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Cost Price Calculator



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Cost price calculator

Recommendations on improving the quotation process

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Preface

This thesis is part of my bachelor Industrial Engineering and Management at the University of Twente. My research is done at Galvano Hengelo, with as main goal to create a tool to improve the quotation process.

Firstly, I want to thank my colleagues at the company for their contribution to this thesis. Working towards a shared goal and always sharing their knowledge with me really helped during my time at Galvano. A special thanks to Ivo Willemsen for creating the opportunity to do my bachelor assignment and making sure that I was given all means needed to finish the assignment in a successful manner. Also, I would like to give a special thanks to the planner Dick Ekkel for his support during my thesis in sharing all his knowledge with me, giving me a better understanding of the details in the process. The guidance of both helped me improve on a personal level as well.

Secondly, I want to thank my supervisor at the University of Twente, Reinoud Joosten, who helped me with writing this report. His feedback and guidance helped me to progress and find some of my strengths and weaknesses in doing research. I also want to thank Abhishta Abhishta for being my second supervisor. The quick replies of both when I asked for help really supported me.

Lastly, I would like to thank all my family and friends for supporting me during my bachelor study. It really gave me extra motivation knowing that they were always there.

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Management summary

We intended to solve this problem by researching the following points:

- Defining the current process.
- The calculation method.
- Documentation of the planner's expertise.
- Capabilities of other employees.

This brought us to the following deliverables:

Database

Galvano Hengelo wanted to have the knowledge of the planner documented concerning the calculation of cost prices. Previously, all quotations were made by depending on the experience and insight of this one employee. The only data available in the quotation process was the outcomes of historical orders. Our analysis of these outcomes showed that borders could be drawn through size parameters which enable employees to make uniform calculations. Our research resulted in a database linked with a code where the border ranges are defined related to the number of products per charge for different shapes of products.

Improvements on the general process

The general process asked for some improvements. After defining the original process, the bottlenecks were determined. We critically assessed the path of the quotes. Since it moves through different departments the flow was not as efficient as it could be. It did not use the theory of a lean organization to a desirable extent. Crossing three departments with two of them twice caused smooth flows to be interrupted which created the question of building a tool where each department is crossed only once. Consequently, the idea of a calculator linked to the database came into existence.

Calculator

The company wanted us to take steps towards improving the general process, eliminating risk in the calculations, and unburdening the planner. By designing a calculator that is linked with the new database where knowledge of the planner is documented the calculations can be done by more employees than before. This creates the possibility of improving the process by removing delays. When a quote only moves through a department once, there is no queue and only one start up moment per employee. The situation where more staff members can do the calculations, the risk of losing the knowledge and experience in generating the cost price is reduced. Also, this unburdens the planner and gives him more time for his other expertise.

Dashboard

All calculations are done on the backend where a code generates the output. The input is entered on the frontend. This is a dashboard where the parameters of a customer's request are noted and followed up by the cost and sales price. The frontend is designed in a way that only a select number of employees can adjust or improve the backend. A security is placed on the calculator and only 2 staff members have the password. The dashboard is available for all employees such that they can use the calculator without any risk. Especially for those unfamiliar with excel it is essential that they do not get stuck with unwanted adjustments.

Advisory report

We build the calculator but unfortunately, we could not be present during the implementation period. We have the following recommendations for the company:

- Educate employees in the quotation process.
- Start using the calculator as addition to the process.
- Keep improving the calculator by adding more shapes and possibly define new shapes.
- Acquire a STEP file reader.
- Link the reader to the ERP system.
- Acquire a simulator that reads the technical drawings.

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Reader's guide

This chapter provides the reader an overview of what can be expected to encounter during our research. For each chapter we give a short explanation on the content.

Chapter 1

The thesis starts with an introduction. This provides of a description of Galvano Hengelo and the problem they encountered. A problem identification and approach including research questions are constructed to solve the problem. Also, the research design and intended deliverables are given.

Chapter 2

To progress we provide a context description of the current situation. This is the quotation process as where the problem was encountered. We give a detailed description on all the taken steps from request to quote. Also, some clear bottlenecks are identified together with a zero-measurement of performance.

Chapter 3

To be able to identify hidden bottlenecks and find possible solutions we describe and relate our research to literature. Methods from lean management are used to find common problems in processes and help to find solutions. Also, literature specific on quotation processes are described to go into detail on our process.

Chapter 4

In this chapter the alternative solutions are described. Both a CPQ system and a CAD system are researched to find what they could possibly give as improvement to Galvano. Also, the CPQ system Merkato is described since we used this software as a demo. The usefulness of STEP-files for Galvano is the last thing that is discussed in the chapter.

Chapter 5

The final solution for the problem of the company is given in this chapter. It consists of a calculation tool which is described in four elements. These are dashboard, data file and code, background calculations, and security of the workbook. After reading this chapter it becomes clear what new tool the company is going to use.

Chapter 6

This chapter outlines the main findings of this thesis. In the conclusion section the answers to the research questions are drawn. The advisory report for Galvano Hengelo is about the implementation and possible future improvements. Also, the shortcomings of this thesis are described.

1. Introduction

1.1 Host organization

Galvano Hengelo is a medium-sized firm specialized in galvanizing. The company has a broad and stable clientele covering almost all market segments of the metal industry. Galvanizing takes place in a modern and dynamic company with a wide range of galvanic and chemical processes. Quality, speed, reliability and fulfilling agreements are important core values. The organization works in a professional, pleasant, and informal environment. The firm is part of the Schoonderwolf Group, a group of companies consisting of various technically oriented companies.

For the bachelor Industrial Engineering and Management graduation assignment I investigated the problem given by the firm.

1.2 Problem given by the company

Annually, the department Work Preparation executes around [REDACTED]. To limit the dependence on people and shorten the lead time, the development of a price configurator is desired to determine the cost and selling prices based on given parameters.

1.3 Problem identification

Galvano has a problem that the planner of the company has too little time for other activities than calculating. This employee spends a lot of time determining the number of products per charge, he is the only one capable of doing this. His decisions are based on experience and insights, which means none of his considerations are documented. He has a lot of other tasks as well, like working in ICT and designing racks to hang products on. Since he spends almost half his time calculating, he has little time left to work on his other tasks. Also, him being the only man capable to determine the number of products per charge brings a great risk. In the worst case, no one can execute the calculations for the quotations.

The company always strives to work efficiently and effectively, as they are always looking for improvements in all activities. One activity to improve following the problem is the Configure Price Quote (CPQ) process.

The stakeholders in the CPQ process indicated that there [REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

A lot of time is spent calculating the price of the quotation. The calculations mainly consist of determining the area of different products which need to be galvanized. The products come in hundreds of shapes. Also, the number of products to be cultivated on one rack (per charge) are considered. Determining these parameters, however, can only be done by the planner.

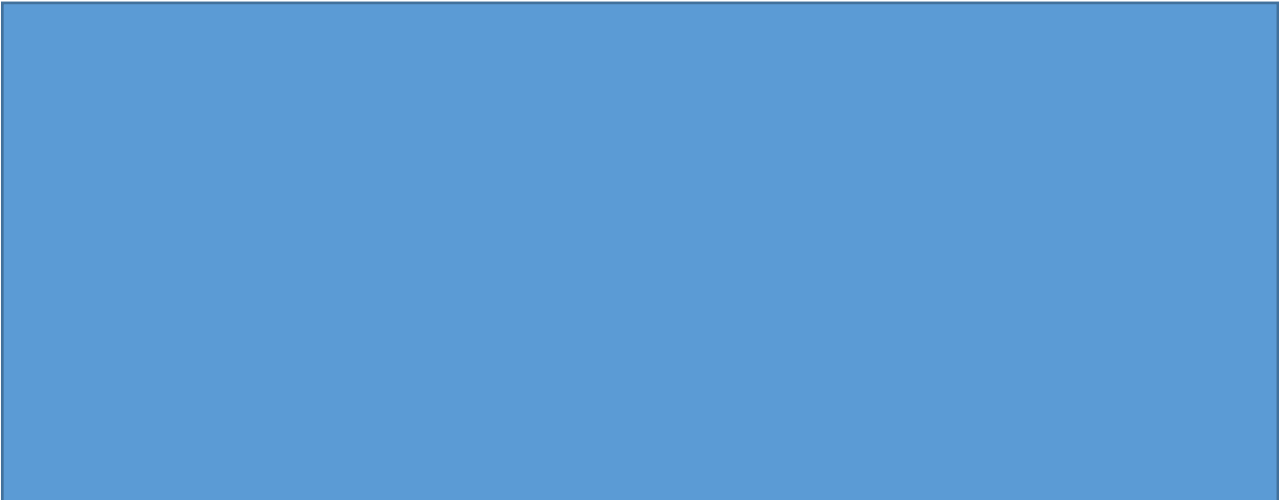


Figure 1: Problem cluster.

Following the problem cluster, we decide to follow the path of the planner being the only employee capable of doing the calculations. If this problem is tackled, then the other two paths are also closer to a solution. It can be identified that ‘Inefficient and ineffective CPQ’ is the action problem. Since this is a cause at the end of the problem cluster.

The calculations within the CPQ process take about [REDACTED]
[REDACTED]. These hours are made up of determining the area of the products and determining the number of products per charge of all the different products. The overall CPQ process should be halved in duration.

1.3.1 Problem description

The aim of my research is to improve the CPQ process. The steps in this process need to be digitalized and automated, so all calculation considerations need to be documented. Pursuing this aim, the current situation is examined. Getting an overview of the steps taken in the current process gives me the opportunity to see which need improvement. It is important to have all considerations documented such that the calculations can be checked after the operation is finalized. The documentation gives the possibility to retrieve mistakes. After these clarifications the bottlenecks in the current process can be identified.

To proceed, we need to know the desired situation. Here it is important to research how, according to literature, processes should be described and steered. Finding the proven methods of researching processes and implementing improvements gives a basis in forming my research. To get to know the desired situation, we research the wishes of the organization by interviewing the management. During my research, we must find a solution to the problem that creates the desired situation. Also, we describe the researched alternatives for the solution and the possible future improvements. Next to that, the organizational and financial consequences are to be identified. This is done to determine whether the solution is acceptable within the host organization.

In the identification of the current process, we investigate the bottlenecks. To assess what the focus points are, we use literature and the knowledge of the stakeholders in the process. Literature is used to describe bottlenecks that usually occur in CPQ processes. Interviewing the employees enables us to clearly describe the current situation. Also, it is desired that the knowledge available give steps

towards solving the bottlenecks. Solving the problem needs to be supported by studying literature to assess how we can describe and steer the process. This gives guidance realizing the desired situation sketched by the host organization.

Following the problem identification, problem approach, and research aim, the following knowledge problem is identified:

‘How can the CPQ process in Galvano Hengelo be improved in terms of effectiveness and efficiency?’

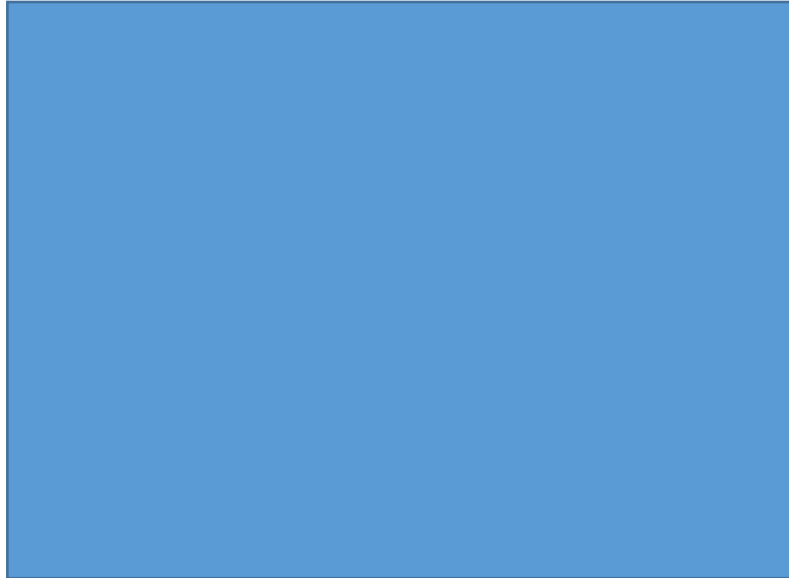


Figure 2: Ineffectiveness and inefficiency CPQ Galvano.

First, to set clear the usage of both terms, we give a definition of both. Effectiveness is *the producing of the intended or expected result*. Efficiency is *performing or functioning in the best possible manner*. The difference between both is, effective is about doing the right things, while efficient is about doing things right (Drucker, 1963).

Part of my research focuses on reducing the lead time between the steps of the CPQ process, so making it more efficient. Reducing the lead time can be done by becoming more conscious of lean management and applying it to the process (Plenert, 2010). Lean is a systematic approach that focuses the entire enterprise on continuously improving quality, cost, delivery, and safety by seeking to eliminate waste, create flow, and to increase the velocity of the system's ability to meet customer demand (Burgess & Radnor, 2013). In this case especially the latter aspect.

We pay attention to how processes are described and steered. Literature is used to find relevant articles about processes like the one in my research. An approach of a process focuses on flows that enter and exit the process. In this process these flows pass through different departments. In this manner it is important to have a clear process planning. The main objectives in process planning are (Scallan, 2003):

- Identify the functions involved in product design and manufacture.
- Define the process planning activity.
- Identify and describe the main tasks undertaken during process planning.
- Identify and describe the various data used in process planning.
- Identify and describe the main process planning documentation.

Elaborating these objectives creates a clear description of the process.

The other part focuses on the documentation of calculation considerations improving the effectivity of the process. Making sure that all outcomes are uniform and correct. Truly effective outcomes measurement requires standards that encompass all critical elements (Busignani, 2021). For our research it is important to make sure that all elements used in the considerations of the planner are taken into the outcomes such that they are truly effective.

1.4 Problem approach

The company's management has the problem that their planner has little time to perform his other tasks. [REDACTED]

[REDACTED]. The planner himself would also like to perform more ICT tasks and spend more time designing racks to hang products on, rather than calculating.

Both the managing director and the company director allow me to speak to anyone needed within the company at any time, and if it is needed customers can be contacted for the research. The planner is the main employee involved in the research. He is the man whose knowledge needs to be documented. The project supervisor from the university is important in giving advice and feedback on the project. Further material and information needed for the research is provided by the company.

To progress, the information of the steps in the CPQ process is needed. This consists of the employees who carry out each step and what they do each step. Interviewing the planner is especially interesting, since his information consists of steps he takes in his head and which things he takes into consideration in his calculations.

1.4.1 The research questions

To find a solution to the core problem, several knowledge questions must be answered. The questions are based on the missing data that are required to find a solution to the core problem. In this section the knowledge questions are defined with the corresponding research method. The questions can be found below:

The current CPQ process

In which way is the CPQ process executed now?

This is discovered by field research. We use this research method because total involvement in the process is required, this cannot be done sitting behind my desk. Gathering the data about the current process is important for my research to get a clear overview of the current way of working. Conversations with participants in the process are held and observations to how the participants execute their tasks. The information is about the path of the process in general and about the details in the calculations. We analysed where co-workers review each other and where reports are present or absent in the process. In case of unclear information, qualitative interviews are held.

The desired CPQ process

What are the wishes of the host organization?

For this question field research is used again. The information for this question is retrieved from interviews with the management board, the planner, and the commercial department. The collection of this data is important for setting up the problem approach. Again, it is required to get involved with the stakeholders in the process, the information to answer this question cannot be collected from my own computer.

The bottlenecks in the current situation

What are the bottlenecks of the current process?

Both field and desk research are done on this question. This is done by analysing the current process and by studying literature on what bottlenecks usually occur in processes like the CPQ process. Both are done at my desk. Defining and analysing the current process leads to a clear overview of the strengths and flaws in this part of the organization. Also, discussing the desired situation and combining this with the bottlenecks found by the company, gives a good view on which path to follow in my research.

The possibilities for now and for the future

What are the possible solutions to the problem and what additions are available for the future?

Desk research is done to find out which solutions are available. For this question we mainly used the internet and the company's network to research what solutions to the problem are already at hand or available at a certain price. Also, the interview about the desired situation is useful. Most information is found through literature where the bottlenecks in other CPQ processes are described and the according solutions.

Organizational and financial consequences

What organizational and financial consequences might appear?

Both desk and field research are done on this question. We analyse the results of the previous questions and think about how these are to be implemented, both are done at my desk. Also, we interview the management as to how they see the implementation of the solution and what they would like the situation to be soon.

1.5 The research design

The research done is mostly descriptive. It describes the situation as it is now and the desired situation. In other words, addressing what the characteristics are of the situation. Rather than answering how/when/why questions. The research consists of observing and describing phenomena. In Figure 3 the phases of the research are visualized.

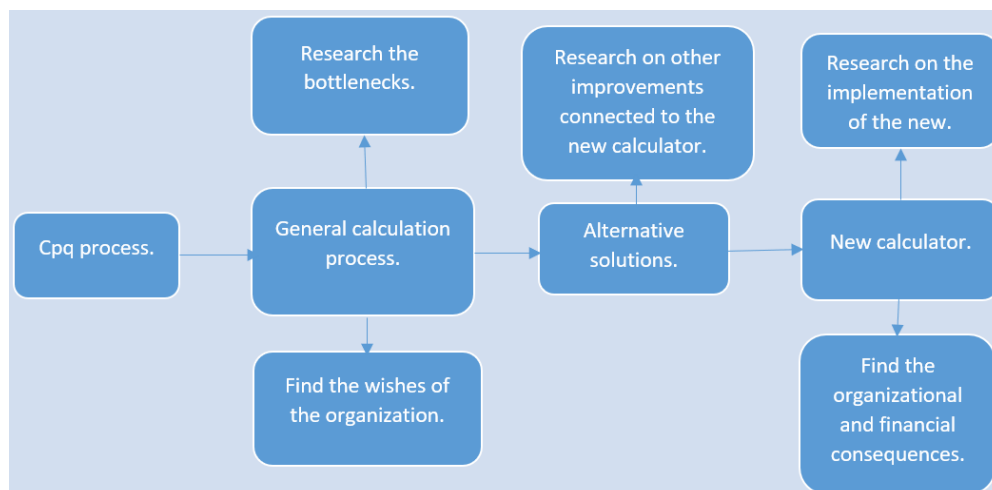


Figure 3: The different phases of the research.

We use two main research strategies. These are case study and qualitative interviews. Case study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project (Simons, 2009), this is very relatable to my research of Galvano's CPQ process. Through

qualitative interviews we can understand experiences and reconstruct events in which we did not participate (Rubin & Rubin, 2005), this is helpful in finding the experiences of the stakeholders in the process.

Case study is done to investigate the process as it is now. We gathered information from different sources and through different types of data like interviews, observations, and analyses of documents. The case in this research is the company Galvano Hengelo, especially their current CPQ process.

The second type of research strategy, qualitative interviews, is used in almost every step in the research. We neatly planned the interviews and critically decided who the interviewees are. Also, how to record and analyse these interviews were points of attention. Interviews are often prone to biases and problems, so during the design stage it was important to take time for the consideration of designing the interview in the correct way.

Following the research strategies, we can determine that the main way of data gathering was qualitative. A lot of data were collected through observation and interviews as well as descriptions by informants.

1.6 Intended deliverables

At the end of the research, we provide the following deliverables:

- **Process description:** defining the process as it is before implementing the new calculator. This is the basis in determining the bottlenecks and identifying the improvements the company needs.
- **Uniform database:** since the calculations done in the past are not directly available when a new calculation is performed the same calculations are repeated. We therefore deliver a database where available historical calculations are used when the parameters are filled in.
- **The new calculator:** the new calculator takes all considerations into account that used to be done by the planner. It reduces the time that is taken for the usual calculations. The time at the company was a bit too short to implement the new tool completely. However, the planner and a commercial employee are well capable of using the tool and they can explain the tool to other employees. Also, the opportunity to adjust the calculator must be implemented.
- **Manual:** we deliver a descriptive manual for the users to fall back on. In the manual we describe all functional and technical details of the calculator and the database. Also, the security manual is available in which we advise the company to only distribute this to a select group of employees. Next to that, we give a description to adjust values in the code.
- **Advisory report:** there are a lot of options that can be added in the future. We describe most of them in the section of alternative solutions. In the advisory report we write recommendations on future research and possible future additions to the calculator.

2. Context analysis

This chapter provides a general overview of the current CPQ process at Galvano Hengelo. We give information on the different stakeholders in the process as well as the time they need to fulfil their tasks. Also, an explanation on the normal flow of the quote through the departments is given. By describing the current situation, we intend to give the reader a better understanding of our findings.

2.1 Current CPQ process

Within the quotation process, as we discussed with several employees who have a role in the operation, five steps are clearly visible and shown in the description. The activities in each step are given including the details of time and employees. Also, the possible bottlenecks are noted.

A lot of different products cross the desks of the commercial section. Products with simple shapes do not cost much time since the parameters are easy to calculate. On a regular basis complicated shapes come across as well, these products cost significantly more calculation time. A product like the one in Figure 4 is easy to calculate. The shape is clear and when the parameters are given on the technical drawing, the calculation process can start. Also, the fact that there are holes in the product gives the opportunity to hang the product. Later in the chapter it becomes clear why this makes the calculations easier. Figure 5 shows a product that can be determined as two combined shapes. The area determination for such products is done by separately considering the two shapes and combining the areas. The outcomes for the number of products per charge are retrieved easily because of the hole in the middle. Finally, Figure 6 shows a complex product. Both the area and the numbers per charge are difficult to compute. The area due to the complex shape and the products per operation due to the missing hanging option.

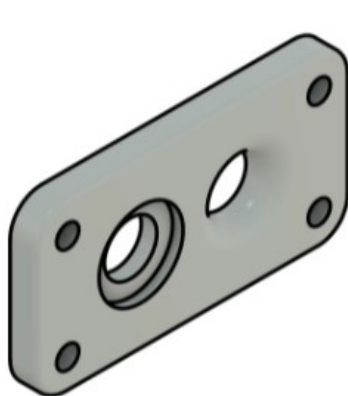


Figure 4: Simple product.

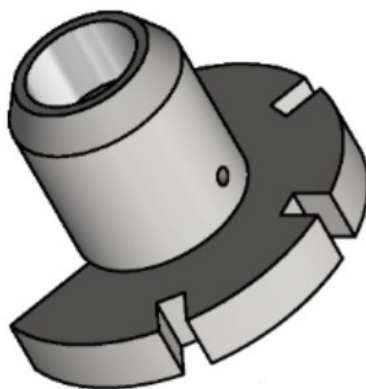


Figure 5: Combined shapes.

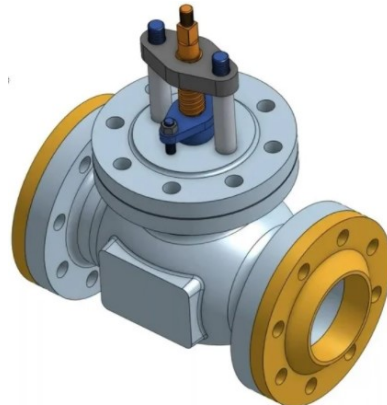


Figure 6: Complex product.



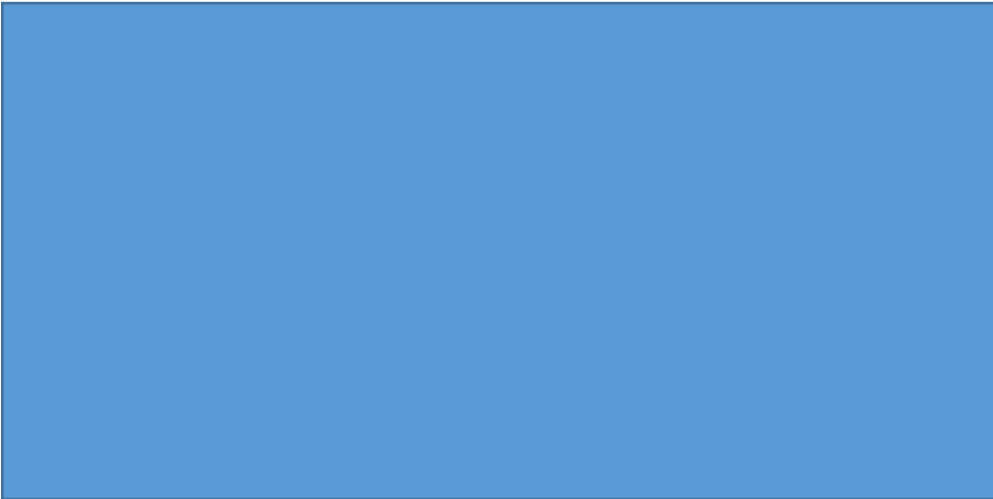


Figure 8: Windows.

Figure 7: Insert piece.

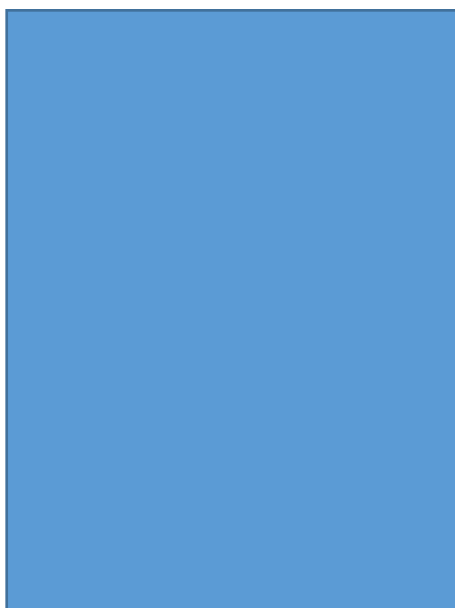
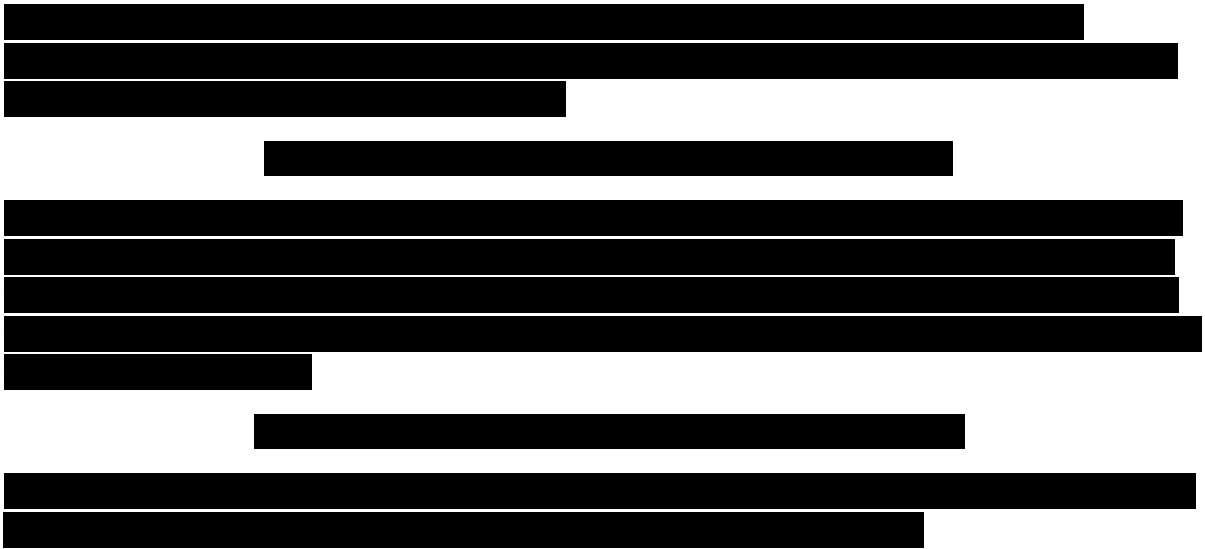


Figure 9: Hanging stick.



2.1.1 Steps



Figure 10: The process of request to quotation.



[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]



Figure 11: Standard quotation process.



Figure 12: Complex quotation process.

2.3 Overview of problems/bottlenecks

The processes described above can be analysed now. Obviously, like in all processes, there are some factors stopping it from reaching full potential. Bottlenecks are obstacles which reduce the capacity of a system (Timilsina, 2012). People, process, and equipment are three key elements of a company's quality system and all of them need to be focused on for an overall improvement in performance (Sundararajan, 2021). Productivity in any system is a function of the marriage between these 3 key elements (Adegeye, 2020). In the quotation process we determine whether the elements form inefficiencies or ineffectiveness.

People

Starting with people, we find in the described process that 3 types of employees are involved. There are several commercial employees, who mainly perform similar tasks. Which means that the risk of having an employee missing out due to illness or unexpected vacancy is covered decently. Also, some other employees in the company are familiar with the tasks of the commercial employees. The same holds for the administrative employees, there are multiple options for temporary replacement. Training new employees does not take too long either. However, for the planner it is a completely different story. The planner has been with the company for about 30 years and is the only one who can perform his task effectively. So, the risk of losing his knowledge for any reason whatsoever forms a large point of attention. In addition, this employee is the internal expert on IT, and the designing of hanging options for which he has very little time remaining. This causes the whole organization to improve slower than possible. So, the amount of time spent by the planner in the quotation process forms a bottleneck.

Process

Looking at the process and zooming out, the build-up of the quote is sent back and forth several times. All parties have their own contribution to the quote, as described in Figure 10, but the distribution is divided in an inefficient way. The red line shows a backwards movement that asks start

up time for the second time in the same department in the same process. Since a great number of products pass the desks of the different departments, each department needs time to recognize a product when it comes back from another department. The recognition time forms inefficiency for all departments and in the end in the total processing time of a quote. This excessive amount of time forms a bottleneck. One of the reasons that this bottleneck is formed again traces back to the fact that too little staff members have enough knowledge to calculate the cost price.

Equipment

In the process the ERP system MKG is the main equipment. Here all received data and the output of the calculations are stored accessible for all employees. Unfortunately, most of the work is not automated yet. All the administrative lines are typed, and the calculations need to be done by hand.

Only the multiplication of surface with layer of coating and price of base material is done in the program. So, the difficult calculations are still on paper. Since only 35% of quotations lead to an order, the time spent calculating has little return. Therefore, the lack of efficiency in the calculations together with the little utilization of the equipment forms a bottleneck.

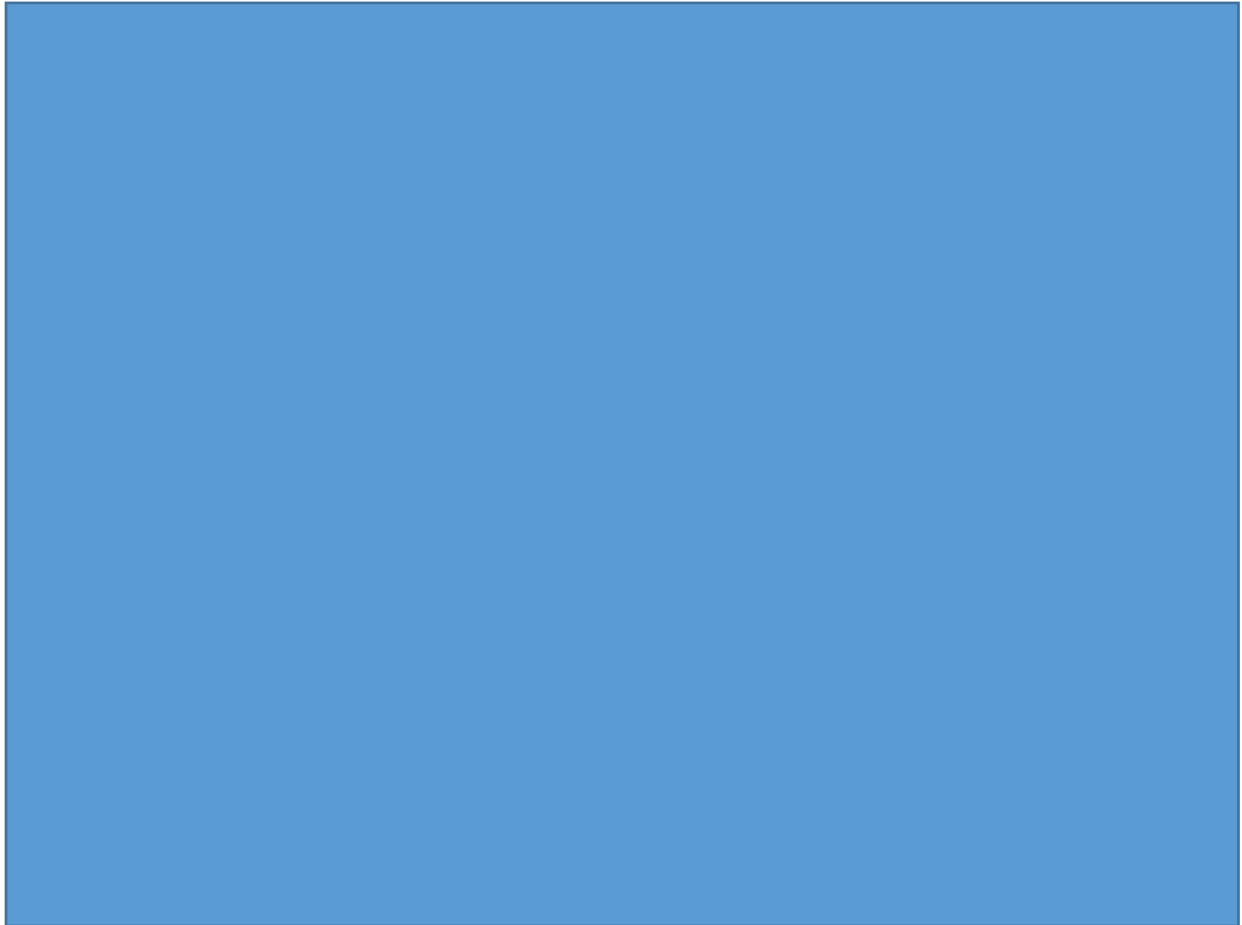
The three elements named show clearly what aspects in the current process form points of attention. People tells us that more employees need to be trained to unburden the planner. It is difficult to pass over 30 years of knowledge and experience, so a combination is to be made between training staff members and automating the calculations. The process flow is another bottleneck. If a constructing quote would just pass through a department once, then the maximum capacity of the system is used. However, due to the specific calculations and lack of documentation it is currently necessary to move the quote back and forth. As a result, the equipment in the process is not used at full potential. Documenting all calculation considerations and training employees to perform them gives the opportunity to use the program at a higher rate.

Summing up the bottlenecks gives a clear overview about what needs to be improved:

- Knowledge of the calculations is not spread
- The flow of the process is inefficient
- Equipment is not used at full potential

2.4 Definition and zero-measurement of performance

Table 1: Bottlenecks of the quotation process.



3. Literature review

3.1 Lean management

3.1.1 Principles

Lean is about eliminating waste and creating customer value and consists of principles that constitute the backbone of a company's philosophy (Hines, 2004). Lean has five main points of attention which are value, value stream, flow, pull, and perfection (Womack & Jones, 2003). These five points describe lean thinking for delivering customer satisfaction using few resources. The concepts provide a way to map continuous process improvement.

Value is the principle of satisfying the customer to a certain level. In the end the purpose of the service delivered is to provide additional value to the customer. Identifying the value of the service for the customer is coupled with the vision and strategy of the company (Stentoft, Freytag, & de Haas, 2011). In our research this principle is about a fast reply to the customer with a quote that pleases their expectations.

The value stream is established after the value principle has been identified. The stream includes all the steps from start to end. The map of steps is set up to find and adjust steps that do not create enough value, hereby eliminating useless ones and decreasing the cycle time (Stadnicka & Ratnayake, 2018). This eventually increases the efficiency of a small process which consequently improves the complete company's efficiency. Increasing value to the customer due to smaller throughput time and less used resources. Reducing the time from request to quote is associated with the reduction of movements. If the constructing quote only passes through each department once, then the cycle time is reduced significantly.

The third principle is flow, which is applicable when the inefficient steps have been eliminated. Here it is necessary that the process of creating value smoothens. Considering the lean philosophy, we suggest that the focus is on the process instead of separate departments. Organizing the process in such a way that there are no queues in the system increases productivity and decreases the risk of errors (Abusukhon, 2021). The main challenge in this principle is to get everyone on the same page and training the employees for the jobs they're given. The focus of people is generally to work as efficient as possible on their own task forgetting to consider the efficiency of the whole organization. It is important to identify the right person for the right job, since the efficiency of the whole process is defined by the weakest link (Christensen & Overdorf, 2000). Creating an environment where more employees can do the quote calculations increases the flow of the process.

Pull means the request of the customer is turned to a provided product or service, and the customer needs are satisfied as soon as possible (Ballard & Howell, 2003). Adopting the strategy set at flow the time from request to delivery is reduced. Due to the adapted flow work hardly ever piles. Resulting in satisfaction of the customer. The process from request to quote in our research is based on the concept of pull. Generally, all delivered products or services come from customer requests.

Last in line is perfection. This point is to analyse all results and decide what non-value adding activity will be removed from the value chain so that the number of steps, amount of time and information needed to serve the customer continually falls (Radnor, 2010). The other principles are about what to do, this one is about how to do it. This point plays an important role in the documentation of the calculations. When a quote is sent to the customer and leads to an order, it is important to check afterwards whether the outcomes leading to the final quote were indeed the correct numbers. If this is the case, then the considerations can be documented and added to the new database.

3.1.2 Problems

Companies are often organized as separate departments which contradicts the lean principle of flow. It is difficult for them to change the existing structure. Often managers even have difficulties describing the release cycle of a customer request. To implement lean principles the first step is to effectively organize collaboration among units (Ong & Sui Pheng, 2021). The greatest source of waste is the sequential work in units, which is switching between departments constantly. This leads to a longer release cycle than necessary. [REDACTED]

Most organizations have problems evaluating work. This problem is caused by the absence of key performance indicators (Marais, de Plessis, & Saayman, 2017). The main thought is ‘delivering work on time using the available resources’. In this manner the performance of work cannot be evaluated since there is no clear material to compare it with. For this matter we have analysed the process and set a zero-performance which can be compared with the process after adjustments.

The problem of not being able to evaluate work causes the lack of documentation. Poor documentation is the cause of many errors and reduces efficiency in every phase of a process (Nanz, 2011). To be able to act, all facts need to be present. They must be present to get an understanding of deviations in the process, which factors stood out in not holding up to standards set in the strategy. We relate this to the evaluation of quotes where we check whether an order could be produced according to the primary calculations. If this is not the case, it is important that all considerations in the calculations are noted such that the origin of the miscalculation can be retrieved. When the miscalculation is rectified, the right outcomes are documented in the new database.

Over the years lean was extended to wider application areas. Now a difference should be made between strategic and operational lean (Kumar & Harms, 2004). Strategic lean relates to lean thinking which happens mainly before the process starts. This area is executed on the basis that focus of the final customer is still missing in a lot of lean supply chains. Focusing on the final customer it is important for Galvano to reduce the lead times from request to quote. Operational lean is related to the operations happening during the process. This concerns the separate steps in the process of generating a quote making sure the departments are used efficiently. Combining these two types of lean will lead to extra value creation using a minimum number of resources.

3.1.3 Bottlenecks

The process activities holding back organizational performance are called bottlenecks. To get to know a bottleneck, knowledge is required about the whole system. This is the case since no process advances quicker than its slowest activity. Systematically locating bottlenecks and defining their causes can be done by a bottleneck analysis (Buddas, 2014). For a mechanical operations system mathematical approaches are mainly used. However, these will not directly work for human preparedness since employees express their feelings and thoughts. Since the process under consideration is executed by humans, we must use different approaches. To assess bottlenecks in a human operation a framework is built. This is done on separate components, which is elaborated on in this section, with process mapping, theory of constraints, critical path analysis and critical success factors. It strikes that these components look quite alike to the lean management steps.

Process mapping

Modelling the relationships in an operation between activities, people, data, and objectives is process mapping. Such a map helps to be able to analyse, streamline, standardize and improve a procedure by rethinking activities (Hunt, 1996). If an activity lacks the ability to define boundaries,

identify the purpose of improvement, consider the depth and width of the process, and fail to include process improvement as a goal it may lead to failing to improve the operation (Klotz, Horman, Bi, & Bechtel, 2008). Creating and recreating a process map of an organization requires insight from different stakeholders. This component is followed in the first step of our research where we define the current process by interviewing the stakeholders and getting involved in the process.

Theory of constraints

The theory of constraints (TOC) assumes that a chain is not stronger than the weakest link. The theory is found on the basis that systems cannot be understood if separated from an entity and analysed in parts (Bostan, 2021). Operations always have constraints that impact by blocking. This component of the bottleneck analysis identifies the bottleneck and takes action to remove it. The TOC can be divided into the continuous improvement branch and the logistics branch. The first one focuses on strategic methods for improving organizational constraints (Goldratt, 2004). The logistics branch focuses on operational methods. We relate this to the elements discussed in our bottleneck analysis. The three elements, people, process, and equipment can be analysed in parts but in the end, it is concluded that the process bottlenecks are a consequence of the people. Likewise, the equipment bottleneck follows from the inefficiencies in the process.

Critical path analysis

The analysis and assessment of process performance can involve exploring cycle time. The critical path analysis is a method for measuring and computing the lead time of all preceding activities forming a process (Chanas & Zielinski, 2001). This method is also used to determine the longest path of activities for completion of the total process. Checking the dependency of activities helps to locate the critical path. This is the reason why we set out the timelines in Figure 11 and Figure 12. The delay of a critical activity will delay process completion. Cutting lead or cycle time in the critical path leads to process improvement.


Critical success factors

Improving process performance requires the assessment of efficiency and effectivity in the process combined with setting a future goal. Critical success factors determine the organizational areas required for the organization to reach its goals (Achang, Shebab, Roy, & Nelder, 2006). Organizational success factors should be set at the managerial level. In my research this is the desired situation of the company, we discuss what they want to see in the future. When that situation is being implemented it can be compared with the zero-performance we set before.

3.2 Quotation process

The quotation process at Galvano involves several organizational units and tends to be time and resource consuming. Standard quotations do not take up too much time and resources. However, complex, and detailed quotations take up quite some time and resources. With the low quotation-to-order ratio many resources were spent that were never efficient.

Therefore, it is desirable to change the process improving efficiency. In the first phases of contact with the customers the quotations should be consuming little time and few resources to quickly get a first quotation (Hvam, Pape, & Nielsen, 2006). Only when the customer tends to place the order, the detailed more complex quotation should be set up. Here the new calculation comes in, this creates the possibility to compute a cost price quickly and effectively.

In Figure 13 below a quotation process is shown which proved to be successful in the book 'Computers in Industry' (Grabot, 2018). 

[REDACTED]

[REDACTED]

Figure 13: General quotation process.

4. Solution design

For the solution design a lot of general ideas came up while interviewing stakeholders in the quotation process. During my research we experimented with 3 different possible solutions for the core problem. In this section we discuss two alternatives, the final solution is discussed in the next chapter. The first alternative is a CPQ system, such a system intends to make the process from request to quote uniform in one application. One program was sampled to find out how useful it would be at this stage for Galvano Hengelo. The second alternative is a CAD system. The reason why this idea came up is that most customers have technical drawings of their requested product, like the one shown in Figure 14, and CAD can read different types of files and analyse them.

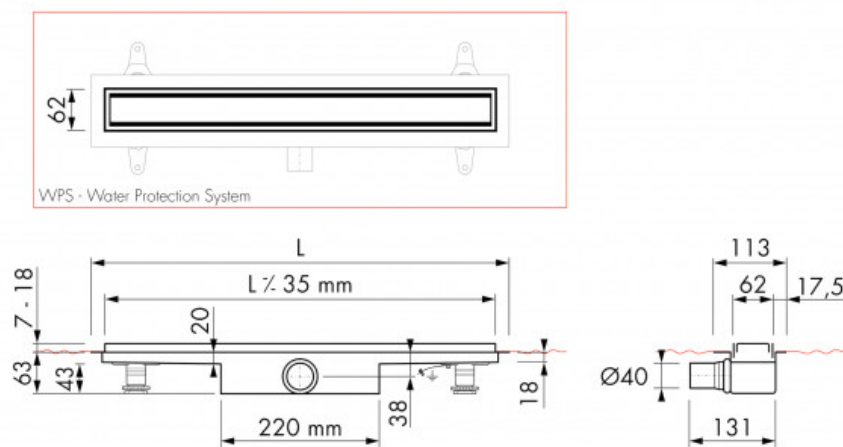
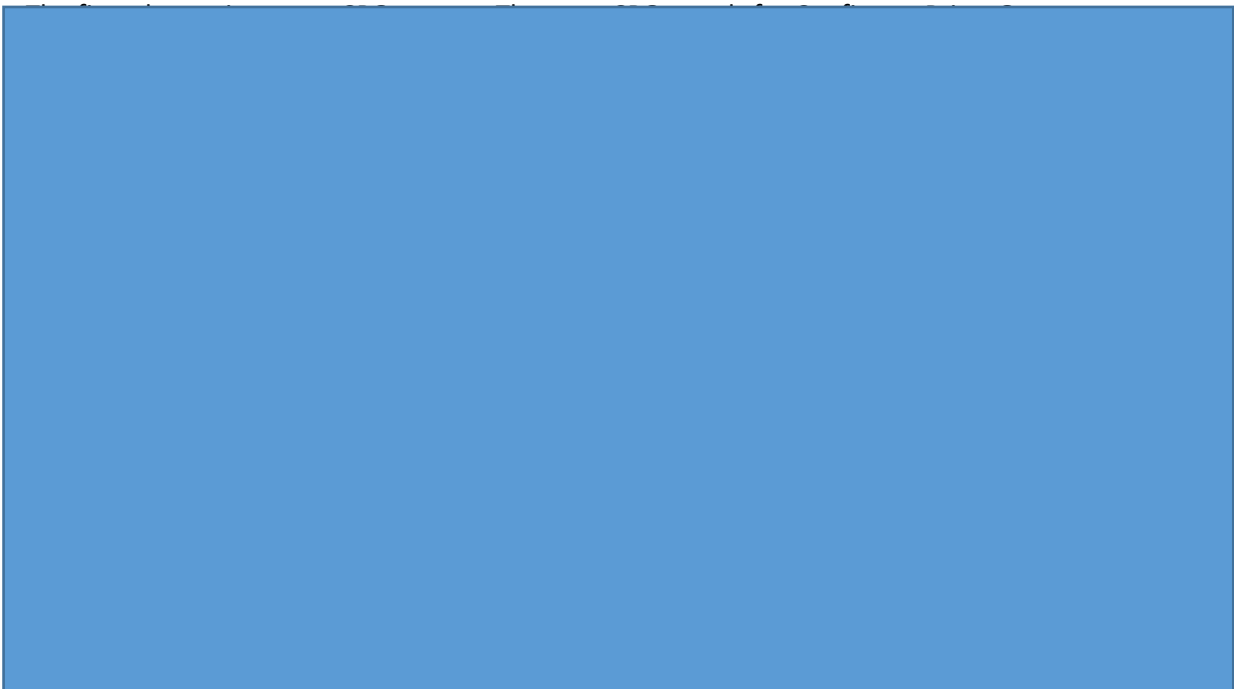
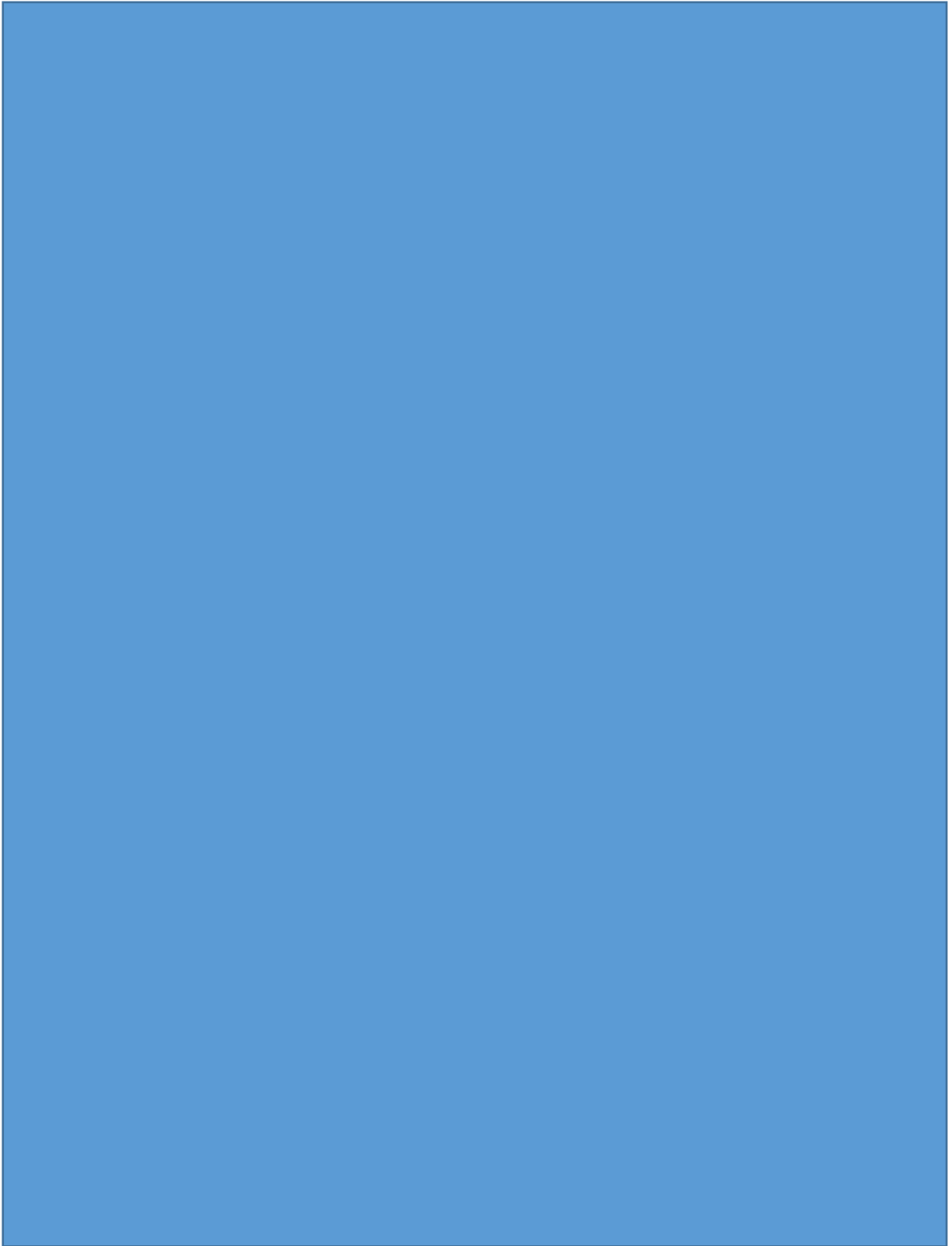
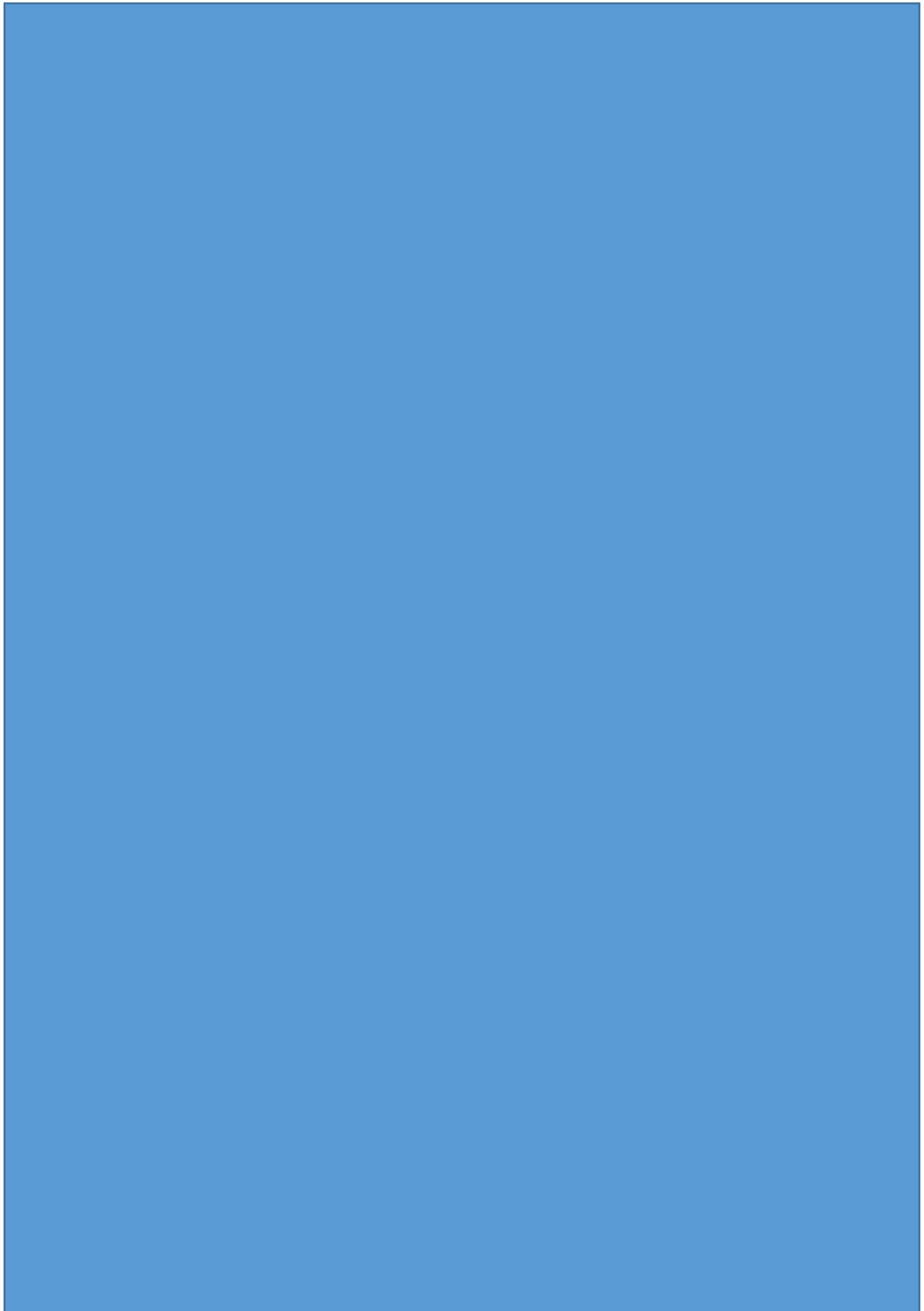


Figure 14: Technical drawing.

4.1 CPQ







4.2 CAD system with STEP files

It was unknown in advance whether Galvano Hengelo's customers are in possession of technical drawings. Based on a survey in telephone conversations, it has emerged that in general all customers have the possibility of exporting their drawings in the requested format. Most customers have their technical drawings in STEP files. A CAD system is capable of reading and analysing these files. The intention of possibly using such a system is that the employees no longer read the drawings of the product and find all parameters, but instead the program provides the parameters within seconds (Liu, Yang, & Zhou, 2018).

4.2.1 CAD systems

CAD was originally written out in full as Computer-Aided Drafting. Today CAD is translated as Computer-Aided Design. Computer-Aided Design is translated with the description: making drawings and designs by using computers.

There is a wide variety of CAD programs on the market for consumers and technical companies. In addition to the specific technical fields for which CAD programs have been developed, a distinction is also made in the dimension of these programs. For example, there are 2D, 2½D and 3-dimensional systems. The 2D systems are suitable for making technical drawings. By means of these 2D systems drawings can be made with different views. An example of a well-known 2D CAD system is AutoCAD LT 2014, which is a simplified version of AutoCAD and is also called AutoCAD Light.

The 2½D systems have been enhanced with depth. CAD-CAM systems can be used for this. CAD (Computer-Aided Design) is associated with CAM (Computer Aided Manufacturing). The CAM package of a machine can be used for loading CAD files and designs. This information is used by the machine to manufacture the product shown in the CAD file, which is why it is also called Computer Aided Manufacturing.

CAD 3D systems are used to create 3 dimensional drawings. This can be addressed in various technical fields. For example, machines can be drawn in 3D CAD systems, but also buildings and other objects. Within 3D systems, surface models, volume models, solid models and wire models are used.

4.2.2 Step file

A STEP file is a widely used file format to exchange a product or design between different 3D programs. The name is an abbreviation of “Standard for the Exchange of Product model data” and the structure of the file is laid down in ISO 10303-21.

Many manufacturers and suppliers who make their articles available in a 3D file choose STEP files. This usually concerns simplified versions of products, in order not to disclose their exact design and to keep the STEP files as small as possible.

The most used technical drawing programs export 3D models to a STEP (.stp or .step) file. They can also import such a file and convert it to their own file format.



[REDACTED]

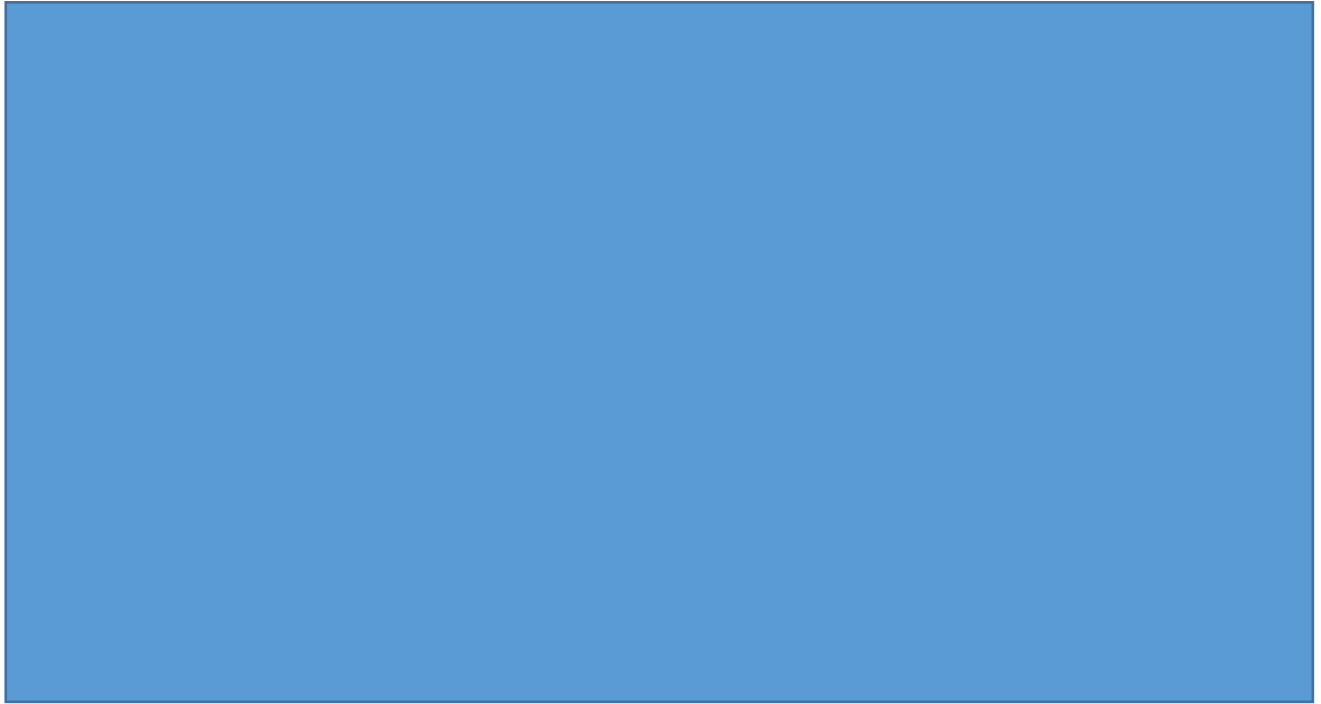


Figure 16: CAD-system.

Galvano decided not to proceed in working out this alternative. The reason behind this is that it is quite expensive to acquire software like the one shown in Figure 16 and it is a too big step from the process as it is currently. [REDACTED]

[REDACTED]

5. Solution tests

We decided that the first step in automating the quotation process is to document all calculation considerations such that the number of products per charge can be found without knowledge and experience of the calculations.

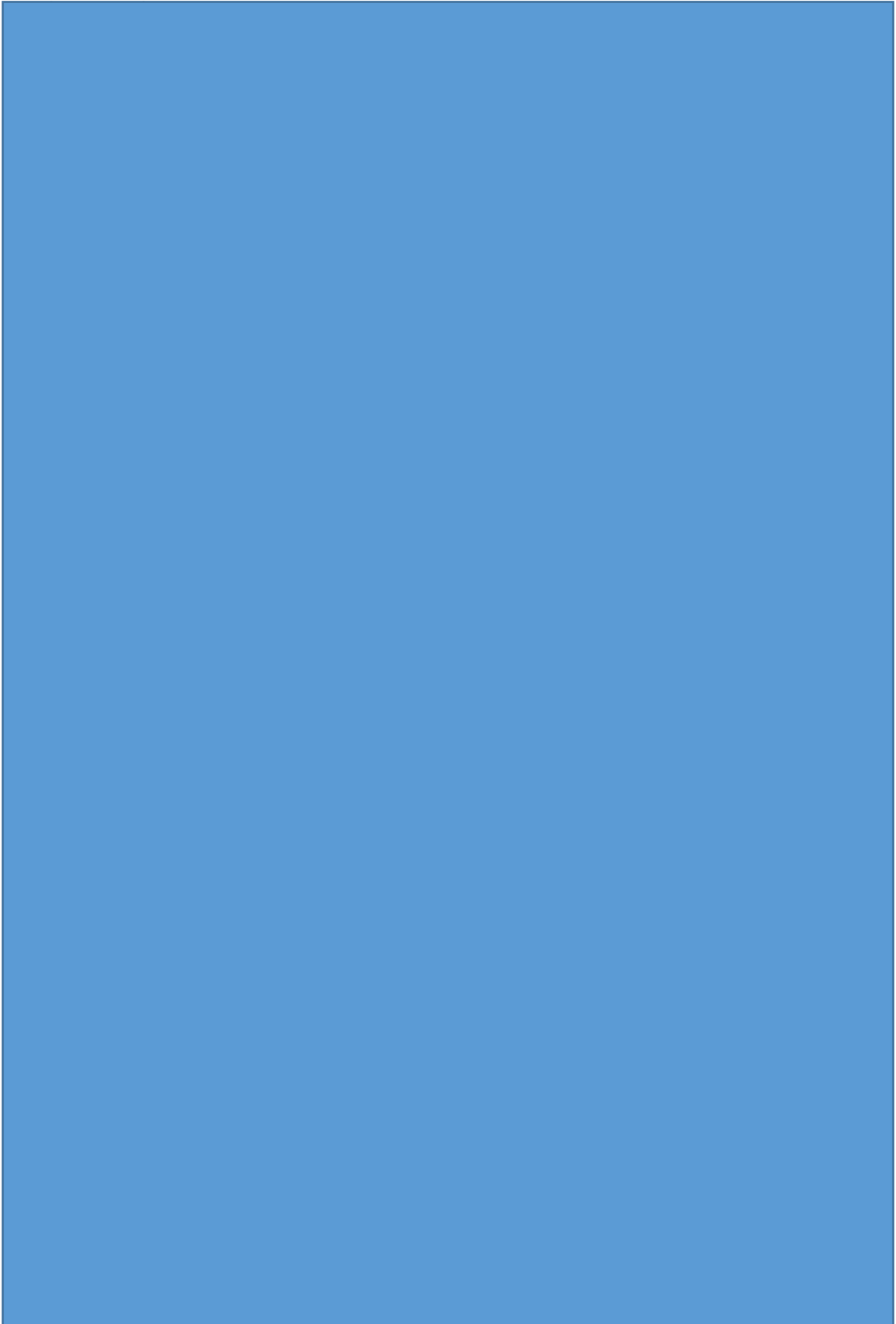
Speaking to the planner and the company director, we came up with the idea to build a calculation tool of our own in Excel. This is preferred to another type of dashboard because the employees are already familiar with Microsoft Office. We decided that the calculation tool must be customizable during the implementation such that new product shapes or findings in calculations can be added without having to learn another coding language. In the first instance, the Excel file was created based on the dimensions of a product to calculate the number of products per batch. These parameters are important for making the calculation in MKG. The Excel file calculates the full price based on the processing price, the material price (based on surface of the product) and the starting price.

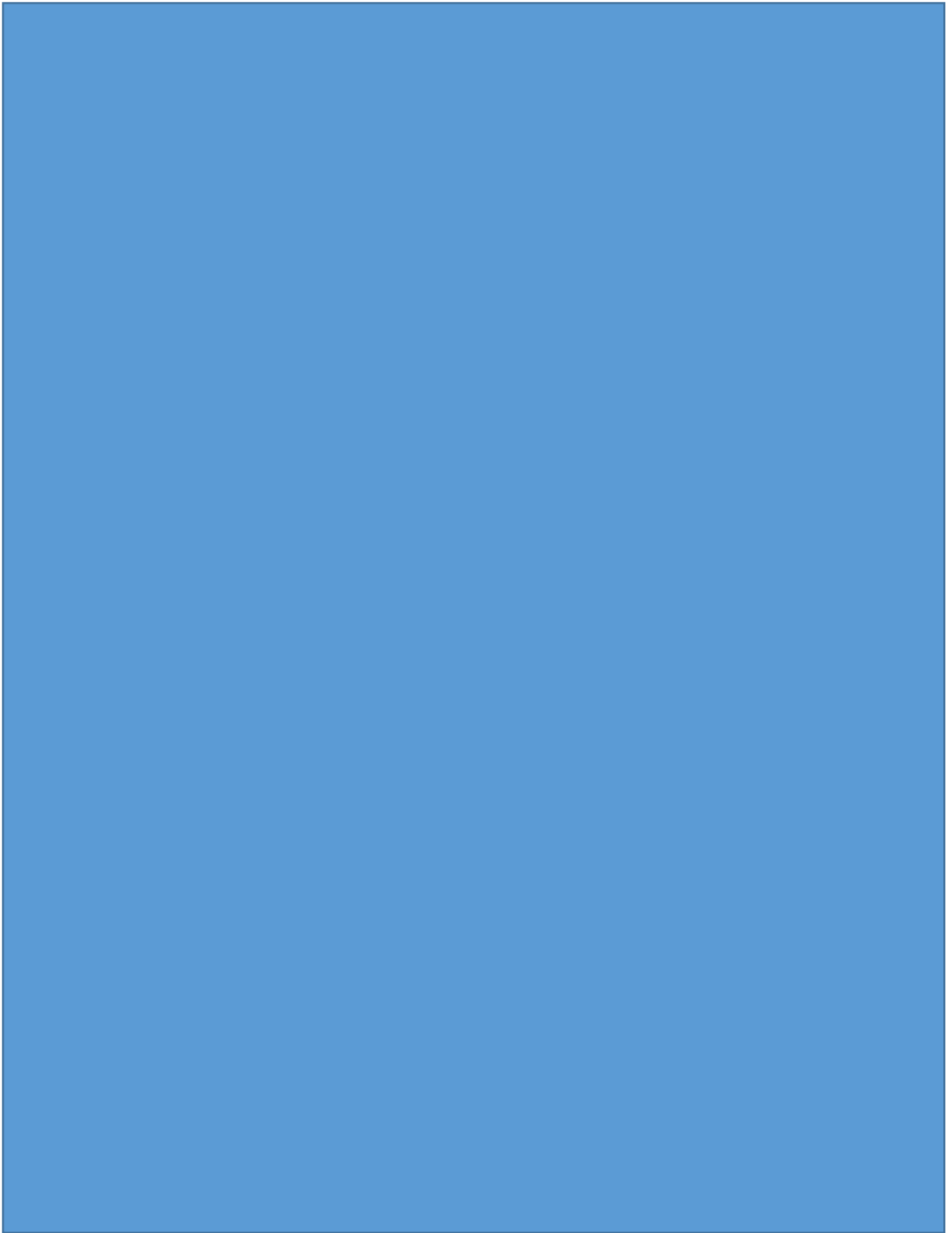
All calculations are based on information given in the technical drawings of the products and on the research done based on historical calculations by the planner. The outcomes of the calculations of the planner are found on the orders that are documented in Galvano's database. The main task in this was to find the number of products that can go into the galvanizing machine per operation based on the dimensions of the products and the type of operation.

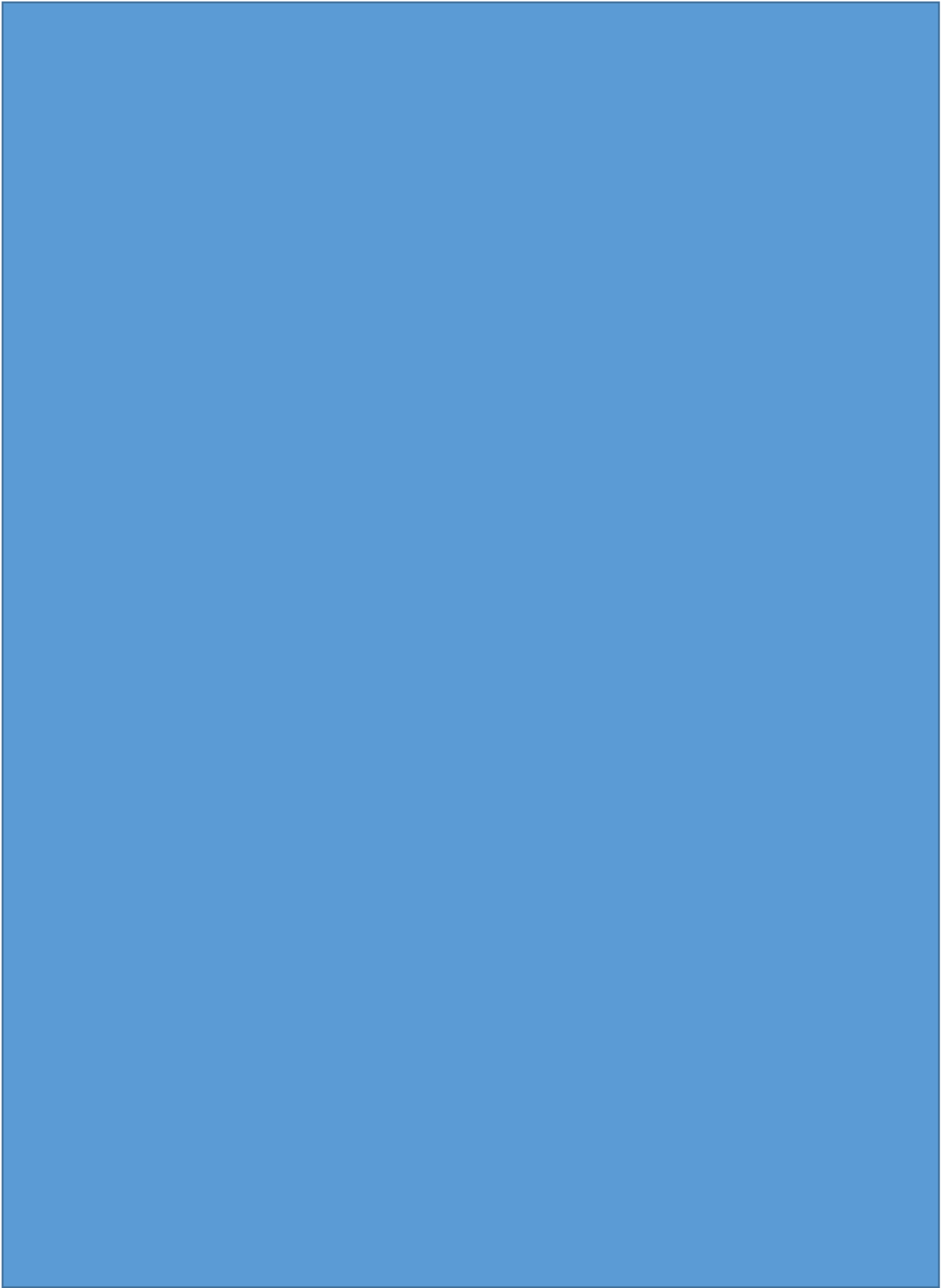
The company gave me the task to make the number of products per operation uniform. In the past it occurred several times that the exact same products with the exact same operation were requested months apart and the calculation had to be done again due to the lack of documentation. In these situations, it happened several times that the outcome of the calculations differed. Doing the calculations for a second time makes it inefficient work but getting to different outcomes makes it ineffective as well. Documenting all calculation considerations gives uniform outcomes whenever the calculations are done. By doing so, the planner does not have to do the same calculations time after time. If the right numbers are found, I thought it would be a logical step to write a code in excel that does the calculations.

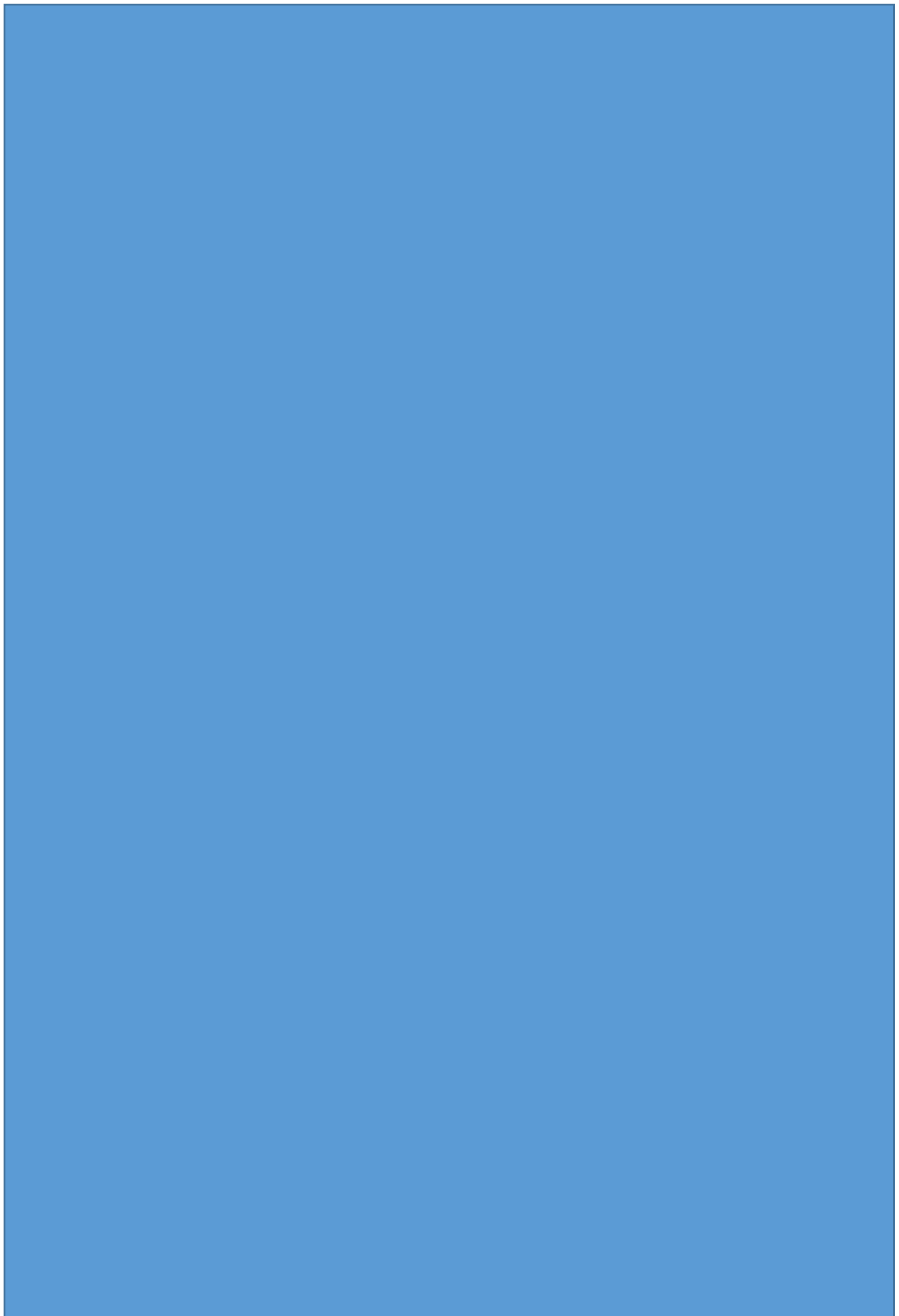
[REDACTED]

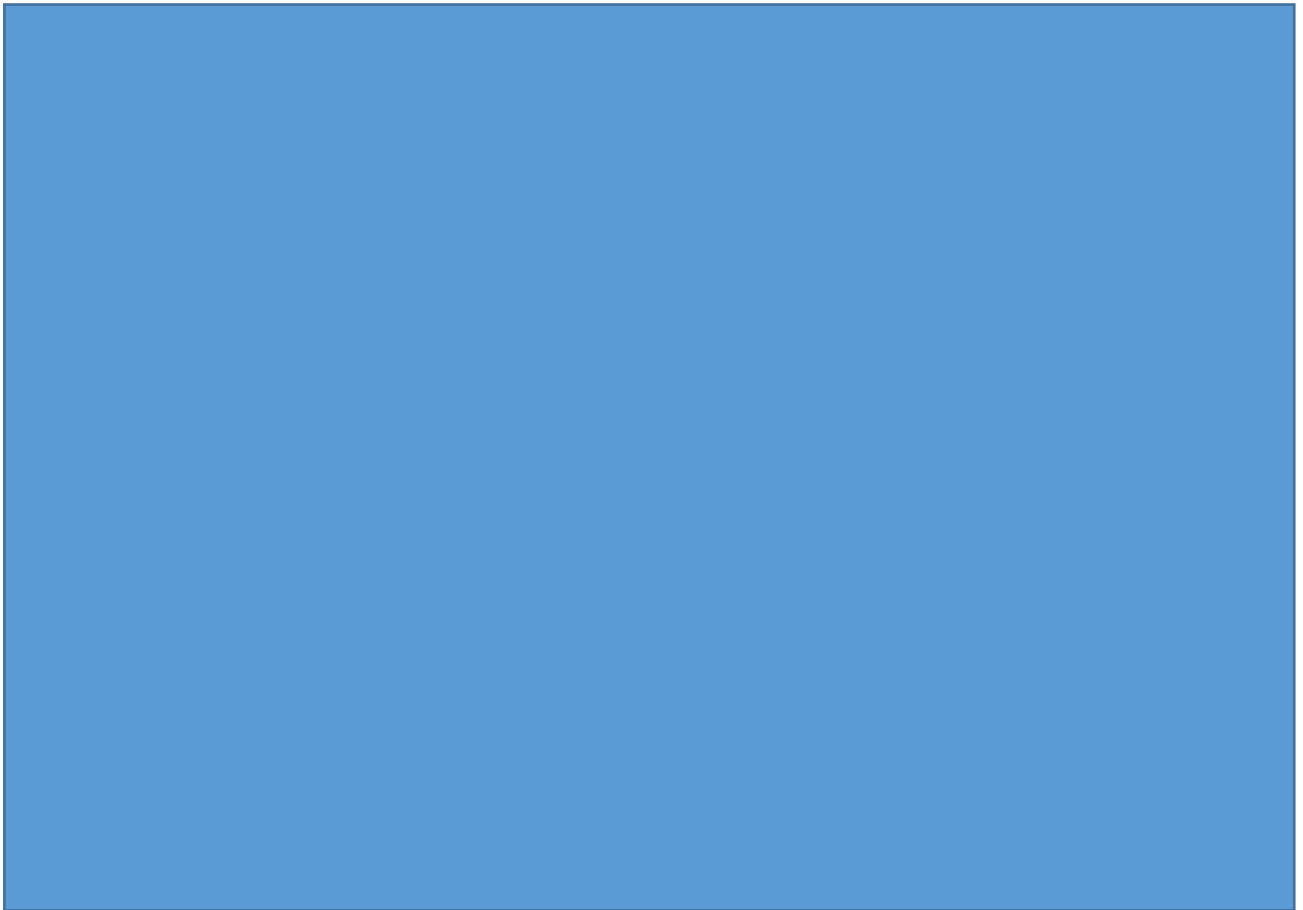
5.1 Explanation calculator

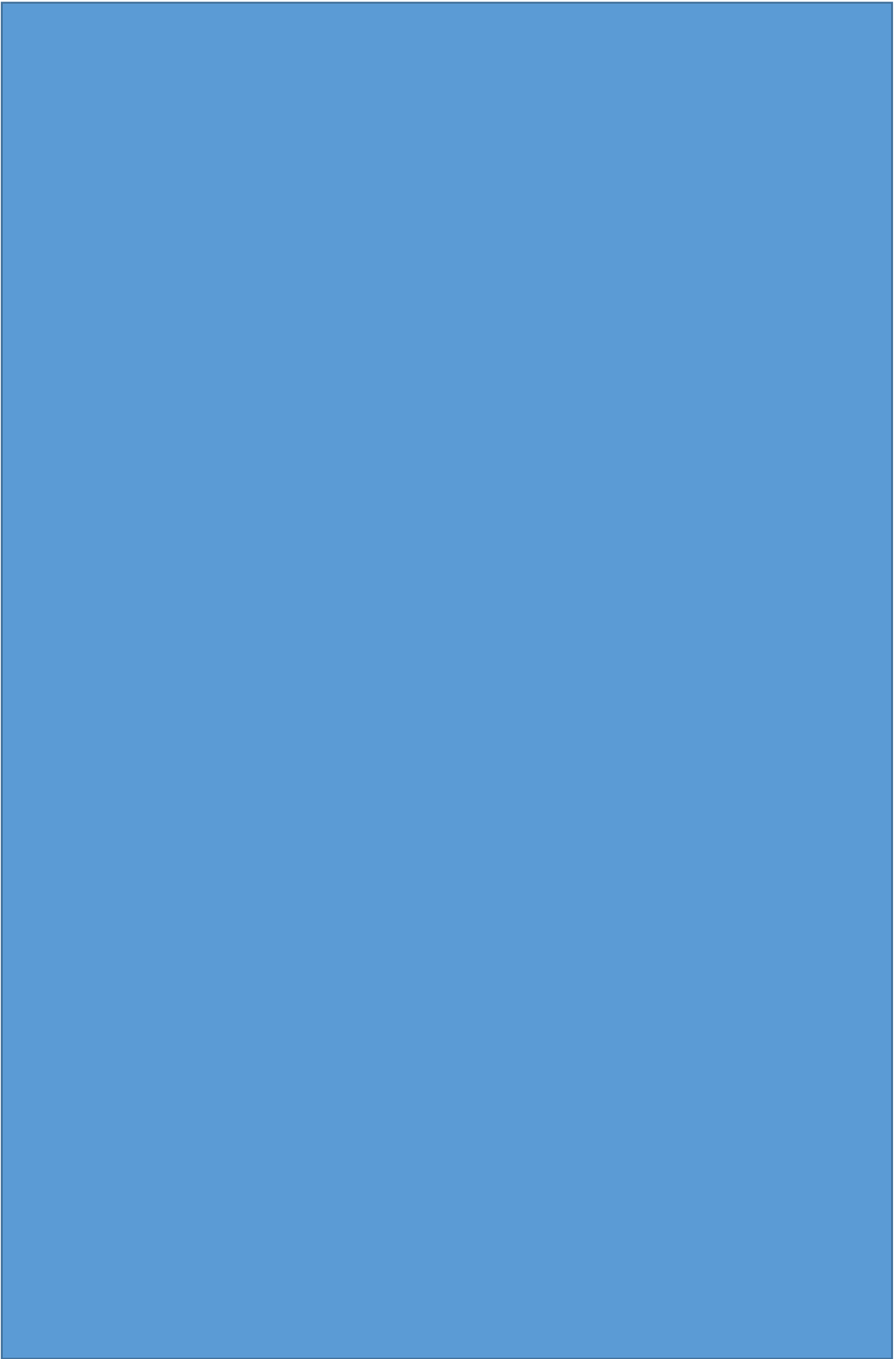


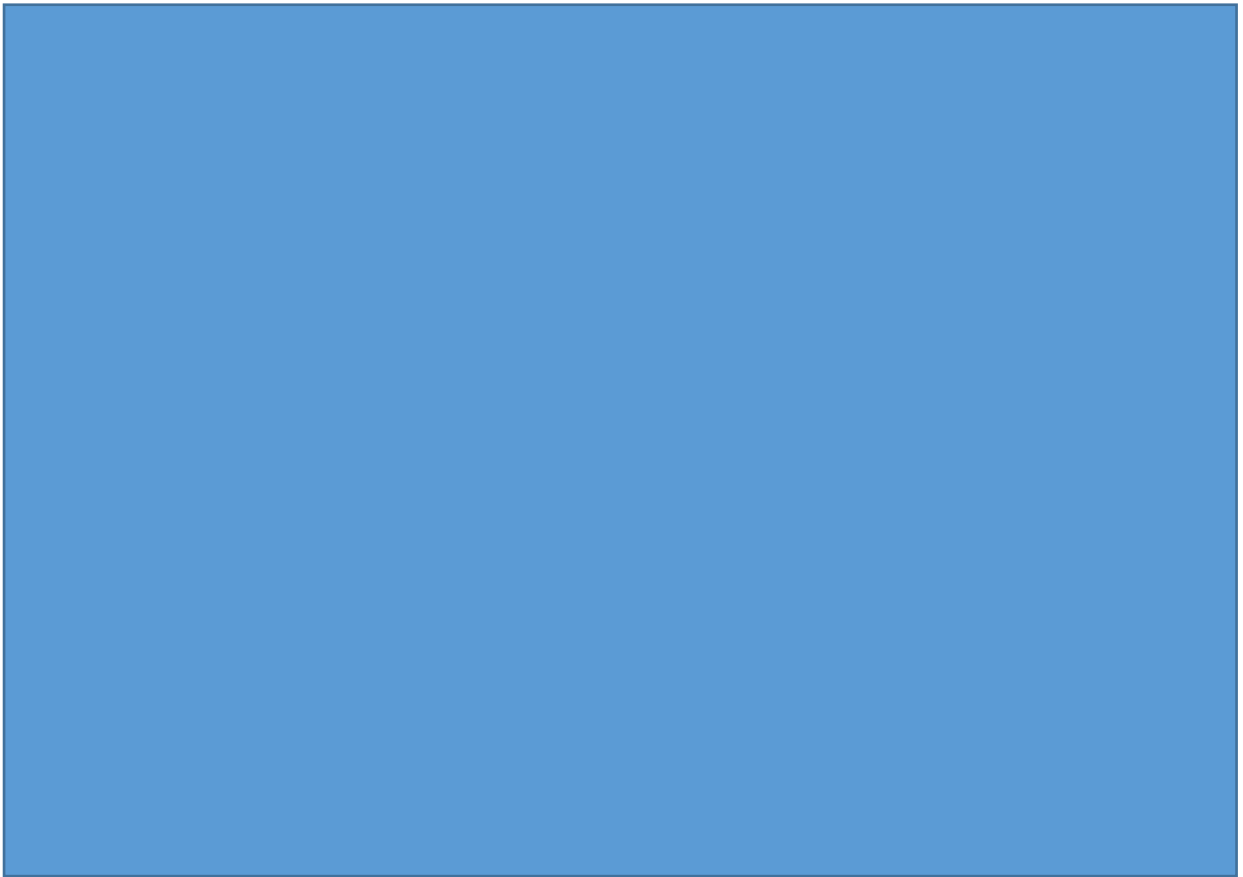




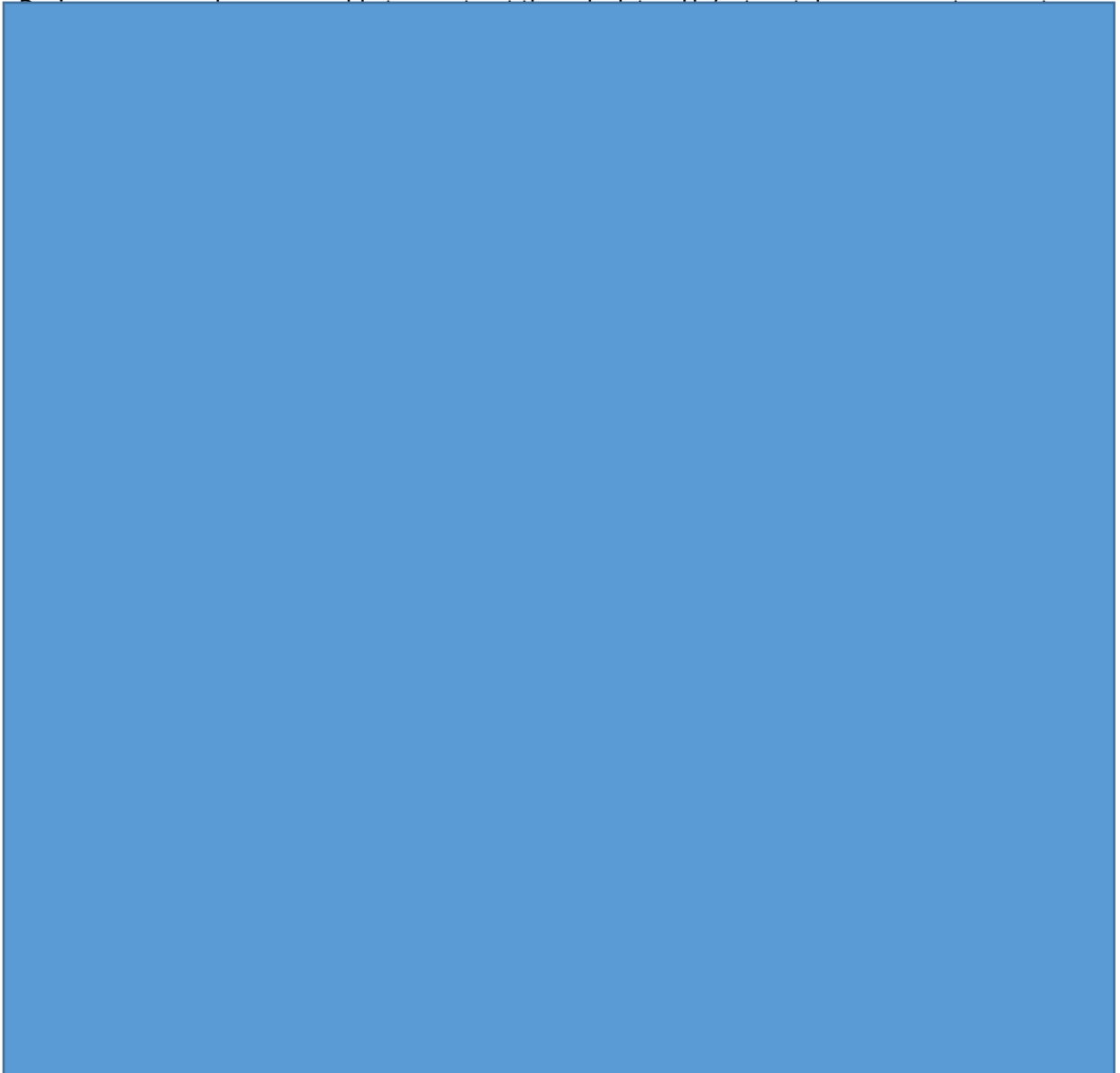








6. Advisory report



7. Conclusions and discussion

7.1 Conclusions

This chapter provides an overview of the research done with considering whether we found a solution to our research problem. The problem is set out in different components and discussed whether the intended goal is achieved for each component. My research was based on answering the following main problem:

The company encountered that the planner needs to be unburdened from the quotation work. Consequently, the main problem of an ineffective and inefficient CPQ was found. The solution to this is set out in the following components which can be checked to whether the goal is achieved.

The current process

We describe the situation as it currently is concerning the quotation process. [REDACTED]

[REDACTED]

The bottlenecks

To determine the bottlenecks in the process, we use the three constraints named by Sill (2006). People, process, and equipment are the three that identify the point of improvement. The first one tells us that more employees need to be trained to unburden the planner, since he is the only one with the right knowledge to execute quotation calculations. It is difficult to pass on 30 years of knowledge and experience, so a combination is to be made between training staff members and simplifying the calculations. The process flow is another bottleneck. **If a constructing quote would just pass through a department once, then the maximum capacity of the system is used. However, due to the specific calculations and lack of documentation it is currently necessary to move the quote back and forth causing two departments to have start up time twice** As a result, the equipment in the process is not used at full potential. Documenting all calculation considerations and training employees to fulfil them gives the opportunity to use the program at a higher rate.

The wishes of the organization

[REDACTED]

[REDACTED]

[REDACTED]

Possible solutions

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Financial and organizational consequences

For the implementation of the new calculator, we have a look at the potential consequences. During my research we considered both the financial and organizational aspect. The use of the new calculator does not have any direct costs, it is designed in Excel and ready for use. If it is used correctly, then the tool will save time in the process which is a benefit. However, the calculator should be expanded in the future of this the costs must be examined. Looking at the organizational consequences, we see that the quotation process is set up differently. The calculator makes it possible, if implemented correctly, to reduce the number of steps in the quotation process such that the quote does not move back to a department anymore.

7.2 Discussion

The main goal of this thesis was to design a calculator for the quotation process where the considerations of the planner are documented. Also, Galvano wanted an overview of the current process from request to quote. For the company it is useful to find where the bottlenecks are and consequently search for improvements.

During my research the intention was to design a calculator for products of all different sizes and shapes. However, after interviewing stakeholders in both the service and operations processes it turned out that for products of special shapes the calculations are very complex. For me it was not possible to turn the considerations of those into a uniform database. The reason behind this was that a lot of shapes were not definable. Fortunately, all standard shapes are available in the calculator and are released to start using. With using a little bit of insight and creativity still the outcomes of a lot of complex products can be computed by the calculator, but the outputs should be double-checked.

Since we needed all the time available to design and work out all aspects of the deliverables, we are not present during the implementation of the calculator. Also, this phase will most probably take years to get the tool ready for a new stage. Since new products keep coming, it is important that during the implementation the calculator keeps getting updated and improved. After this period, Galvano is ready for more automatization in the quotation process.

[REDACTED]

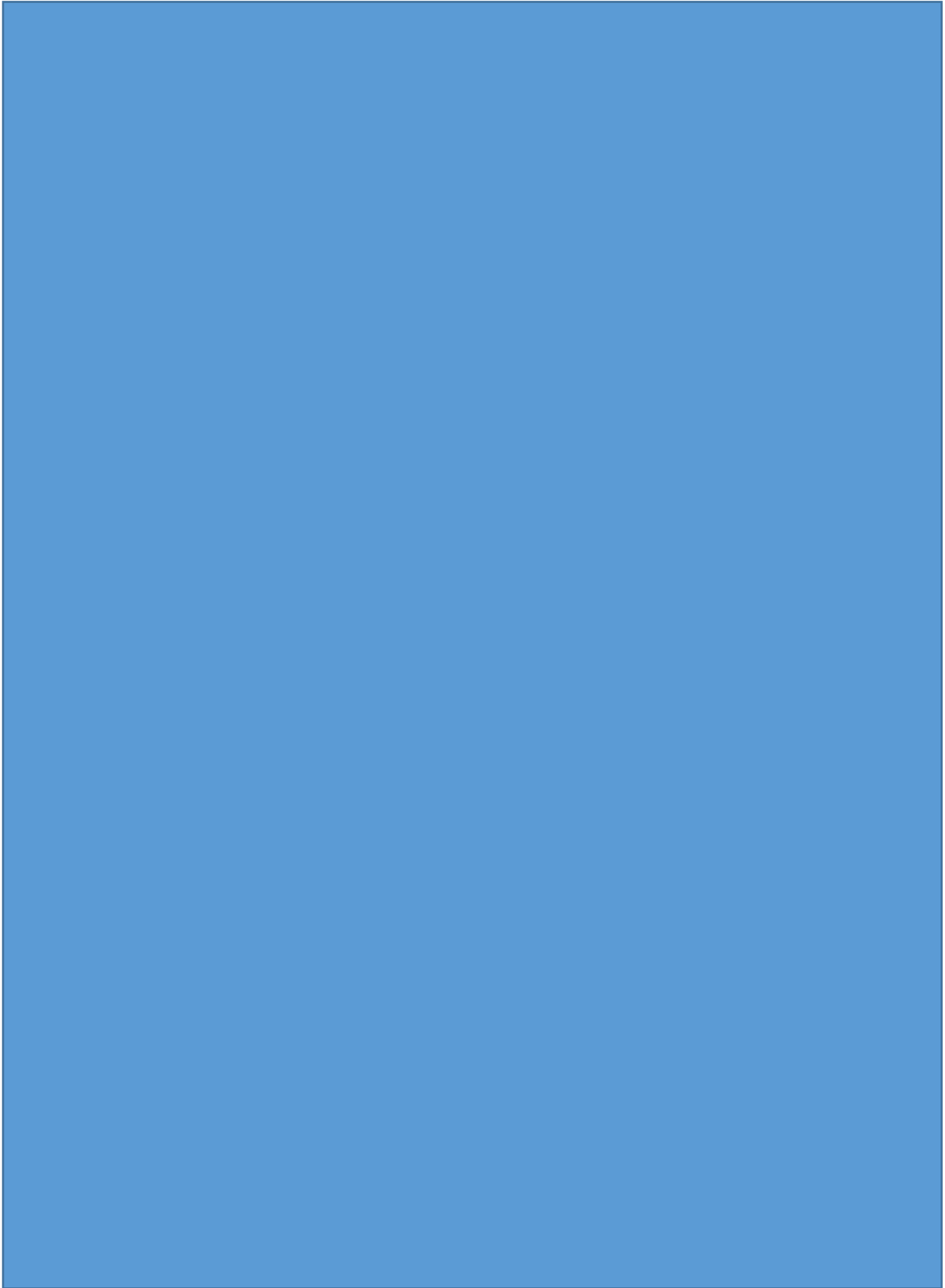
All in all, we are very satisfied with the results that we were able to achieve. During my research, the calculating process has significantly improved in terms of uniformness, and we feel like the company can really find benefits in it. In my time at the company the wishes of the stakeholders in the process kept changing and consequently the calculator needed changes as well. As time passed, the requested changes reduced and those that had to be implemented were less significant. We experienced our time at the company as very pleasant. It was a great learning experience to see the operations within such a company and how all departments are connected. This will benefit us in the future.

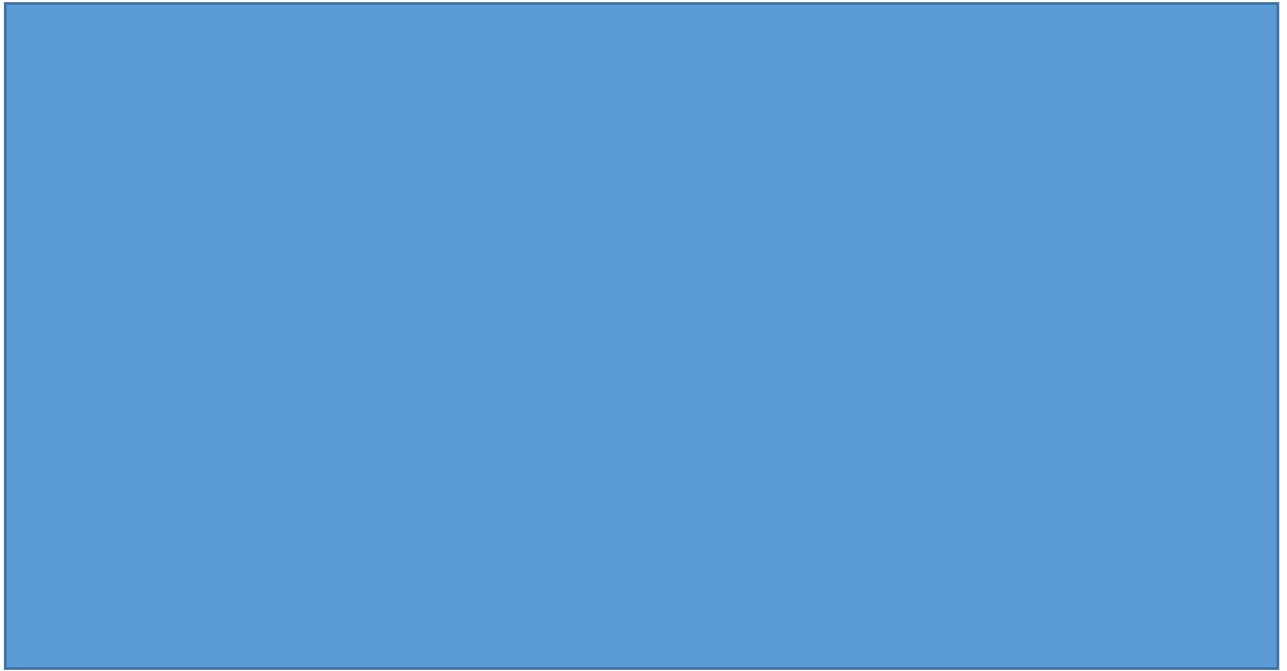
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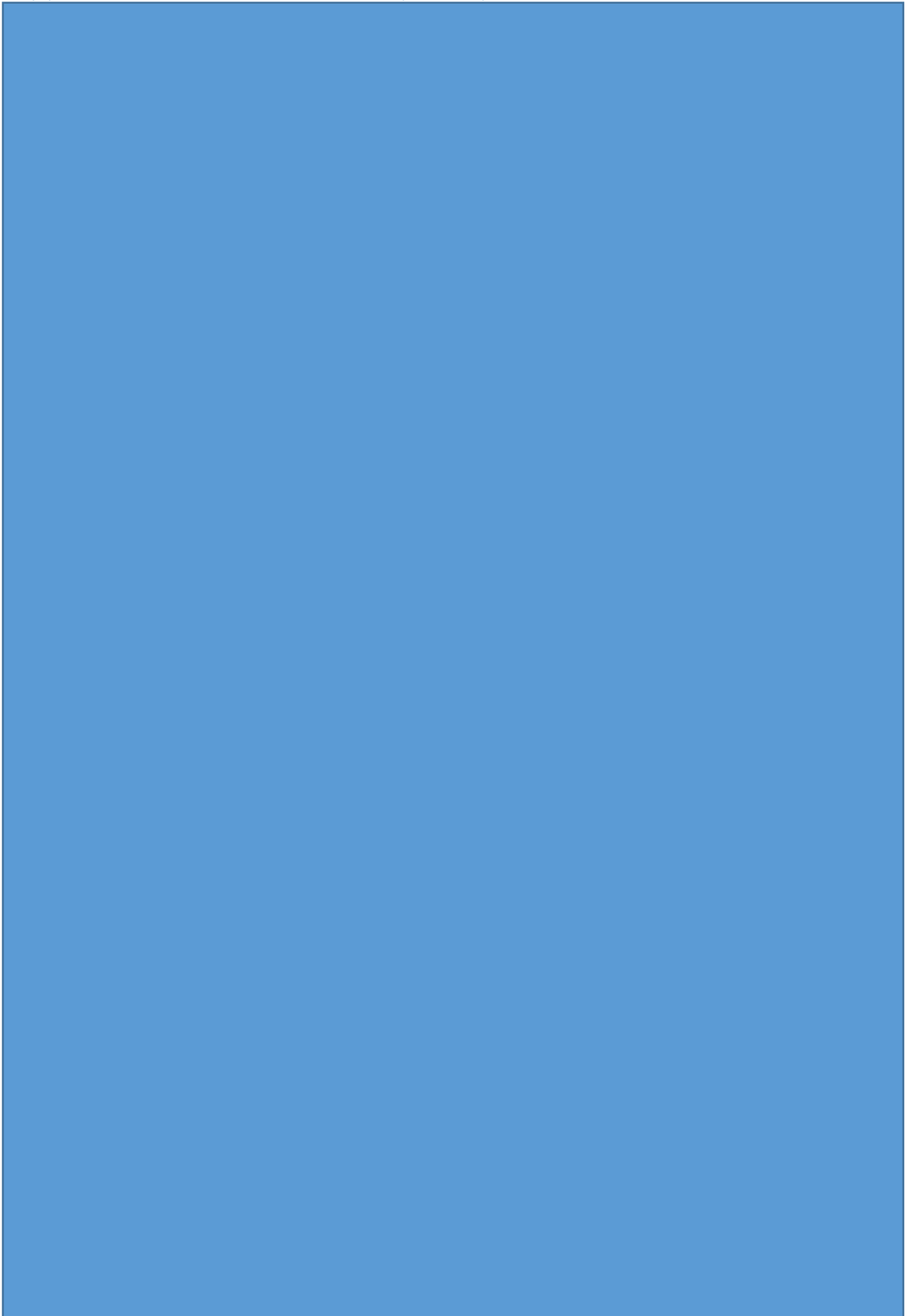
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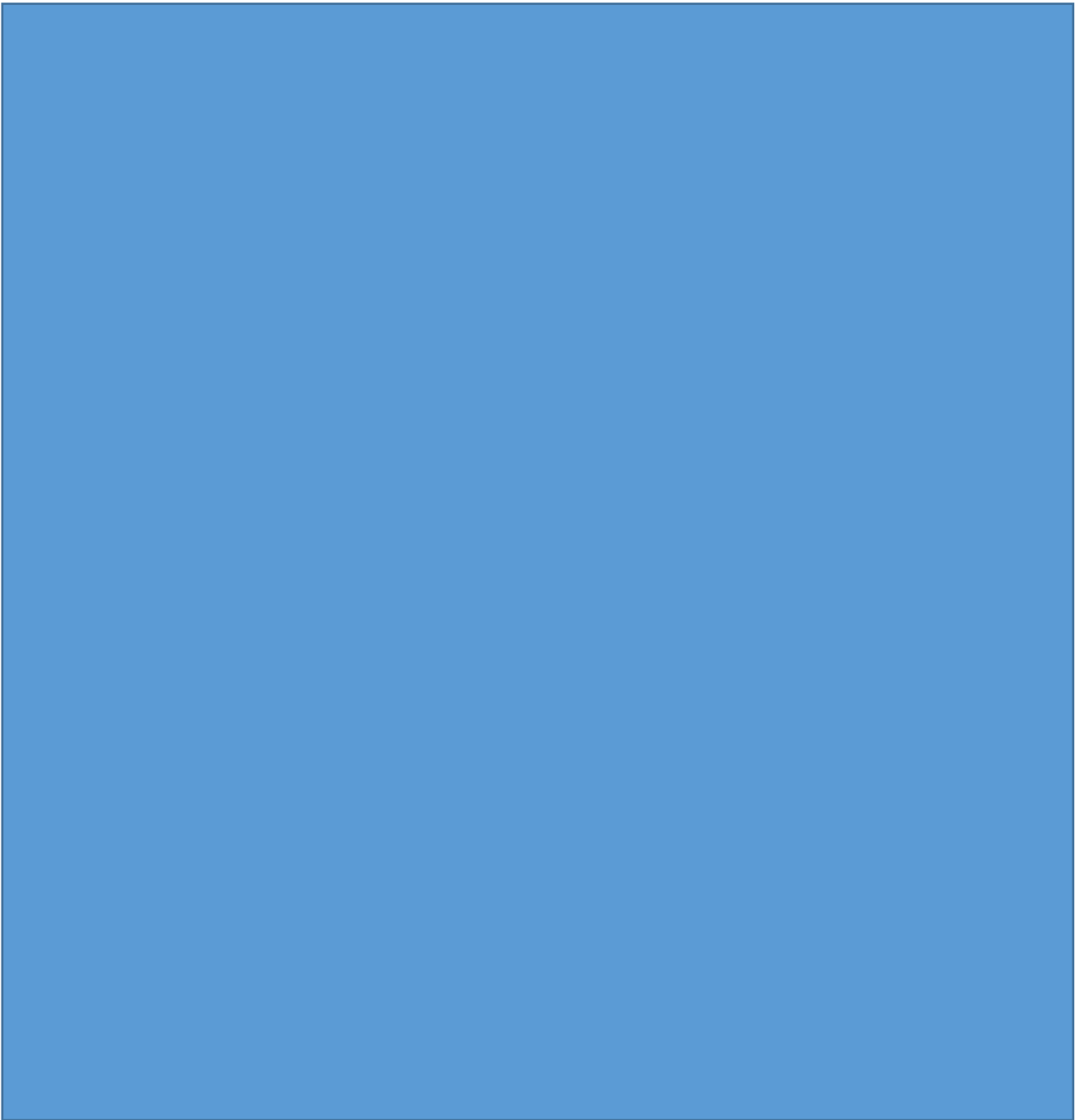
Appendix A: Interviews

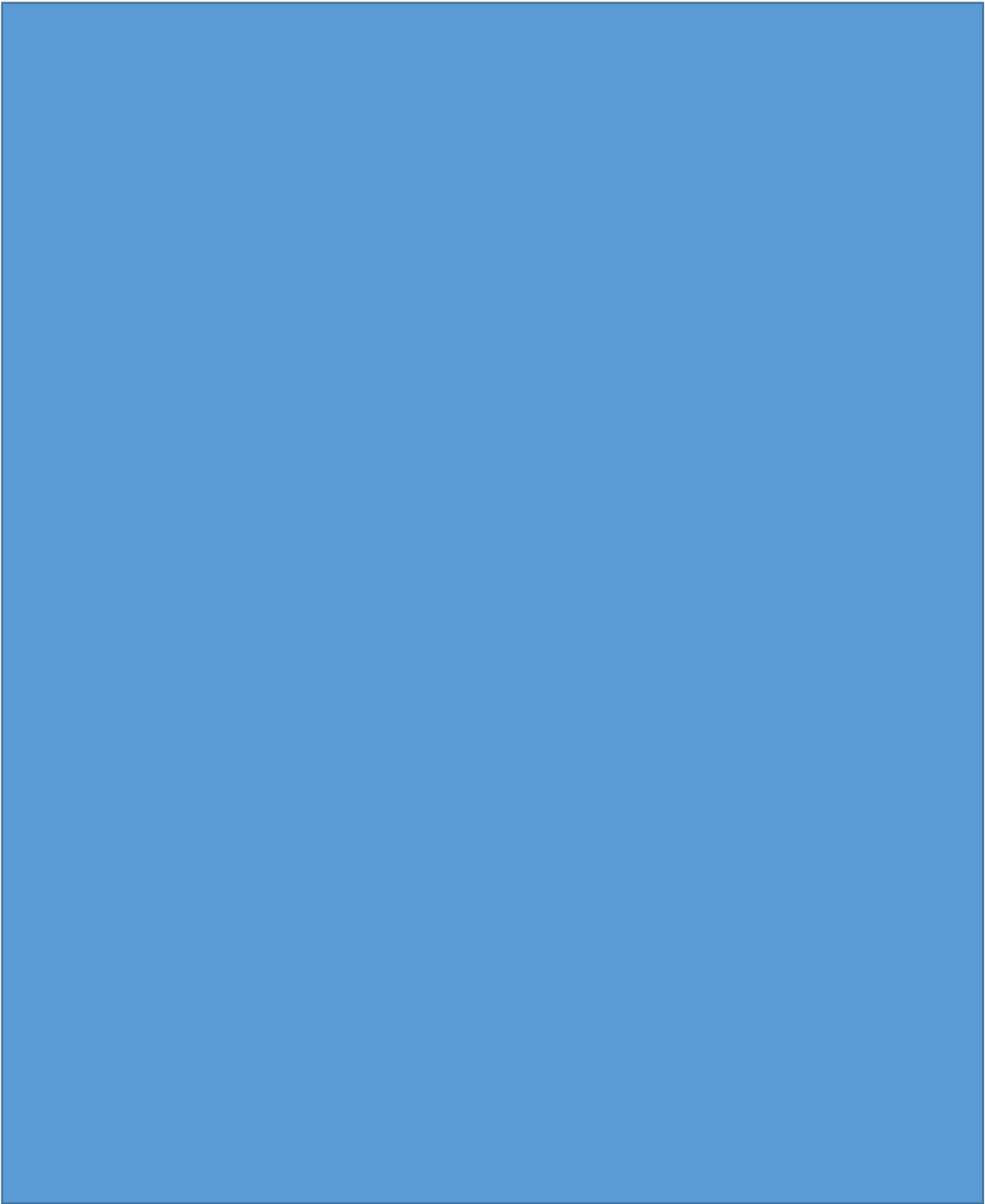




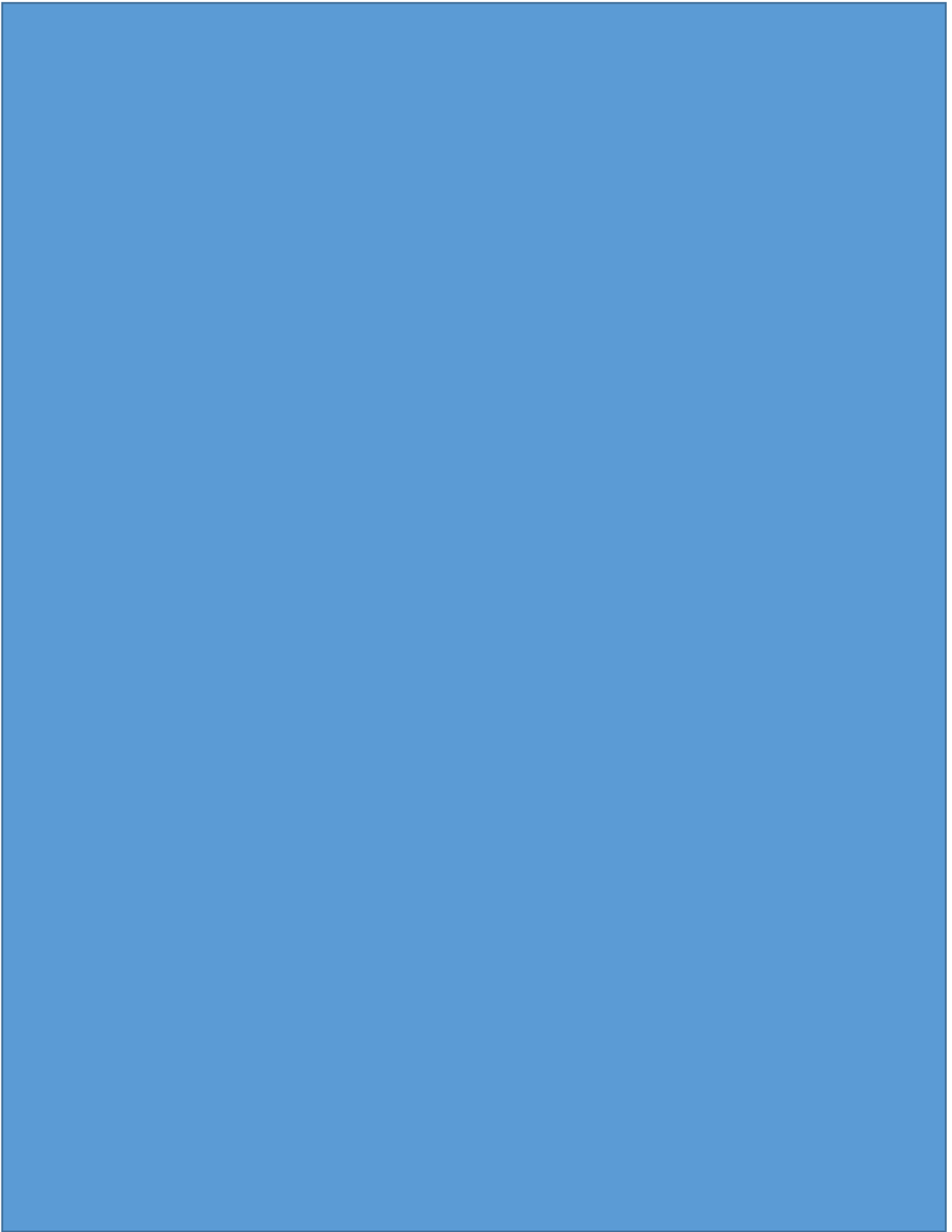
Appendix B: Manual calculator (Dutch)

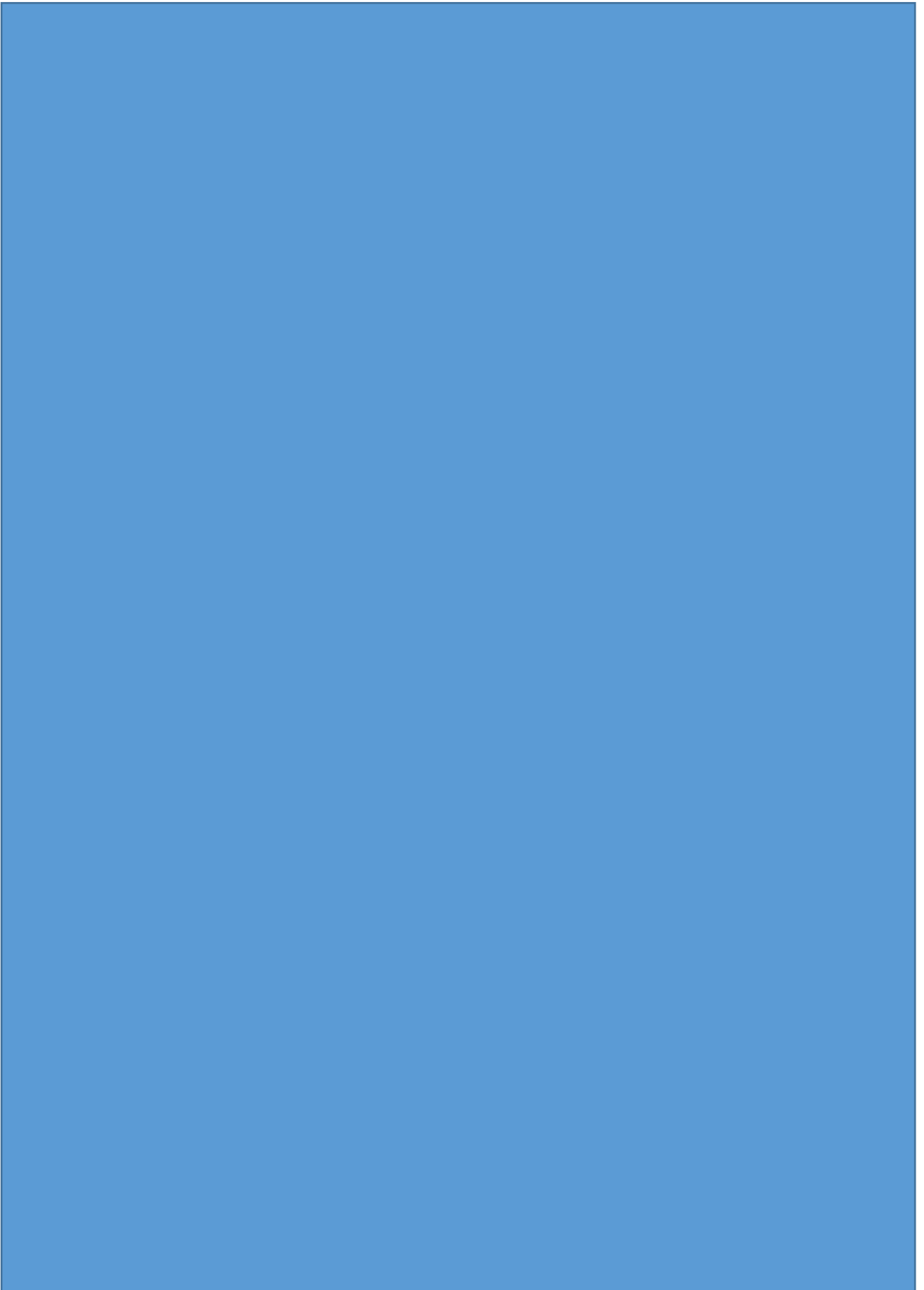


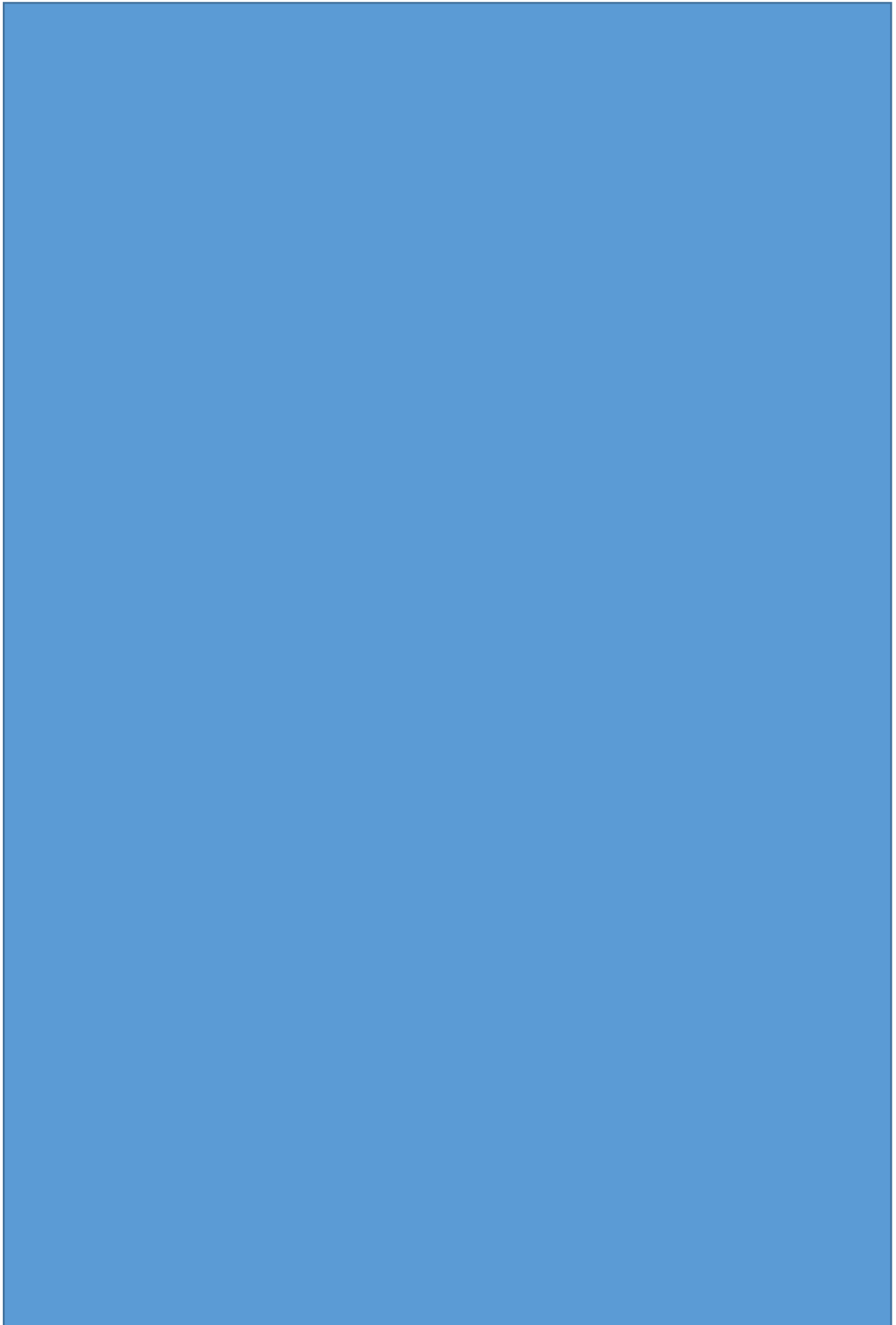


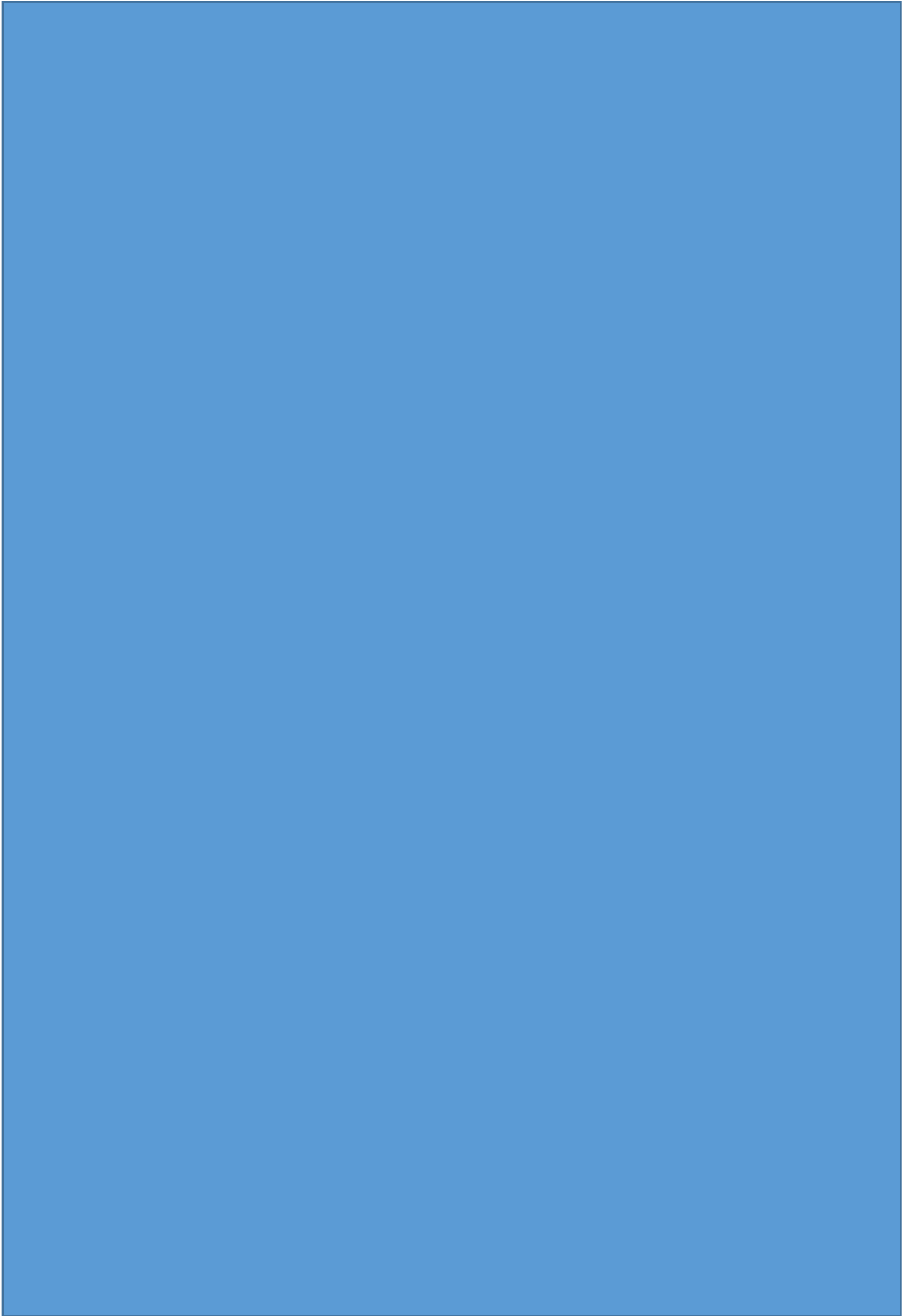








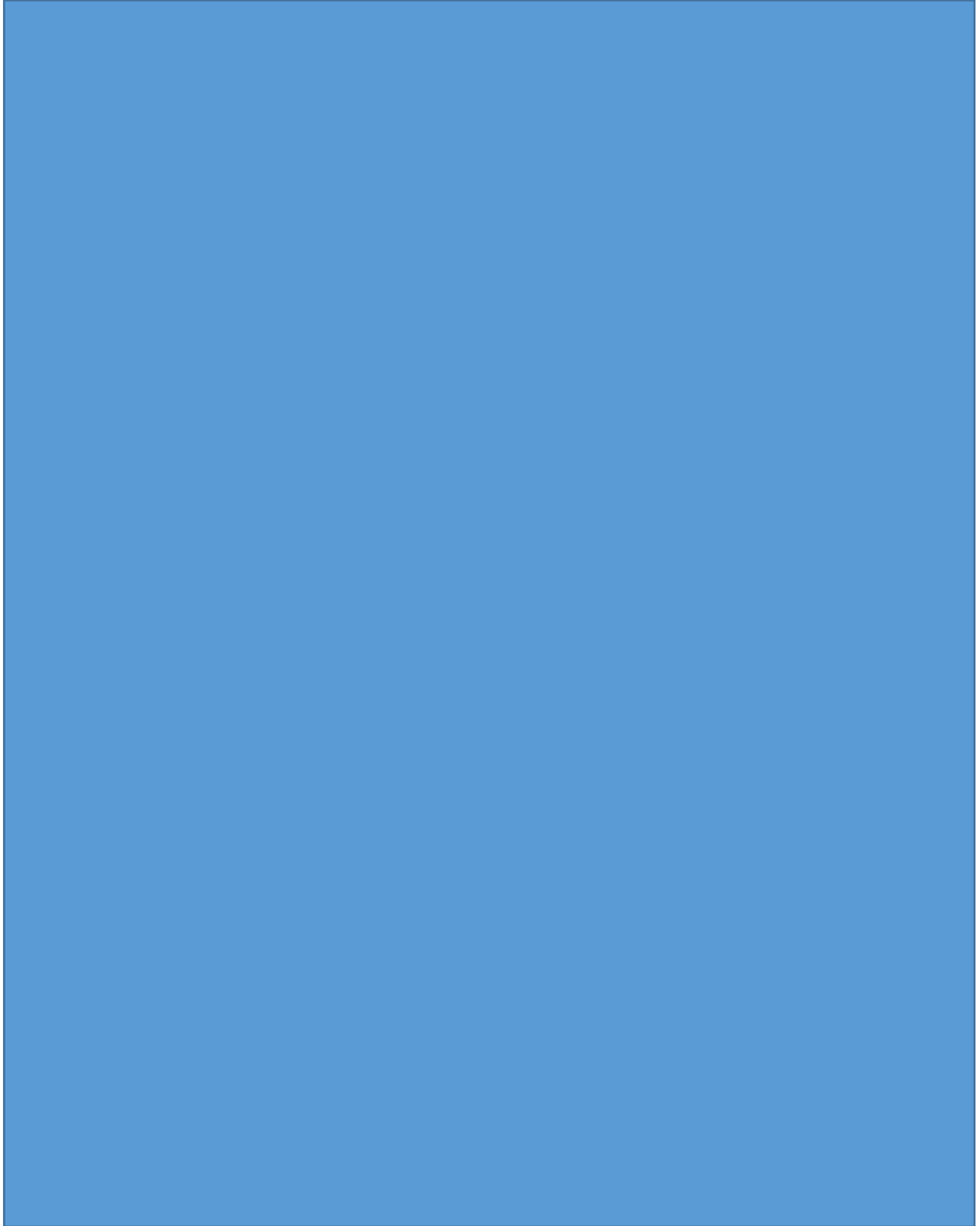


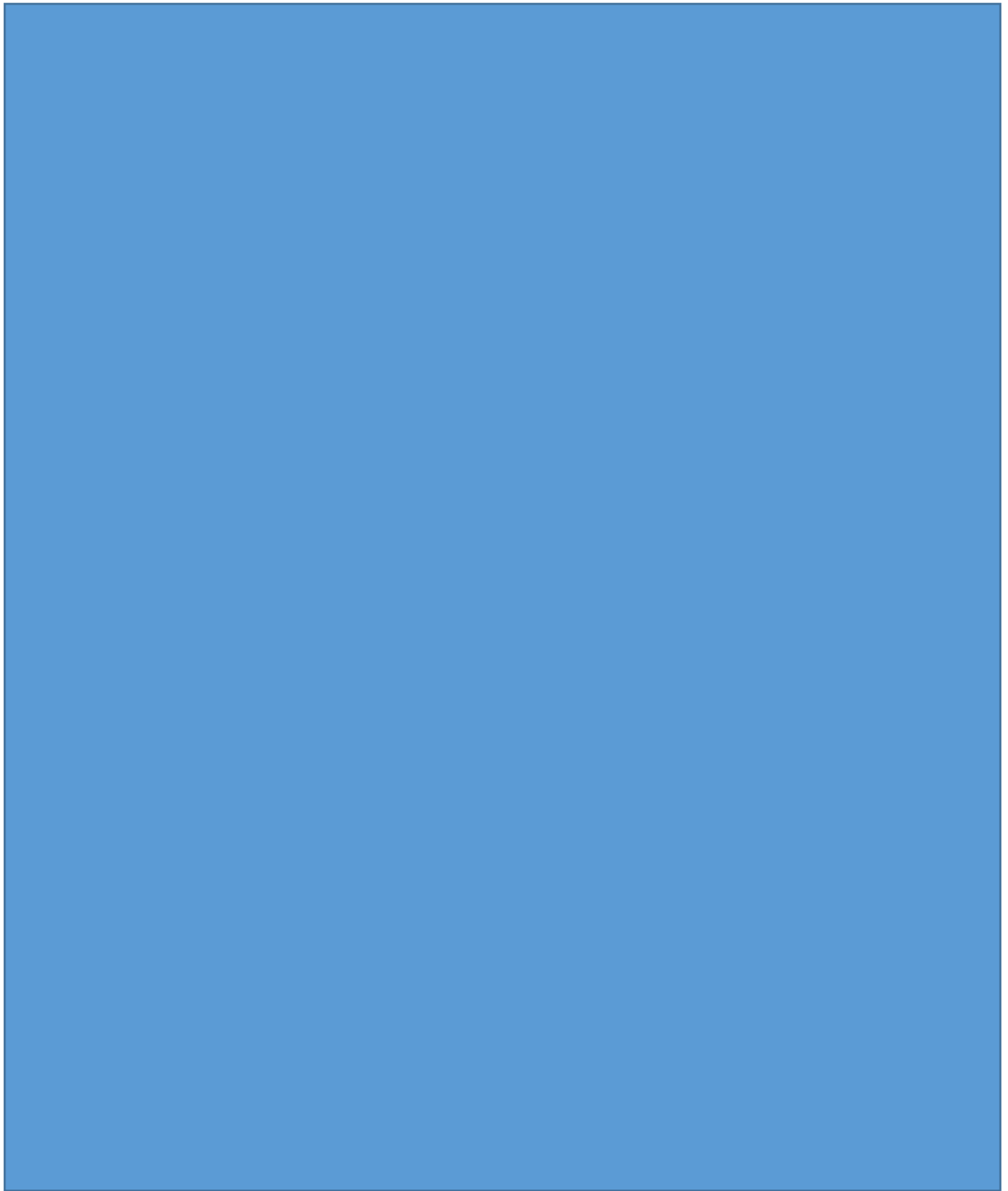




Appendix C: Code

Strip placed vertically

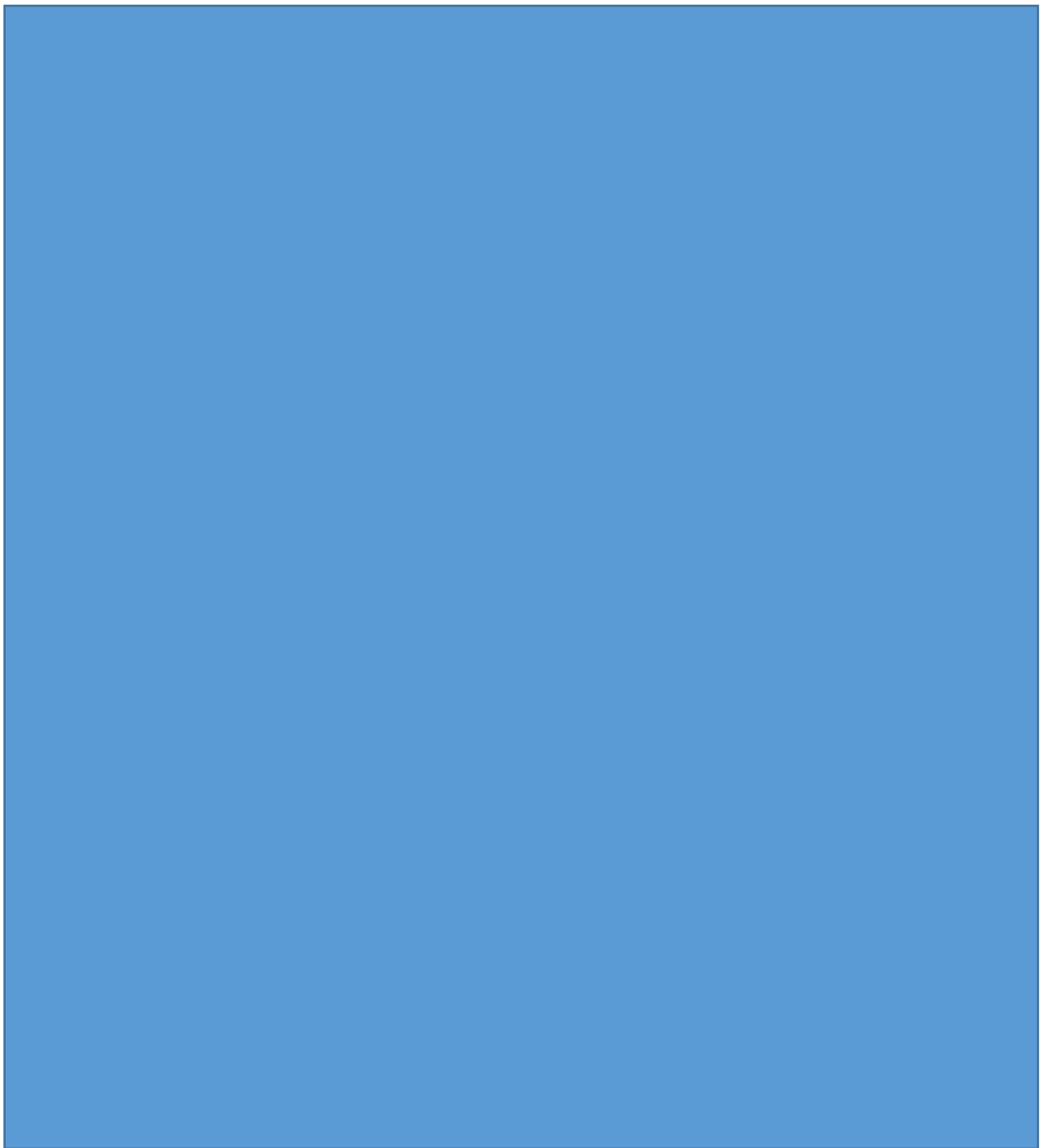


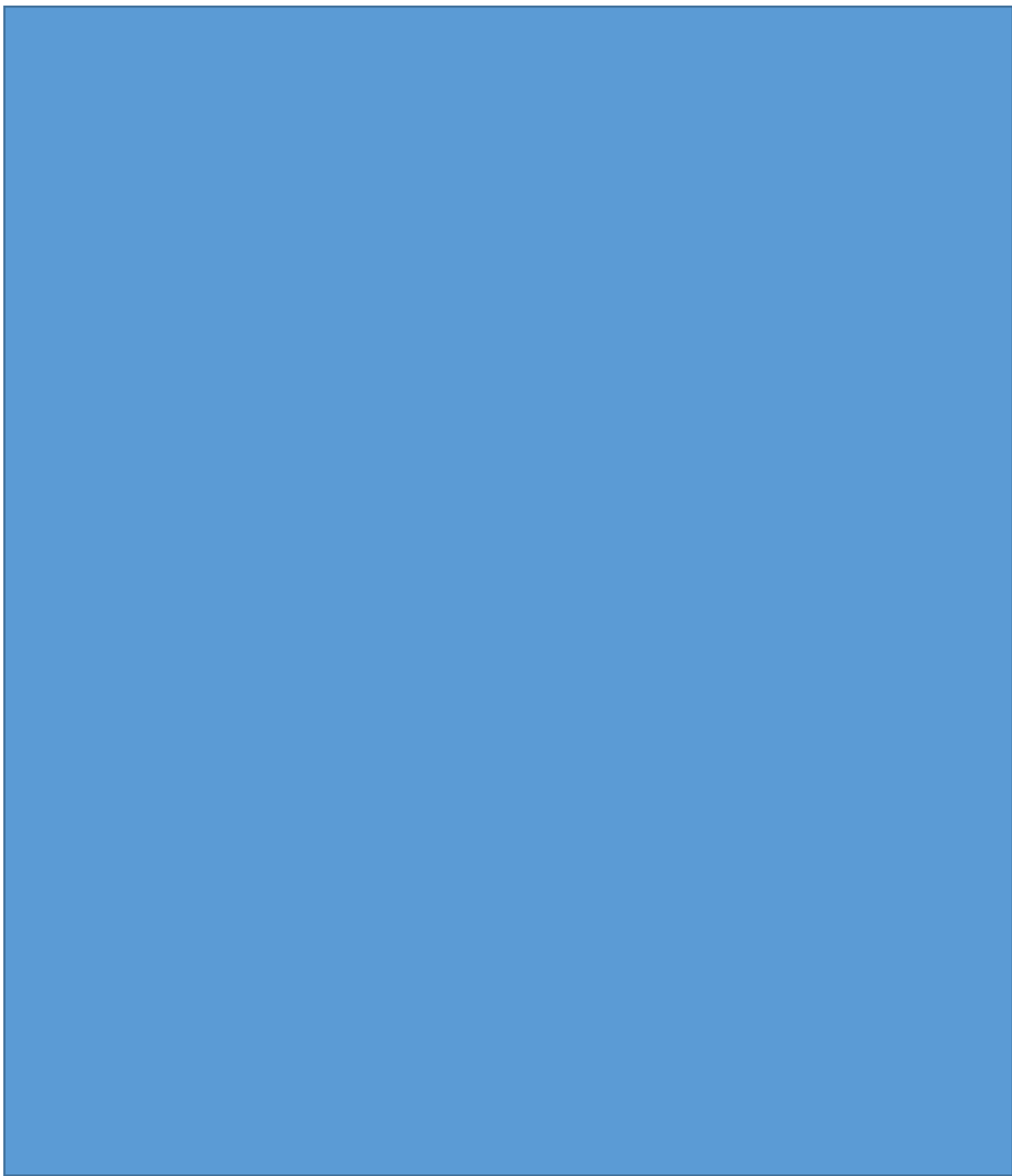




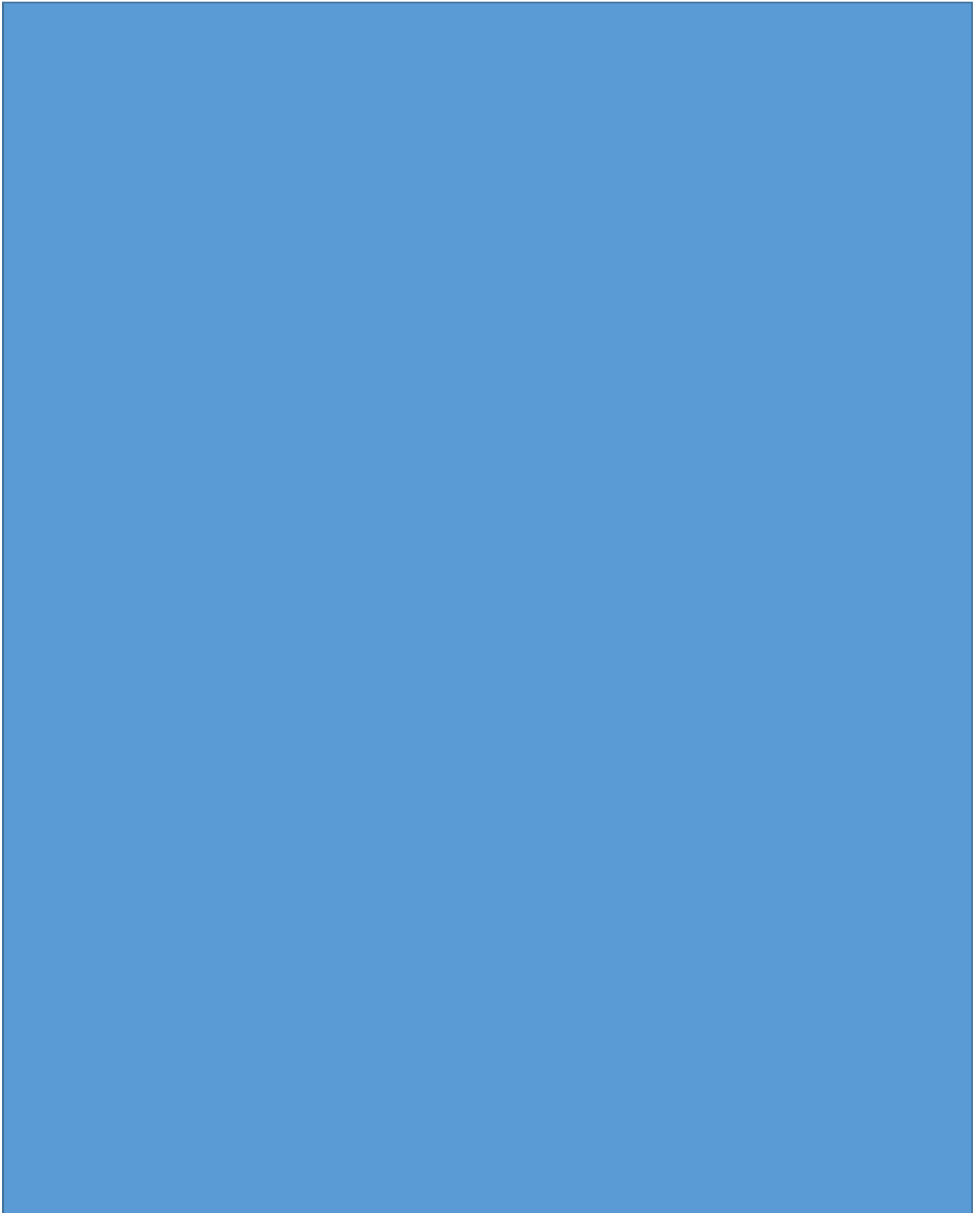
Cylinder placed vertically on an insert piece

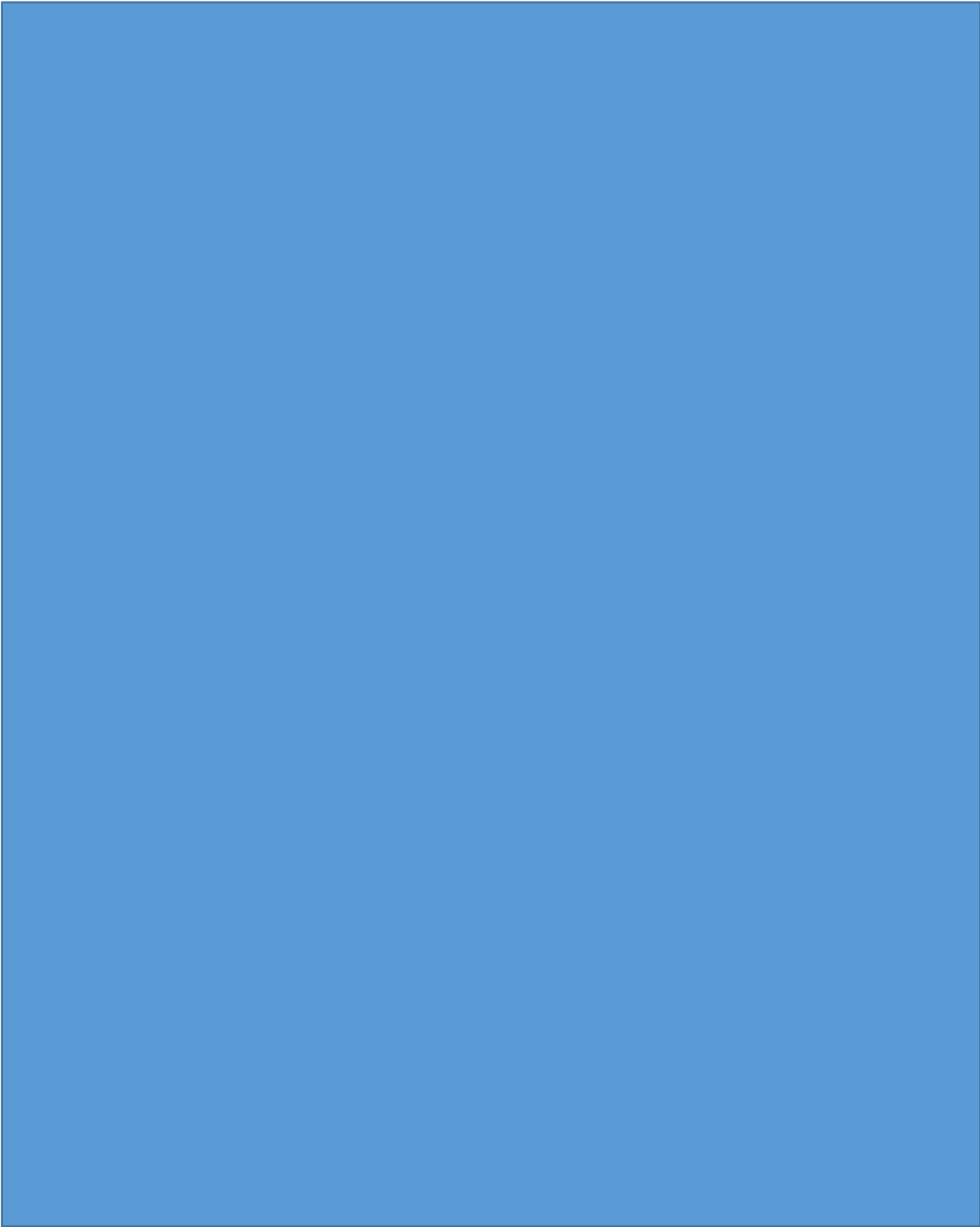






Ring placed on an insert piece





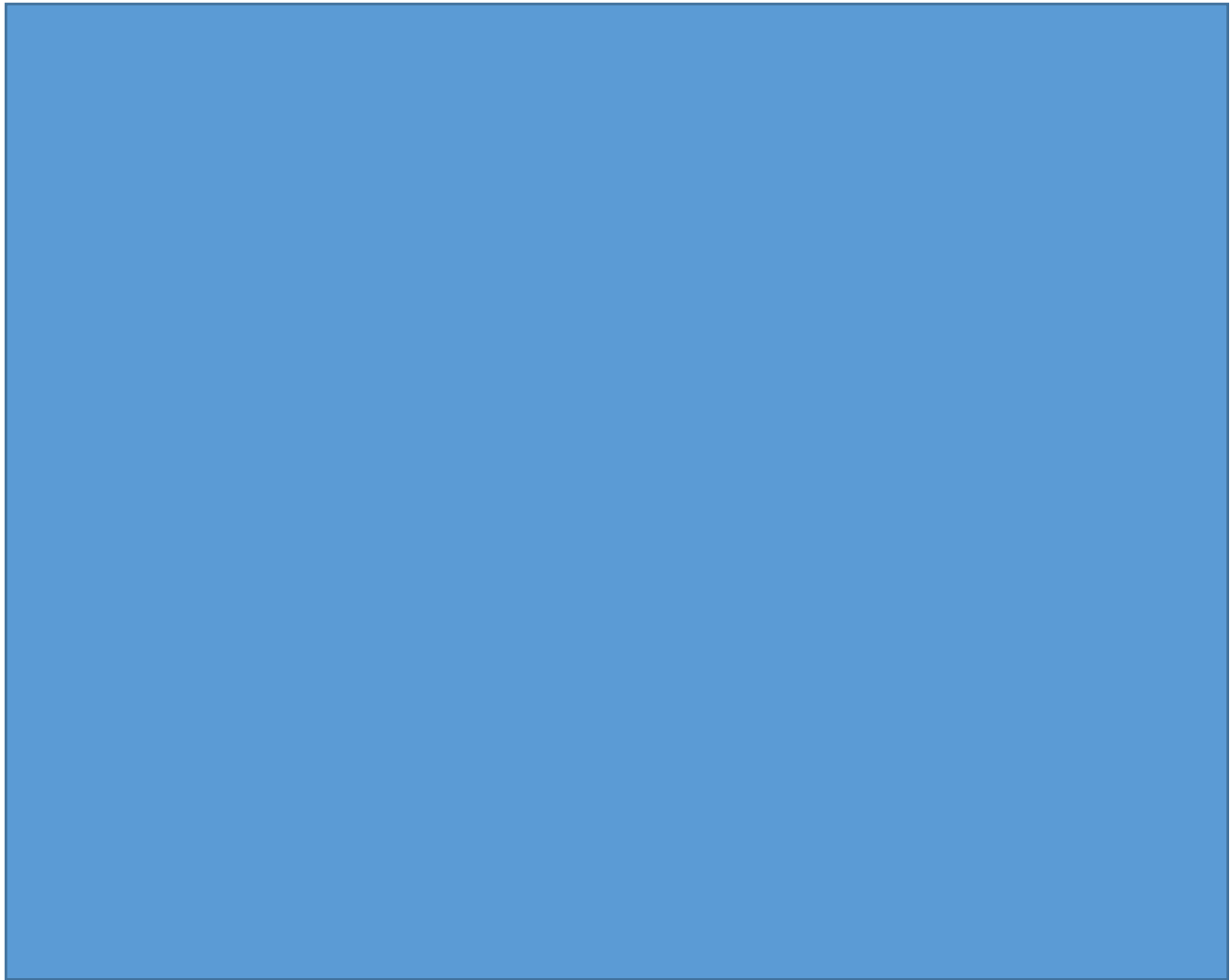
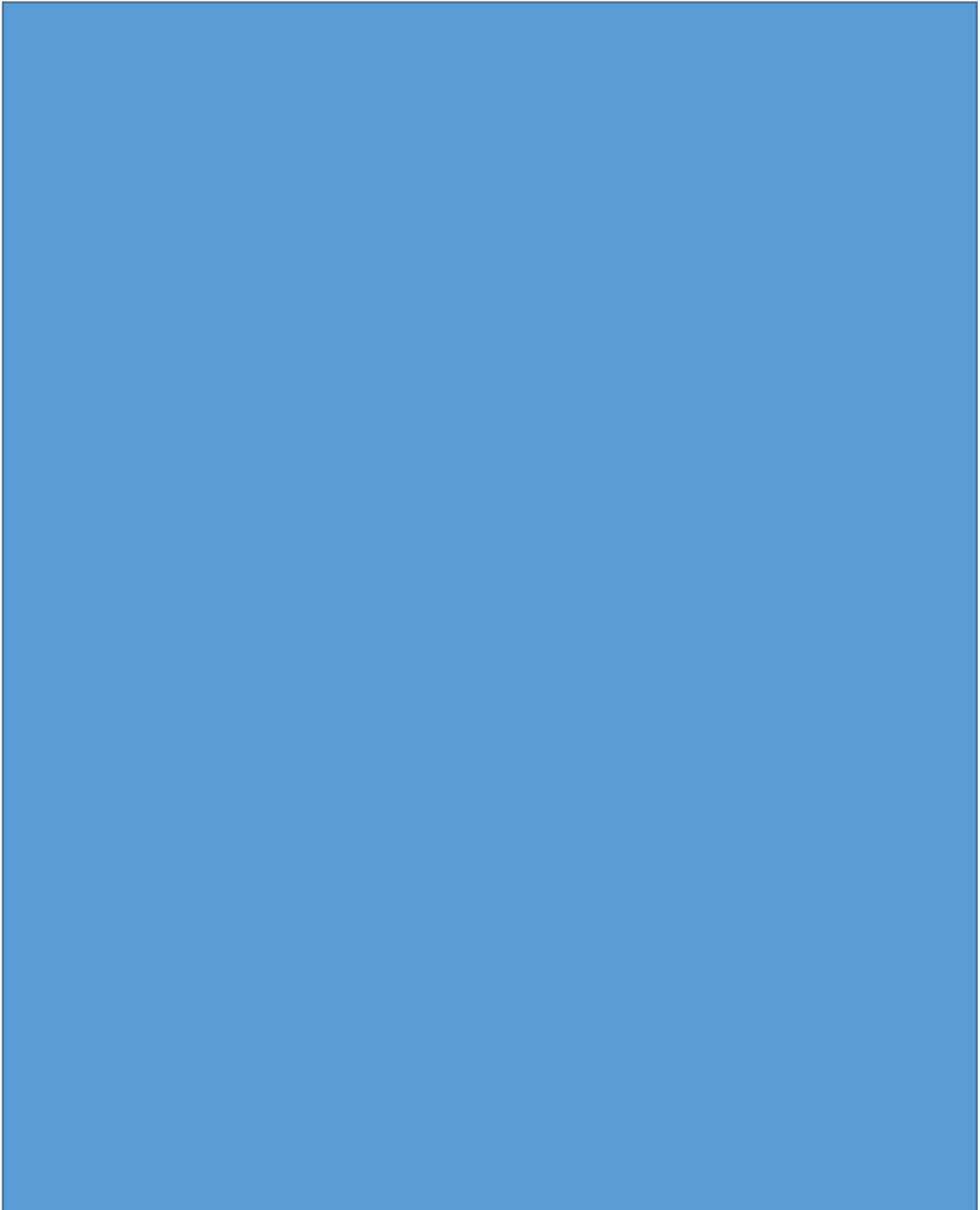
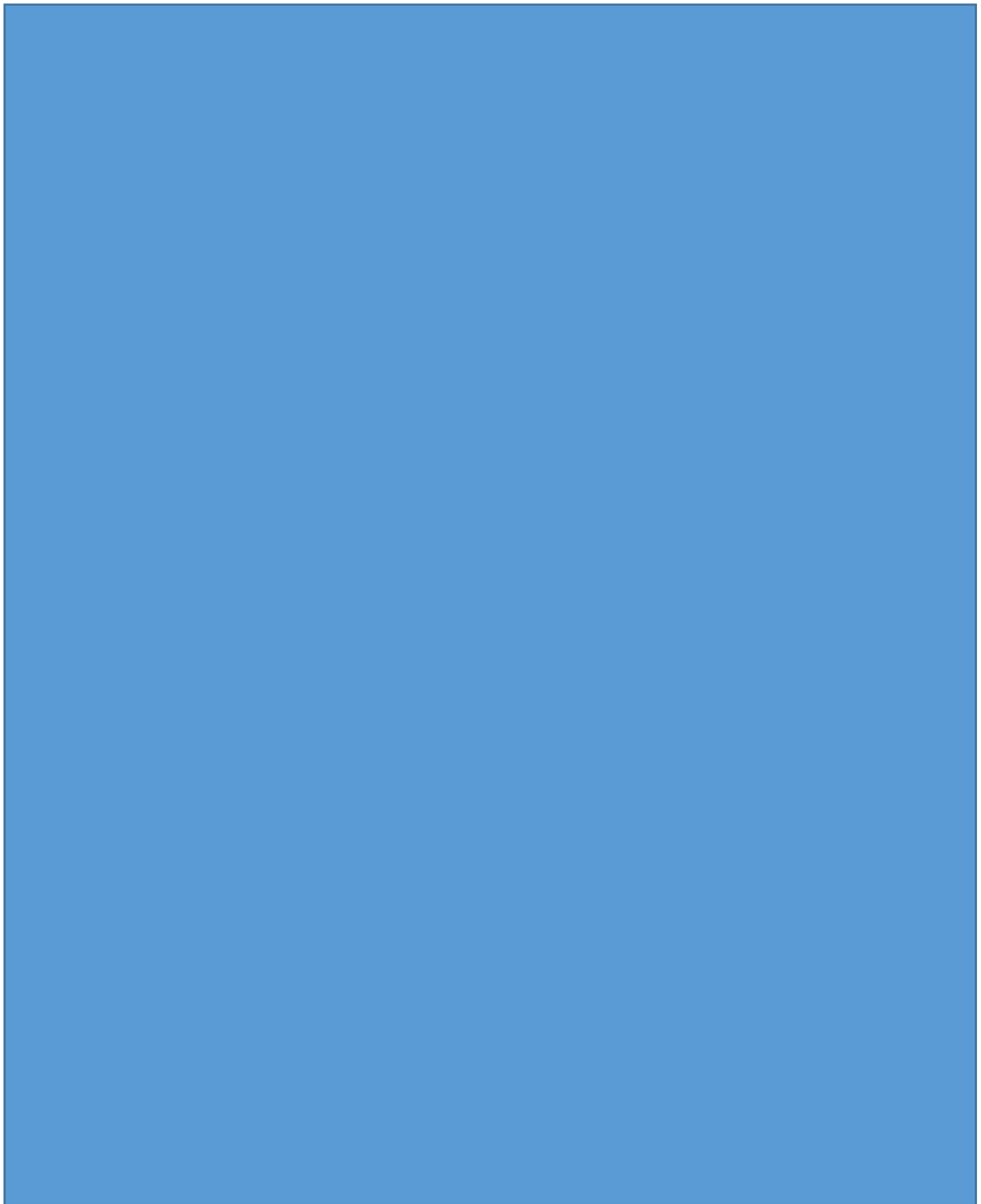
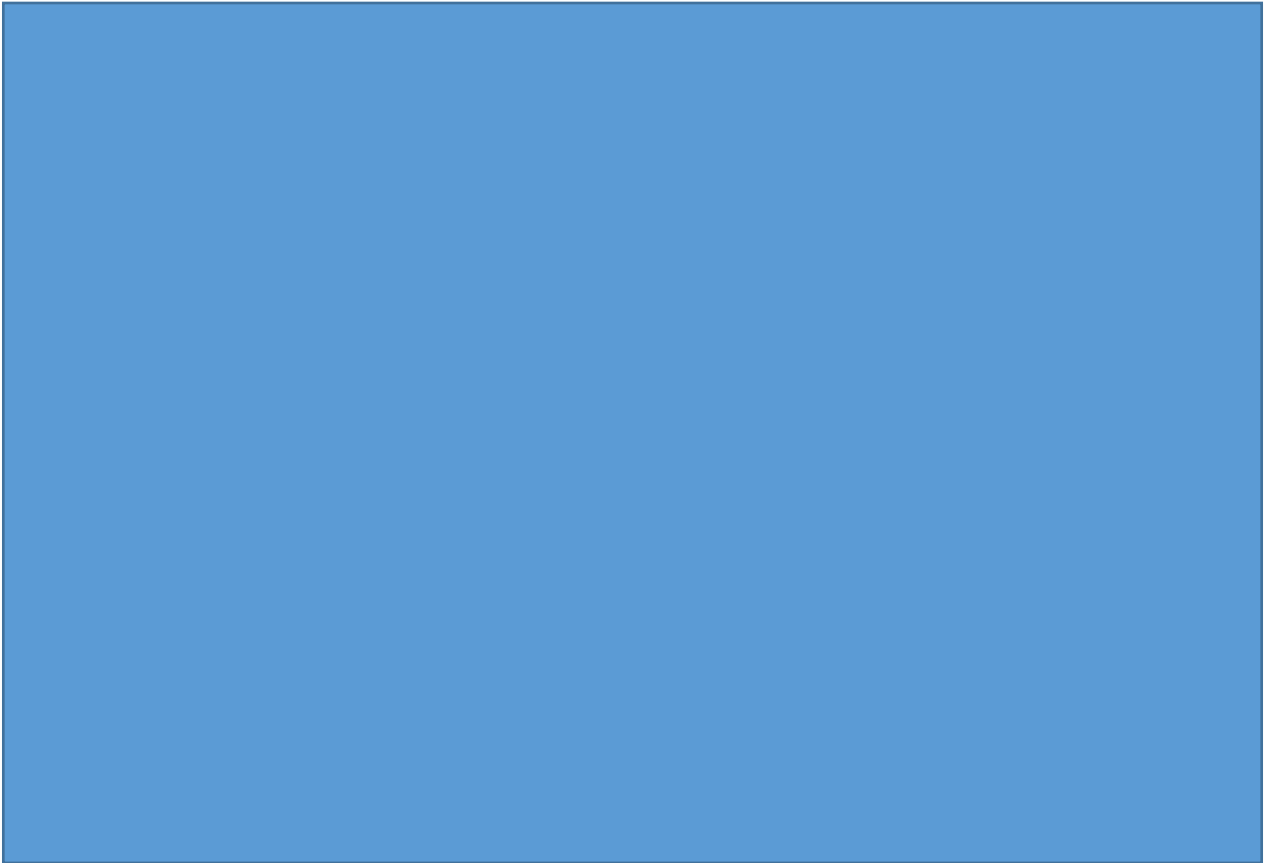


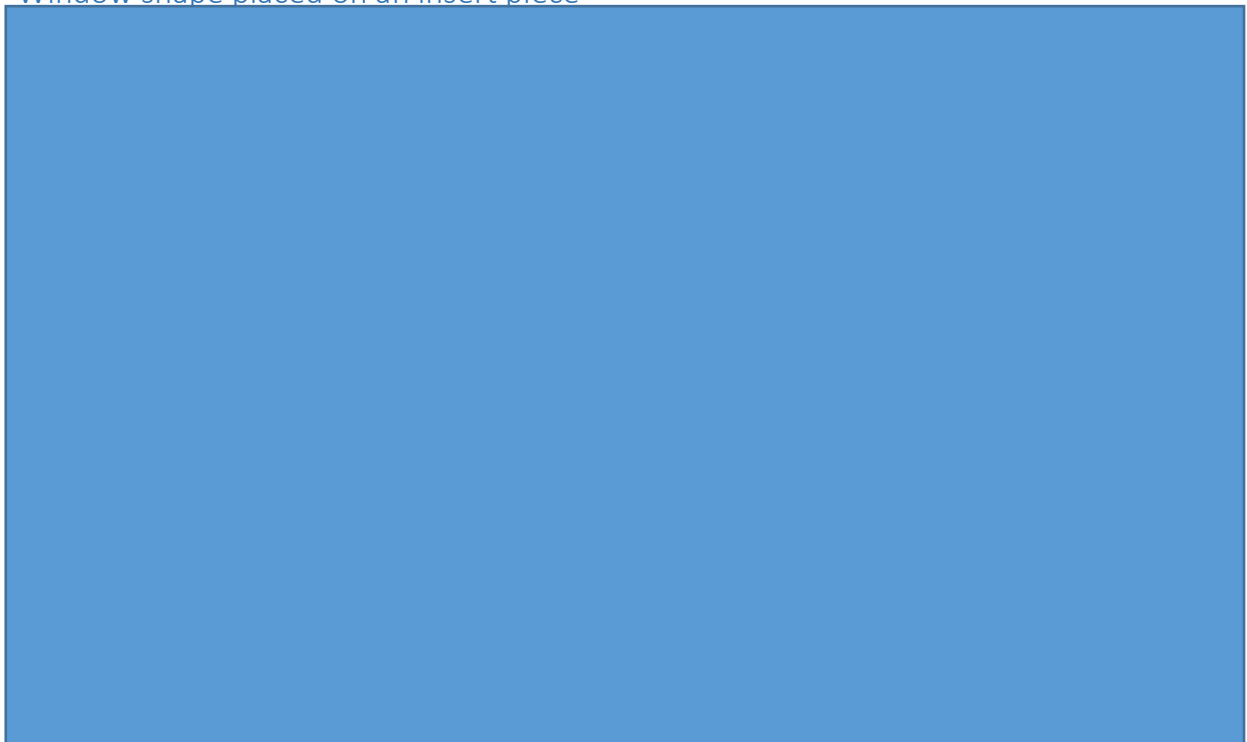
Plate placed on an insert piece

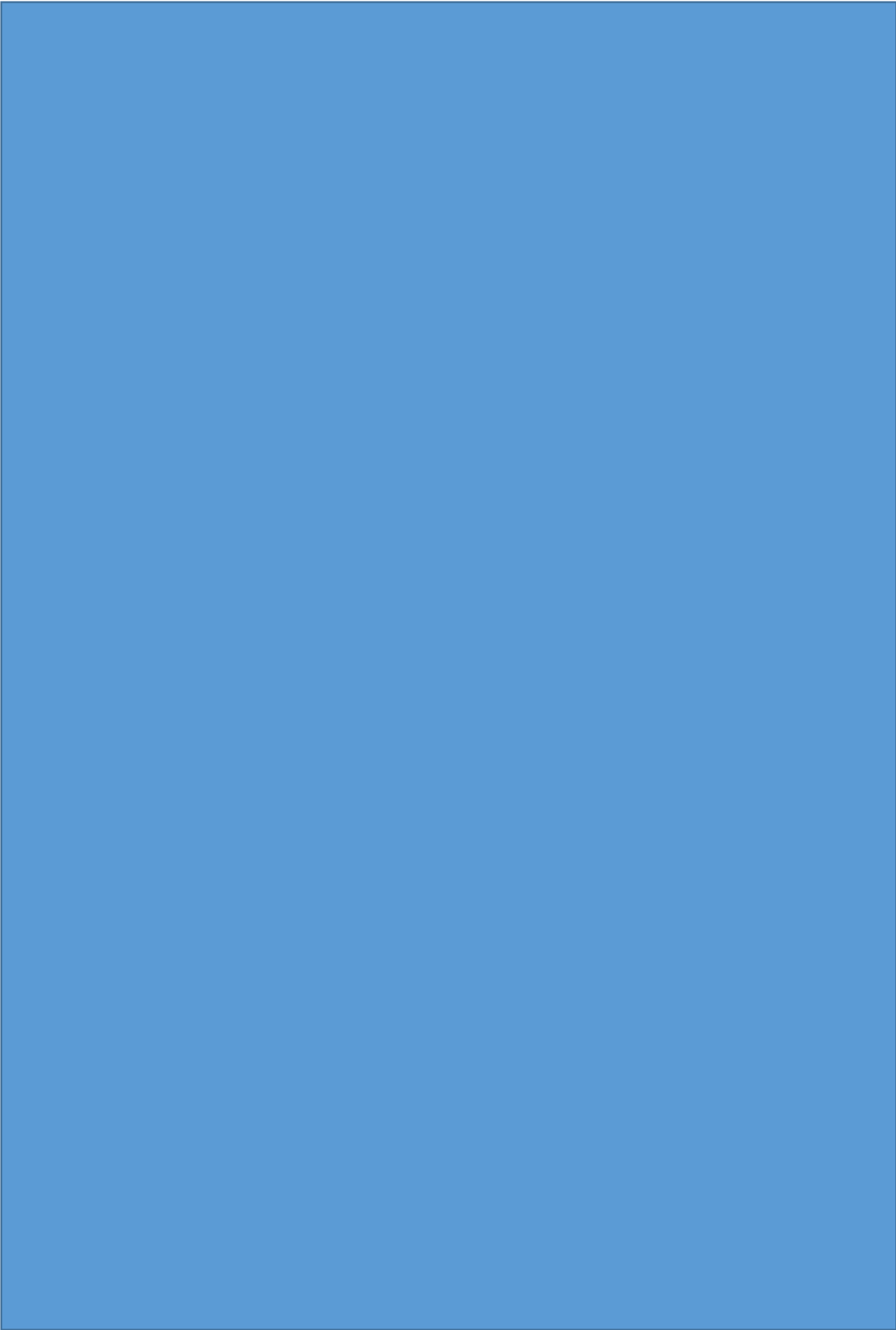


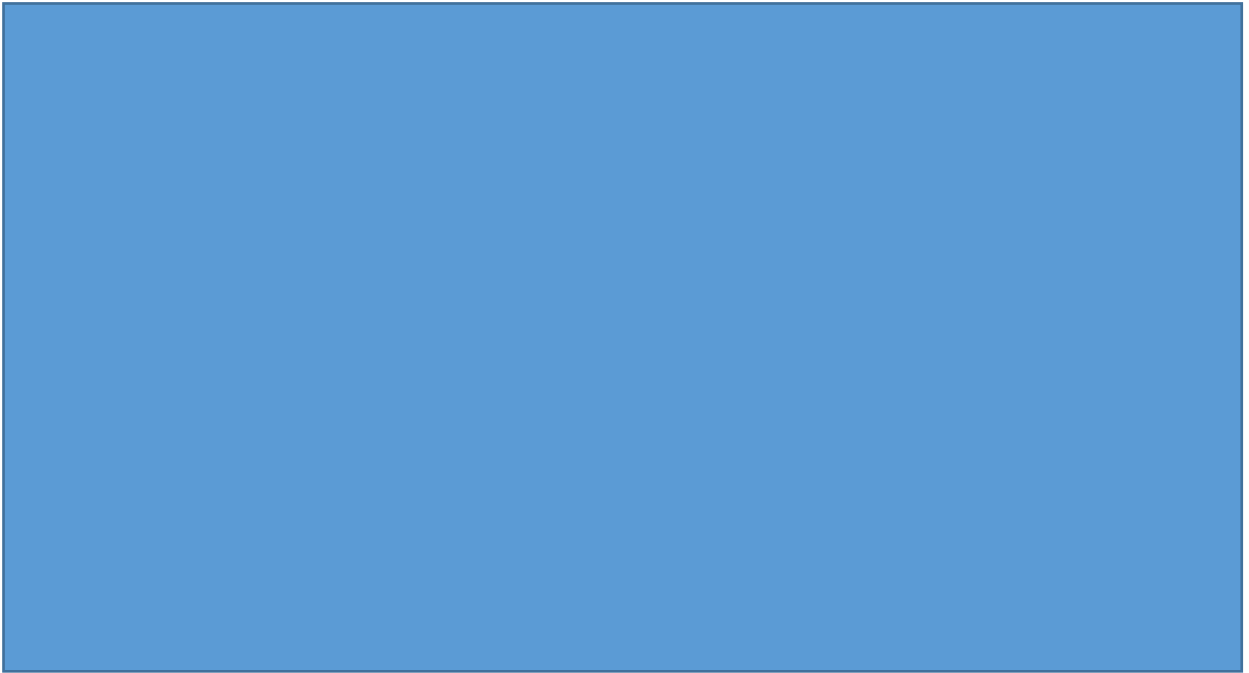




Window shape placed on an insert piece

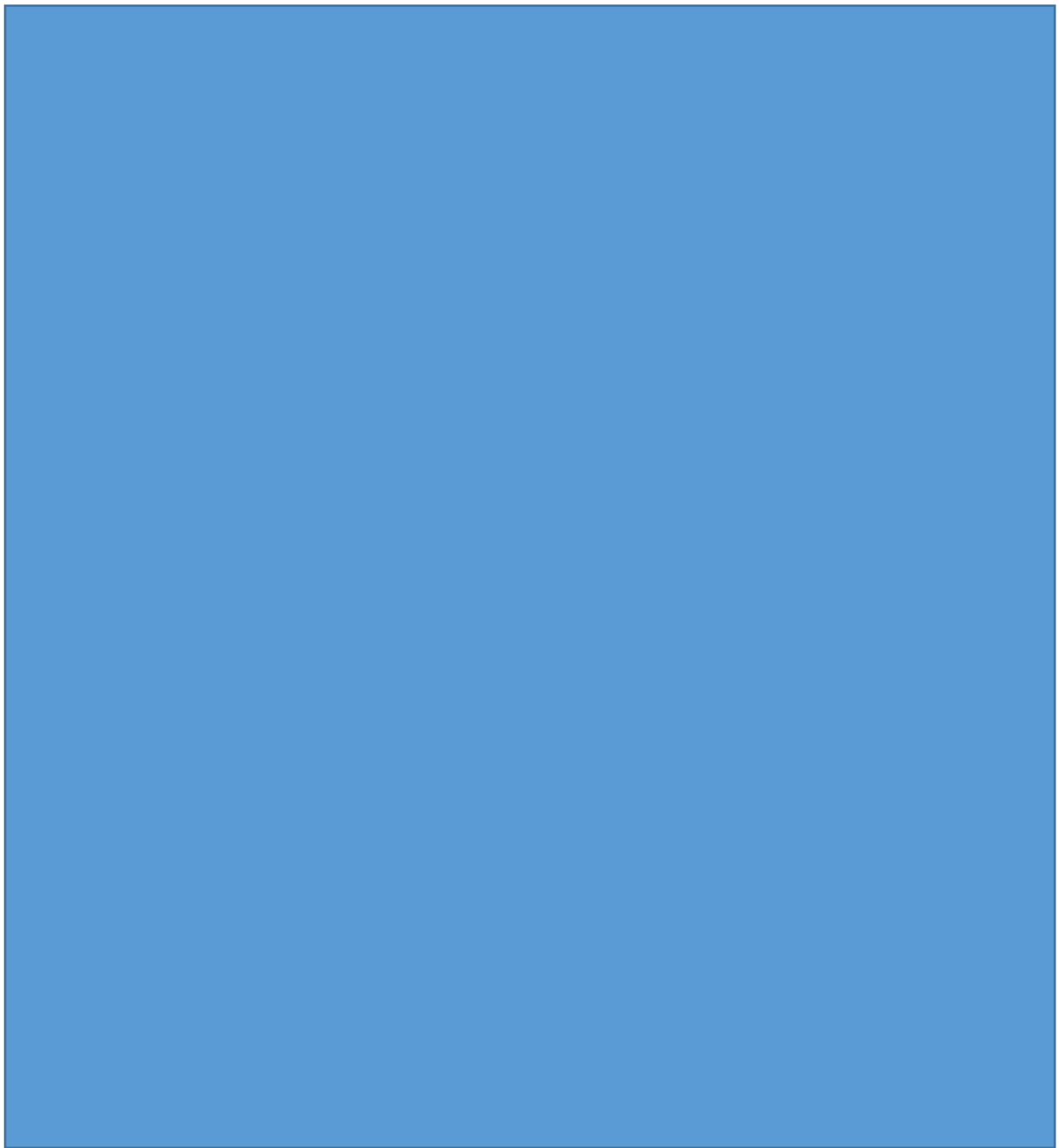


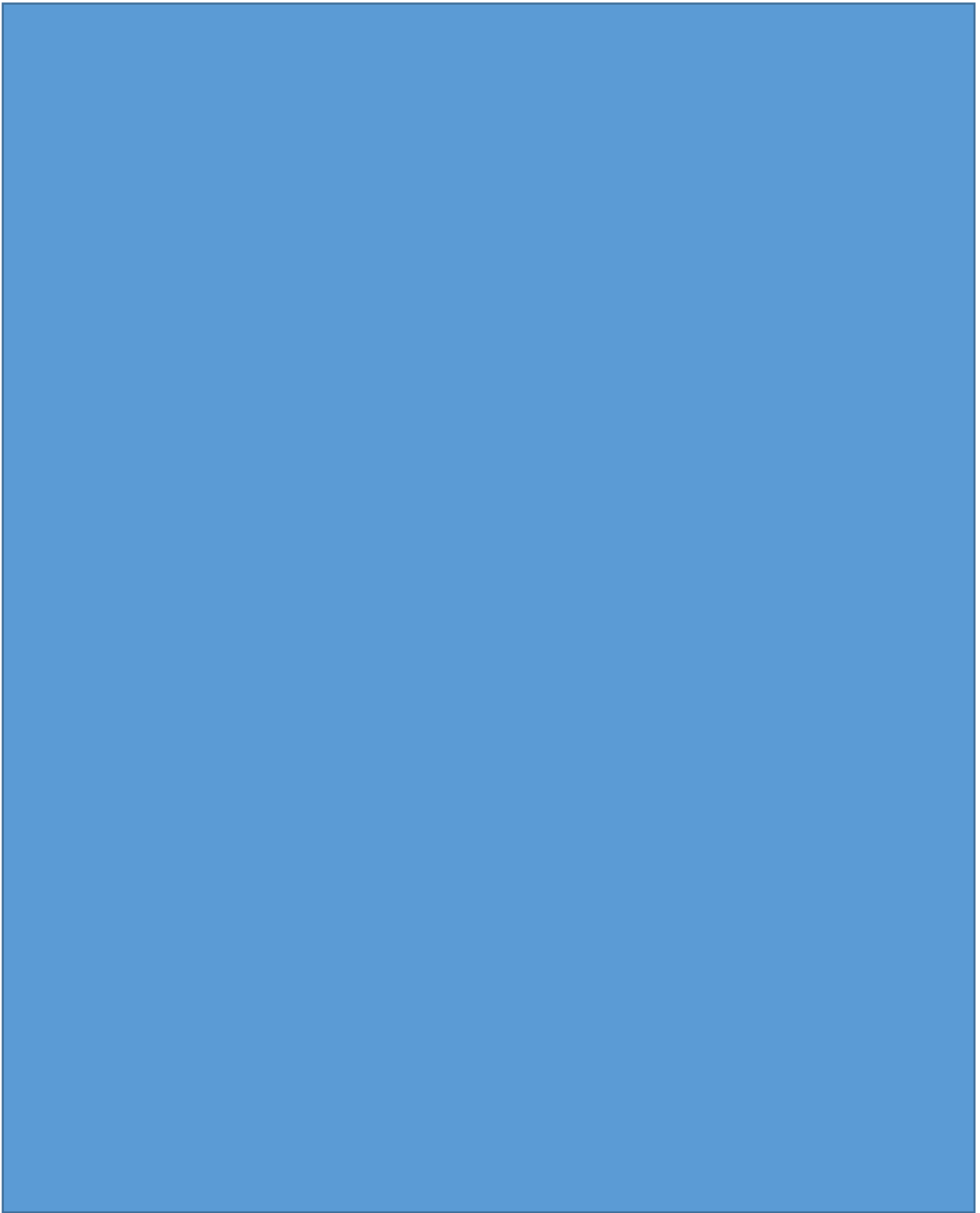




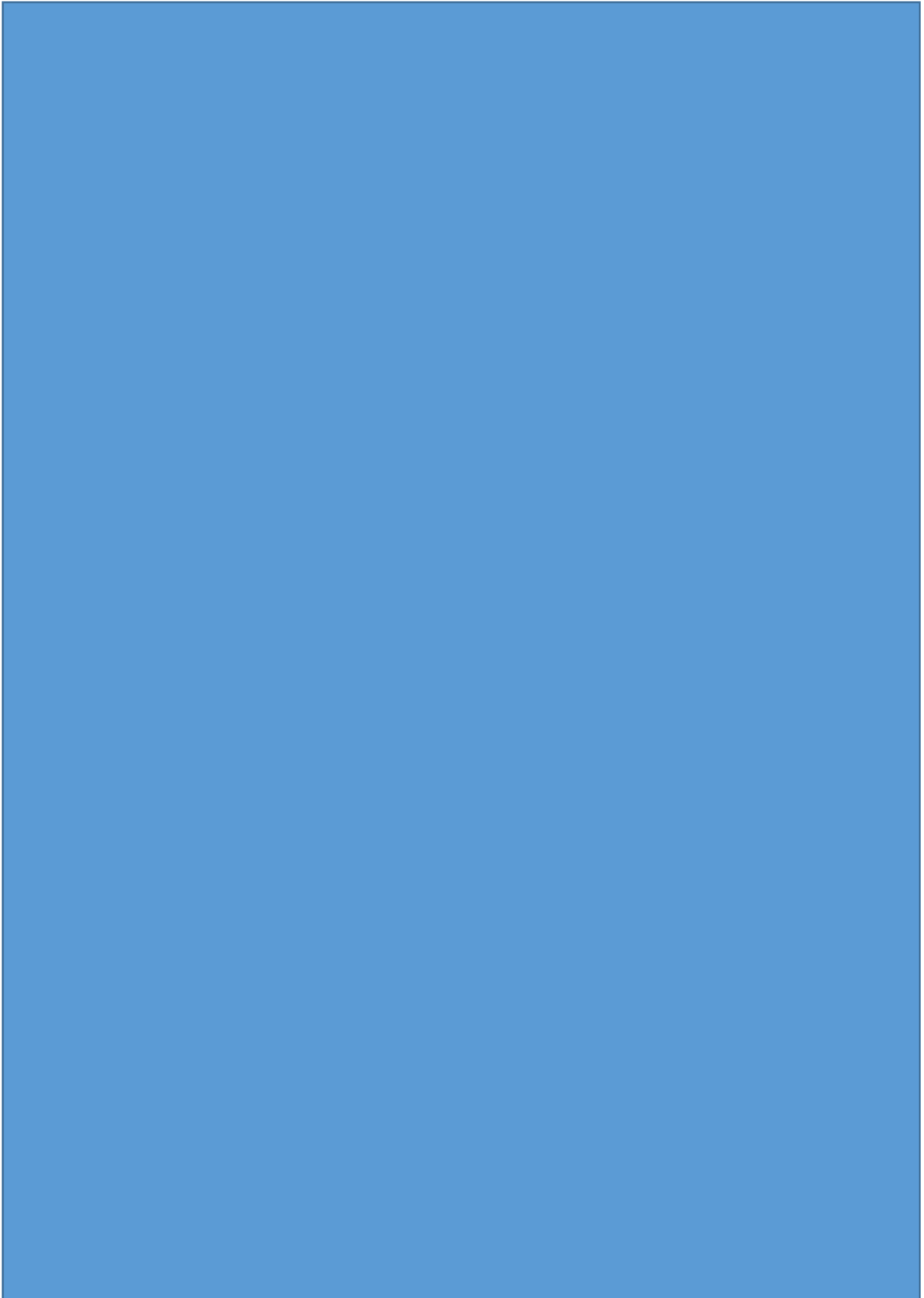
L-shape







Strip placed horizontally



Cylinder placed on a stick

