect at the first try; books and stories are often reviewed and rewritten, sometimes assisted by formal reviews. Programmers review each other's code and suggest changes, or fix bugs in existing code bases. In this adaptation, the high level translating again plays a big role. If writers decide to remove a character from a story, they need to make sure it is deleted from all chapters. If programmers changes their architecture, this will result in changes to many classes and methods.

4 A deep dive into activities

So far, we observed what we believe is the main aspect in which writing and programming are alike, namely the translation of high level ideas into the low level of words and letters. We will now examine the exact steps of which the activities of writing and programming consist in more detail, draw comparisons and highlight differences.

There are a number of models of the writing process available (e.g. [8], [15], [6], [19]), all similar in the broad picture they paint. The writing process can roughly be divided in three phases (pre-writing, writing, post-writing), which may be divided in two or more sub-phases. Similarly, the process of 'writing' a computer program is generally divided in three phases, which resemble the phases in the writing process: design, implement, test, or problem solving, implementation, maintenance [5]).

There are more fine grained models too, which we will use here to explore the commonalities between writing and programming as extensive as possible. Huizenga

[1] http://thewritepractice.com/plotters-pantsers/

Table 1 Writing and programming process

Seven steps in writing [8]	Seven steps in programming Prata [17]
1. Gathering information	1. Defining program objectives
2. Selecting information	2. Designing the program
3. Structuring information	3. Writing code
4. Translating	4. Compiling
5. Stylizing the text	5. Running the program
6. Formatting the text	6. Testing and debugging the program
7. Reflecting on the text	7. Maintaining and modifying the program

[8] for example described 7 steps in writing. Prata [17] describes 7 steps too, for programming. Table **??** shows both lists.

While there are other steps that could be distinguished, we compare these two as an exploration of the activities. We do encourage readers to find other sources, or even define their own steps on one of the two activities and compare those.

We believe that the detailed comparison of steps will help us gain insights into both processes better. Where are the procedures similar? Where can we learn from each other? Do we understand striking differences?

Looking at these steps, we initially observe similarities, which are graphically depicted in Figure **??**: *Gathering information* corresponds to *Defining Program Objectives*, since both relate to analyzing the environment of the text or program.

The following steps are similar too. *Selecting information* and *Structuring information* are related to *Designing the program*, since in both decisions are made about the underlying, often invisible structure of text and program.

After these first three (writing) and two (programming) activities, the differences between the models seem to be getting bigger. Where in programming we see the third step *Writing code*, in writing, there are three separate steps related to getting the words in their final form: *Translating*, *Stylizing the text* and *Formatting the text*. This level of detail in could be one of the areas where programming could learn from writing, maybe it is a good idea to regard these steps as different activities in programming too?

In programming on the other hand, there is *Compiling* and *Running the program*. This represents a difference between writing and programming, in programming, the programmer gets feedback very early on whether the program text is executable, during compiling. Furthermore, they get feedback on whether the program is working as intended. One could argue that, in writing, the first 'execution' of the program happens when someone else reads it, and that it is thus takes longer to know whether a text has the desired intend. Of course writers themselves can read the text and 'execute' it, but the question is if that really executes the text alone, if the writer can really read the text, without also taking into account the context and intentions.

In the remaining sections, we will first discuss the similarities in the first and last steps, and then the differences mainly occurring in the middle parts.

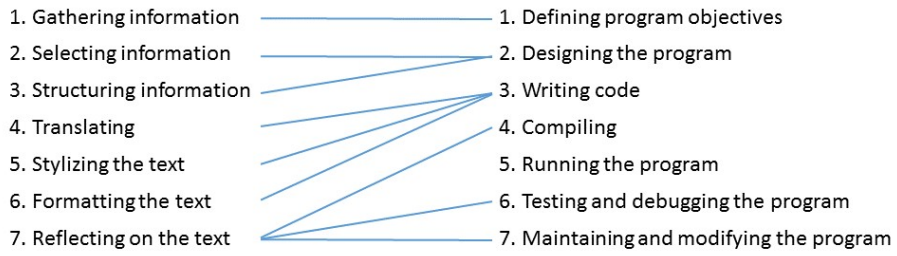

Figure 1 The similarities between both models visualized.

5 Similarities

In this section, we zoom in on the similarities in the steps, which we feel occur mainly in the beginning and end of the process.

5.1 Getting to know the context

The first steps in both field concern with the context of the text and code. What needs to go in? Who is the target audience? What do I want my text to convey, or my program to do?

When starting a new project, assignment, or exercise in writing or programming, the first step is setting of the goals. What subject must the text be about, or what problem must the computer program solve? What kind of text does the writer wants, or has, to write; a fictional story, recipe, or maybe a blog on his website? Who is the intended audience and what are the demands of a possible client or reader? With these goals in mind, writers start gathering information about the subject. They may use various kinds of sources like their own imagination and emotions, experiences of others, information found in external sources like books, videos and websites about the subject.

In programming, the gathering of information is a field of research in itself: requirements engineering. There are numerous different techniques for eliciting the requirements from a user [10, 22, 16].

In this context, we are mainly talking about the process in which software is made for a customer. Of course, there are also projects that start because programmers really want to make something for themselves, without fixed requirements. Even in that case, a first step will often be gathering information, such as which programming language, library or api to use, or what similar system might exist.

5.2 Making plans

After the exploration of the context, there is a focus on designing the artifact. What will the storyline be? What is the structure of the argumentation? What characters are going to appear in what chapters? These contemplations could be comparable to questions like: What will the architecture of our system be? What classes and methods will we have? or What programming paradigm fits our problem best?

Out of all the gathered information the writer then (after gathering the information, or, more likely, during this process) selects the useful information for this specific task. That is, writers choose which information is relevant for the reader to understand the story line and also fits the chosen subject of the text.

The selection of relevant information too is a skill important in programming, again, especially in the commercial setting of creating software for an internal or external costumer. Different features of the program to be created are classified by importance, for example using the MoSCoW model[4], or 'user stories' are created, which are then grouped into sprints. By categorizing important features, programmers are deciding what information is most important for the program.

In writing, the gathering of information can be more vague, especially for writers of fiction, maybe the gathering is more of inspiration than of information.

After gathering information and selecting the relevant parts, the writer organizes all information in a way that suits his habits in writing and fits the requirements of the text identified by the goals.

Ideas can be collected and structured in various multi- or one-dimensional ways. For example using a mindmap which represents relations between concepts, arguments and/or characters. In case of a recipe or manual writers may use a flowchart to structure their ideas. They may also provide short descriptions for characters, situations or scenery. Once gathered and organized ideas, the writer has an abstract representation of the text in mind.

Structuring in programming means creating a high-level design for a program. In this phase, design decisions are made about the program, such as, for example: what programming language and database system will be used? What type of software architecture will we follow, for example a model-view-controller or a microservices setup. Lower level decisions are also made, such as what classes are needed and how they will related to each other. That is often done using a class diagram or an entity relationship diagram when data is being structured.

5.3 Translating

In writing, the step following *Structuring information* is to transfer abstract concepts to linear natural language. While putting the design into sentences and words, the writer has to abide by rules. These rules might be rules of the language, for example, words need to be spelled correctly and sentences must be correct grammatically, but may also depend on the context of the text, for example in a scientific article, references have to be correct and in an persuasive argument, the text structure should be logical.

Similarly, the programmer now moves from the whiteboard to the keyboard, to start produces lines of code which implement the high-level design. Like in writing, the programmer needs to do so while applying rules. For example, code must be syntactically correct in order to be compiled or interpreted. In addition, some languages have stricter rules about what is allow, like typing rules that the programmer must obey.

According to [6], in this process, the writer has to juggle different specific demands of written language varying from generic and formal, syntactic and lexical to the motor tasks of forming letters or typing on a keyboard. For example, when a writer has difficulties with the spelling of the words, this process will use up so much of their working memory that they have no room to think about the structure of a paragraph. This high 'cognitive load' has been studied in the context of programming, and programming education, as well [7, 23, 21]

5.4 Reflecting and Reviewing

We will reflect on differences in the remaining steps in the next section, but for now, let's move to the final step of writing and the 6th of programming: *Reflecting on text* and *Testing and Debugging* and *Maintaining and modifying the program*.

After the text is written — and often also during the writing process — the writer reflects on their process and product. Are the goals met? Have I lived up the expectations of the assignment or client? Is my text readable?

Likewise a programmer reflects: Does my program function as expected? Is this code well-structured and free of *code smells*? Here, of course, there is an interesting difference between writing and programming, since a programmer can party rely on the computer to validate their program. Firstly or course by the compiler and the type-checker. Increasingly often, programmers use tests to ensure the correctness of their programs. To find bugs, but also to ensure code quality, programmers use static analysis tools.

Failure to compile, to pass all tests, or too many code smells might impose a need for a revision of the source code. This type of product-inherent warnings for review is not present in writing texts. While this is a clear benefit, this might also reduce the need for or interest in manually reviewing the source code, not for functionality, but for readability. Recent systems for collaborative programming, like GitHub and their support for code review via pull requests have spurred interest in code reviews for readability and maintainability.

These steps seem very similar, as they concern verifying that the text or program performs the task it needs to. However, programming has a seventh step, in which the program is maintained. Often, of course, programs are updated after they have been deployed, while books or articles typically remain the same.

6 Differences

In this section we highlight differences between the models of Huizenga and Prata. As said, there exist other, different models, which would lead to different comparisons. These two list are our choice, but we encourage others to make more, and different comparisons.

In our lists, we observe that not all steps are as similar as the first and last few steps. In the middle, we observe more differences than similarities, which we will elaborate on in this section. The most important difference is that in programming, making

Figure 2 Queneau's Exercises in Style: Surprises

How tightly packed in we were on that bus platform! And how stupid and ridiculous that young man looked! And what was he doing? Well, if he wasn't actually trying to pick a quarrel with a chap who–so he claimed! the young fop! kept on pushing him! And then he didn't find anything better to do than to rush off and grab a seat which had become free! Instead of leaving it for a lady!

Two hours after, guess whom I met in front of the gare Saint-Lazare! The same fancypants! Being given some sartorial advice! By a friend!

You'd never believe it!

the source code is just one step: *Writing the program*, while in writing, there are two additional steps related to the layout and formatting of the text. In this section we will elaborate on what these steps mean in writing and how they could be interpreted in programming.

6.1 Stylizing text

When the ideas of the writer have been translated into text, a writer will apply rules of style. For example, a letter will have a formal style with longer sentences and advanced jargon, while a children's book has a happier style and simpler words. It is generally agreed upon that in order to write a good document, the writer has to stay within the same style for an entire document, otherwise the text might be harder to understand, or less enjoyable to read.

Style can also depend on the intended audience of a text. When writing a letter, for example, the choice of style is related to the intended addressee. The style of a letter directed towards a loved one differs in various ways from the style of an application letter.

In addition to these type of styles, prescribed by the goal of the text, many writers have their own personal style. This personal style might consist of the excessive use of adjectives to describe scenery, or the strict avoidance of multiple clauses. Other examples are the use of different perspectives, such as first or third person, or the omniscience of a narrator. Such a personal style will automatically be applied by the writer throughout the entire text, which in different for a style that is imposed on the writer by external factors such as audience and text type. In the latter case, writers have to review the text and make sure they used the same style throughout the text. As the French writer Raymond Queneau shows in [18], many styles can be used to communicate the same content. By using different styles, the atmosphere of the text can vary. Writers can experiment with different styles to find out which one fits the intended feeling best.

Figure 3 Queneau's Exercises in Style: Hesitation

I don't really know where it happened...in a church, a dustbin, a charnel-house? A bus, perhaps? There were...but what were there, though? Eggs, carpets, radishes? Skeletons? Yes, but with their flesh still round them, and alive. I think that's how it was. People in a bus. But one (or two?) of them was making himself conspicuous, I don't really know in what way. For his megalomania? For his adiposty? For his melancholy? Rather...more precisely...for his youth, which was embellished by a long...nose? chin? thumb? no: neck, and by a strange, strange, strange hat. He started to quarrel, yes, that's right, with, no doubt, another passenger (man or woman? child or old age pensioner?) This ended, this finished by ending in a commonplace sort of way, probably by the flight of one of the two adversaries.

I rather think that it was the same character I met, but where? In front of a church? in front of a charnel-house? in front of a dustbin? With a friend who must have been talking to him about something, but about what? about what? about what?

Figures **??** and **??** show two exercises from Queneau[2]; Surprise and Hesitation. Readers can check for themselves that on every singly line, in every single sentence, the writer has stuck to the chosen style. This reflects in specific words (e.g. 'how' in *Surprise* and 'but', 'don't really' in *Hesitation*), types of sentences (short and firm in *Surprise* and long and intermittent in *Hesitation*) and punctuation (exclamation marks in *Surprise* and dots and question marks in *Hesitation*).

Prata's list of steps of programming does consist the style of a program, which of course makes it interesting to think of what exactly 'style' would mean in the context of a program. Some authors who have explored different styles in programming, for example Lopes[13]. Her book describes a number of different styles to calculate term frequency, including continuation passing style, and functional style. However, if we look at the steps in programming, we feel this is more related to *Designing the program* than it is to stylizing.

There are however several places in source code where developers have freedom in giving 'a style' to their code. One of the concepts related to style could be whether or not the code has comments. Some programmers feel that good code should explain itself, but many also agree that comments are a good coding practice. The most extreme form of this style might be the idea of *literate programming* introduced by Knuth[9]. He envisioned a style of programming in which program statements are interspersed with documentation in a natural language, to ease in understanding the program. However compelling the idea of literate programming, in practice it is not used widely, with the potential exception of 'notebooks' like Mathematica or iPython.

Another area where a style can be expressed, is when programmers are selecting keywords. Choosing how to name a keyword can be seen as a literary activity, since the

[2]Translation from http://altx.com/remix/style.pdf

programmer is defining the meaning of a variable with meaningful words. Arguably, the programs 'x := 5' and 'total := 5' are executed in the same way by a compiler, but not by the brains of future readers. A more elaborate example is shown in Figures 1 and 2. These two programs could be seen as different styles of the same programs, embodying the difference between simply presenting facts and taking the reader along in a story of what is happening.

Figure 4 A program that prints the area of a rectangle.

```
decimal x = decimal.Parse(Console.ReadLine());
decimal y = decimal.Parse(Console.ReadLine());
decimal area = x * y;
Console.WriteLine(area);
```

Figure 5 A second program printing the area of a rectangle.

```
//this progam calculates the area of a rectangle
decimal lengthSide = decimal.Parse(Console.ReadLine());
decimal widthSide = decimal.Parse(Console.ReadLine());
decimal area = lengthSide * widthSide;
Console.WriteLine(area);
```

While these differences might seem small, keywords are known to play a large role in programming, as about three quarters of characters in a code base consist of identifiers [11]. Studies have shown that code with better identifiers is easier to read for developers.

Better identifier names have been known to correlate with improved program comprehension. For example, [12] reports on a study performed with over 100 programmers, who had to describe functions and rate their confidence in doing so. Their results show that using full word identifiers leads to better code comprehension than using single-letter identifiers, measured by both description rating and by confidence in understanding.

Here, observing this difference leads to thought about programming and programs. Could we envision a class of programs which, like fairy tales, always have a similar style in all their occurrences? What is a surprising program, or a hesitant one? Do they compile to the same output?

And can we think of a group of programs which, like letters, share a goal, but could be stylized in different ways? We believe contemplating these type of questions will make programming as a field richer and we encourage readers to come up with style of programs they like to see.

6.2 Formatting text

Another step that is missing in Prata's programming steps is formatting. In writing, formatting means the writer layouts text, for readability or aesthetic reasons. Formatting text is typically one of the last steps in the writing process. A few activities which are commonly performed while formatting are adding images and figures to make

Figure 6 Two versions of a diamond poem, with different formatting

1: lion
2: majestic, proud
3: roaring snarling, prowling
2-2: mane, muscle – fleece, fluff
3: bleating, leaping, grazing
2: meek, gentle
1: lamb

the text more attractive or easier to understand. Or, when the writer wants to draw attention to a specific part of the text, they can use add emphasis with font options, such as making text bold, italic or changing the font color.

Sometimes, for example when the text is being published by a publisher, the formatting step might be done, partially of fully, by someone other than the writer.

Figure **??** shows two versions of a diamond poem: in the first draft the text is formatted using practical constraints, the writer has only outlined the poem by its requirements (number of characteristics of the animal per line), the final version of the text has a different shape (diamond), different font, different background color and there are images added.

Formatting, like stylizing, is an particular interesting concept in programming, since it is often seen as an afterthought. This is underlined by the fact that there is no formatting step in Prata's model.

Again of course the question arises that formatting means in the context of programming. In some languages, programmers have no freedom in some aspects of formatting. For example, in Python the indentation level of the statements is significant, meaning that code in which, for example, the body of a loop is not indented does not work.

Most other languages do not have formatting requirements that strict, but many have formal of informal code conventions, from which a deviation is seen as a bad habit. Some people argue that these now informal formatting rules should be made mandatory. For example, in 'The best software writing', Ken Arnold argues that:

For almost any mature language [...] coding style is an essentially solved problem. I want the owners of language standards to take this up. I want the next version of these languages to require any code that uses new features to conform to some style.[2]

More than tools used for natural language writing though, tools for programming, called integrated developments environments (IDEs) have features that format code automatically. Recently, researchers have successfully attempted to learn formatting conventions from a code base, in order to increase its consistency automatically[1].

Despite the existence of these required, advised or automated formatting measures, programmers do still have some freedom in the formatting of their source code. As an example, consider the two code snippets in Figure **??**.

Both programs are following code conventions, however, they feel different. The distance between the declaration and the use of a variable might influence the understandability of a piece of source code, or simply the enjoyment with which someone would read it, underlining the importance that formatting can have on

Figure 7 Two similar programs with different formatting

```
int a;                  int b;
int b;                  int x;
                        int y;
int x;
int y;                  int b = x + y;
int z;
                        int a;
int b = x + y;          int z;
int a = b + z;
                        int a = b + z;
```


a program, even within the limited freedom that a programming language offers, compared to natural language.

Finally, there is a way in which formatting in programming is richer than in writing, and that is *syntax highlighting*: the coloring of lexical tokens in source code text according to a certain categorization. For example, coloring keywords blue, variables red and operators black. Experiments done with syntax highlighting have shown that it can reduce time needed for a given task and reduces context switches. This effect is greater in novice programmers than in programmers with more experience[20]. It would be interesting to see if effects like this exist in natural language comprehension as well, for example by using colors to identify part of speech.

6.3 Compiling and running code

A final, seemingly, difference we want to highlight is that in programming, code can be type checked, compiled and ran during the development process. While in writing of course writers themselves can read the text, and distribute drafts to people, this is not as easy and effortless as hitting a compile button.

This leads to the deep questions of what does it mean for a text to run? Maybe this can only happen in the mind of a reader? Or could we envision an algorithm that mimics this, and predicts the thoughts and even emotions of future readers?

There are tools that attempt this somewhat, a simple spell checker comes to mind, or the more advanced Hemmingway app[3] which highlights bad writing style like long sentences and passive voice. While these are useful, they do not seem to resemble the execution of a text in a human's brain very closely yet.

7 Concluding remarks

In this paper, we aim to draw a comparison between writing and programming by comparing their goals and challenges. Looking from a distance, both can be seen as

[3] http://www.hemingwayapp.com/

having a very high level idea and representing that with low level constructs. We observe that some steps as defined by writing and programming authors are similar, *Structuring information* is like *Designing program*, in that for both the performers need to take in information and decide on how to structure it to fit their goal best. We would love to explore our beliefs further in the future, for example by conducting think aloud study with people writing or programming, or by placing people in an fMRI scanner and measure their brain activity.

Other steps present in writing, like *Stylizing* and *Formatting*, are not commonly described and studied in programming, and we hope our paper leads to more discussion on these activities in programming. Is adding whitespace style or is it formatting? Having clearly, agreed upon definitions like in writing can ease teaching and communication on these type of topics. Can we learn from best practices in writing? The other way around, programming has explored the step of reflecting and adapting in more detail probably due to the collaborative nature of modern day programming projects. There writing could be inspired by ideas like pull requests and formal code reviews.

There are also places where writing could be inspired by programming: Programmers attempt to get feedback from the “environment" earlier than writers, by compiling and running their program. Can writers similarly somehow have a machine reflect on their text while they are still writing?

There are certain things that we consider out of scope for this paper. For example, in the above, we have followed [8] and [17] in their linear representation of writing and programming, but often, in both domains, the processes can also be represented as a cycle. For example, in writing the consensus is that writers continuously switch between the steps of the process as described above. In programming a cycle that is often referred to is Beck’s Test Driven Development cycle[3]. We presented the cognitive processes and skills in a linear way, but the reality is not so strict. The process is not even cyclic, although this fits reality more than a linear representation. In reality the writer or programmer switches between writing or programming stages freely and uses different skills throughout the entire process.

Future work in exploring this comparison should surely examine the cyclic (or even messier) order of steps in more detail. There is one more observation: the fact that the activities are similar leads us to think that also the skills and the way we teach could learn from each other. These thoughts are further explored in [14].

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