Perceptum Technologies

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January 21, 2008

Mr. Patrick Leung
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
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Re: ENSC 440/305 Project Proposal for the Novus Tabula Learning Board

Dear Mr. Leung,

Our product, Novus Tabula, created by Perceptum Technologies for ENSC 440/305 is outlined in the attached document. The product is an applied teaching-device we aim to market to high schools to effectively introduce the fundamentals of electronics.

The attached proposal discusses our products features, design constraints, specifications, company structure and system overview. We will also discuss the advantages our device has for use in teaching and promotion of electronics.

There are four engineers that constitute Perceptum Technologies: Kyle Huffman, Paul Carriere, Daniel Galeano, and Ben Shewan. If there are any questions you may have about our product, you may contact us at ensc440-perceptum@sfu.ca . We look forward to discussing this unique product with you.

Sincerely,

Kyle Huffman

Kyle Huffman

Director of QA, Perceptum Technologies

PERCEPTUM TECHNOLOGIES

Novus Tabula Learning Board Proposal

Project Members: Kyle Huffman
Paul Carriere
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Submitted To: Steve Whitmore, ENSC 305
Patrick Leung, PEng, ENSC 440
School of Engineering Science
Simon Fraser University

Issued: January 21, 2008

Version: A.1

Executive Summary

> *"Do not train children to learning by force and harshness, but direct them to it by what amuses their minds, so that you may be better able to discover with accuracy the peculiar bent of the genius of each."* - (Plato, 2008)

Electronics permeate every facet of daily life and have become a necessity for people around the world, yet many do not understand the driving fundamentals of these devices. Albeit an expansive and sometimes complex field, easy and fun ways of teaching the public and future engineers alike is beneficial to our general welfare; we understand the world around us and we promote the development of better technology.

Digital and analog circuitry is ingrained throughout the fabric of modern society and continues to grow more complex as new discoveries are made. Despite this truth, advances in methods of teaching the fundamentals of circuitry have remained stagnant. When someone learns about circuitry for the first time, it generally consists of a battery, a switch, and a light bulb; if students are lucky, they will be exposed to some Boolean logic or basic properties of electrical components. This approach does not even scratch the surface of electronics, and can hardly be viewed as doing justice to such a subtle and multifaceted field. The Novus Tabula is a hands-on approach to teaching students the fundamentals of electronics: the logical control of current and voltage.

Why must one only be introduced to the true power of electronics on paper? The accepted physical teaching devices (oscilloscopes, function generators and power supplies) are expensive and cumbersome. Perceptum Technologies has developed a new device that is cheap to reproduce and has plug-and-play capabilities. The software accompanying the electronic board has easy to follow scenarios, allowing students to explore the implementation of devices and circuits that will control tangible, interactive outputs. This proposal presents an overview of the Novus Tabula, which is Latin for '*New Board'.* Our product embodies the mission statement of Perceptum Technologies, which is:

"To make knowledge of technology as accessible as technology itself"

Perceptum was created in January 2008 and is composed of four engineering students from Simon Fraser University; each adept with circuitry and electronics; each recognizing the lack of useful teaching methods for would-be engineers; each wanting to promote interest in engineering before there exists a serious shortage. The backgrounds of the founders incorporate a variety of knowledge from microelectronics, theoretical physics, nano-technology, software design, along with their own experiences of learning electronic fundamentals. The product prototype is expected to be completed over a 3 month period with a live demonstration in April 2008.

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1 Introduction

Technological development is a favoured economic objective for any nation. Arguably the world's largest industry, high technology (in particular electronics) represents an enterprise which is both profitable and relatively independent of resource turbulence. While countries like Japan have bootstrapped their economy through electronics, Canada's continues to remain resource driven. A robust Canadian future requires a pool of young, ambitious, high-tech oriented citizens. This workforce can only begin within our own education system.

Canada represents the 10th largest electronics market, yet we are the 17th largest producer of electronic goods (EMarketForecasts DataBase, 2007). Although this shortfall is the result of a host of economic factors, one obvious culprit is the lack of a qualified workforce stemming from our education system. Besides a short discussion on resistors and Kirchoff's Laws in Physics 12, electronics are mostly ignored at the high school level.

In one particular case, a founder recalls taking a high school elective called 'Power Tech' which would '*...introduce students to the field of electronics*'. This introduction consisted of buying a pre-fabricated strobe light circuit, and soldering the elements as instructed. The student gained no insight into how electronics operate, with the exception that strobe lights easily burn out. In fact, many SFU engineering students have no concept of electronics until *after* their first semester.

Perceptum Technologies was founded to address this gap in education. Our product, the Novus Tabula, is designed to introduce grade 11 & 12 students to the fundamentals of electronics. Essentially, the Novus Tabula offers the functionality of the breadboard/function generator/oscilloscope environment in a low cost, easy-to-use package.

When interfaced with a USB-enabled PC, Novus Tabula behaves like a simple electronics lab bench. Using step-by-step instructions, along with modular hardware, students control straightforward electronic circuits. The lessons assume little or no theoretical knowledge. Each lesson and module demonstrates fundamental concepts such as frequency, resistance, filtering and logic. The system input is provided using a command-line interface. Alternative interfaces were considered, but we believe this interface doubles as an introduction to hardware programming.

Novus Tabula is by no means a comprehensive presentation of electronics. It is designed to be an engaging demonstration of the power of modern electronics. By manipulating both the software and the hardware of our system, students are left feeling empowered and informed. With Novus Tabula, we believe that electronics will become the field of choice for talented Canadian students entering post-secondary education.

2 System Overview

The Novus Tabula is designed to be the controlled and observed at both the software and hardware level. This approach is meant to demonstrate the integration of electronic equipment. By using a PC interface, the user associates these new phenomena with a familiar tool. This format also reduces the complexity and cost of our product. A user interface flow diagram of the Novus Tabula is shown in Figure 1 below:

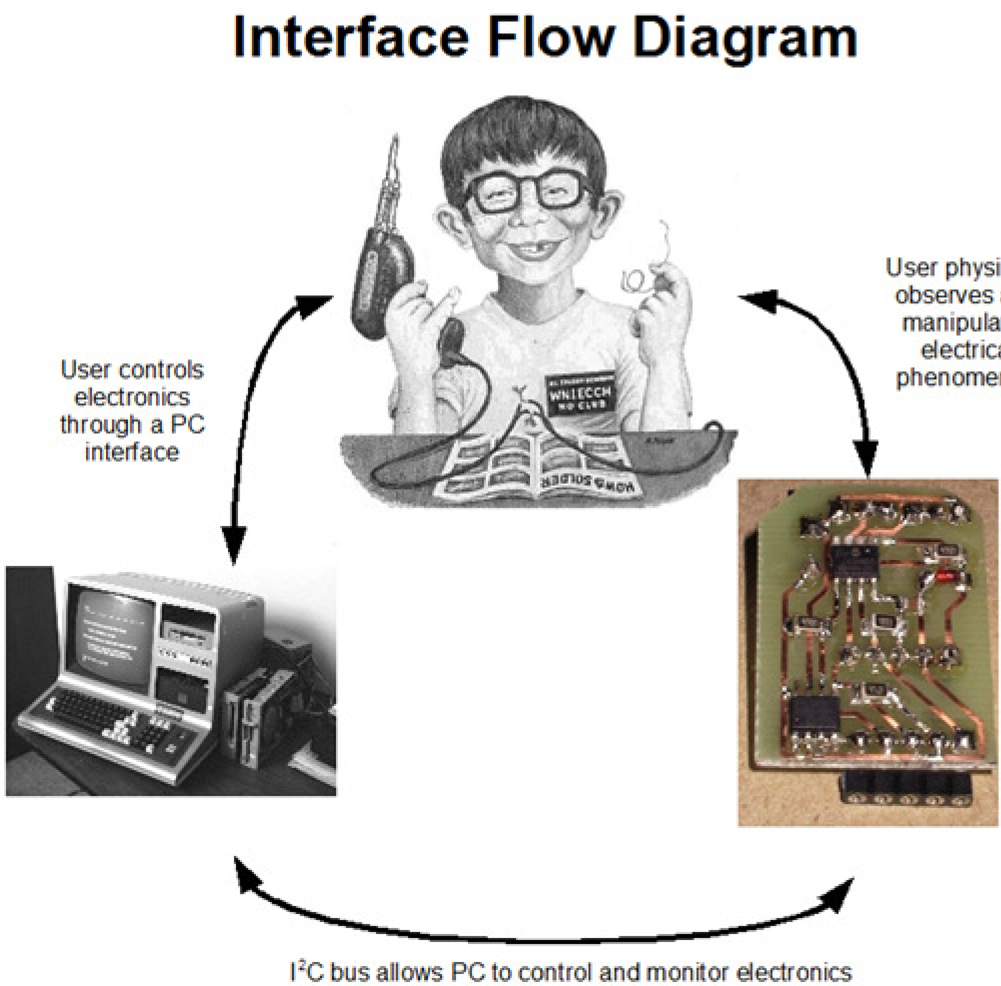

Figure 1 High level diagram of Novus Tabula

Images Used from: (Bishop, 2007), (LaRosa, 2005), (MAD Comics, 1973)

The Novus Tabula has been designed with modularity in mind. This approach offers the capability to expand our product line, while also allowing us to revise old modules as our program matures. The structure of Novus Tabula is meant to be an iterative learning process, where new concepts are learnt on the basis of old ones. A hardware diagram demonstrating our modules is shown in Figure 2 below:

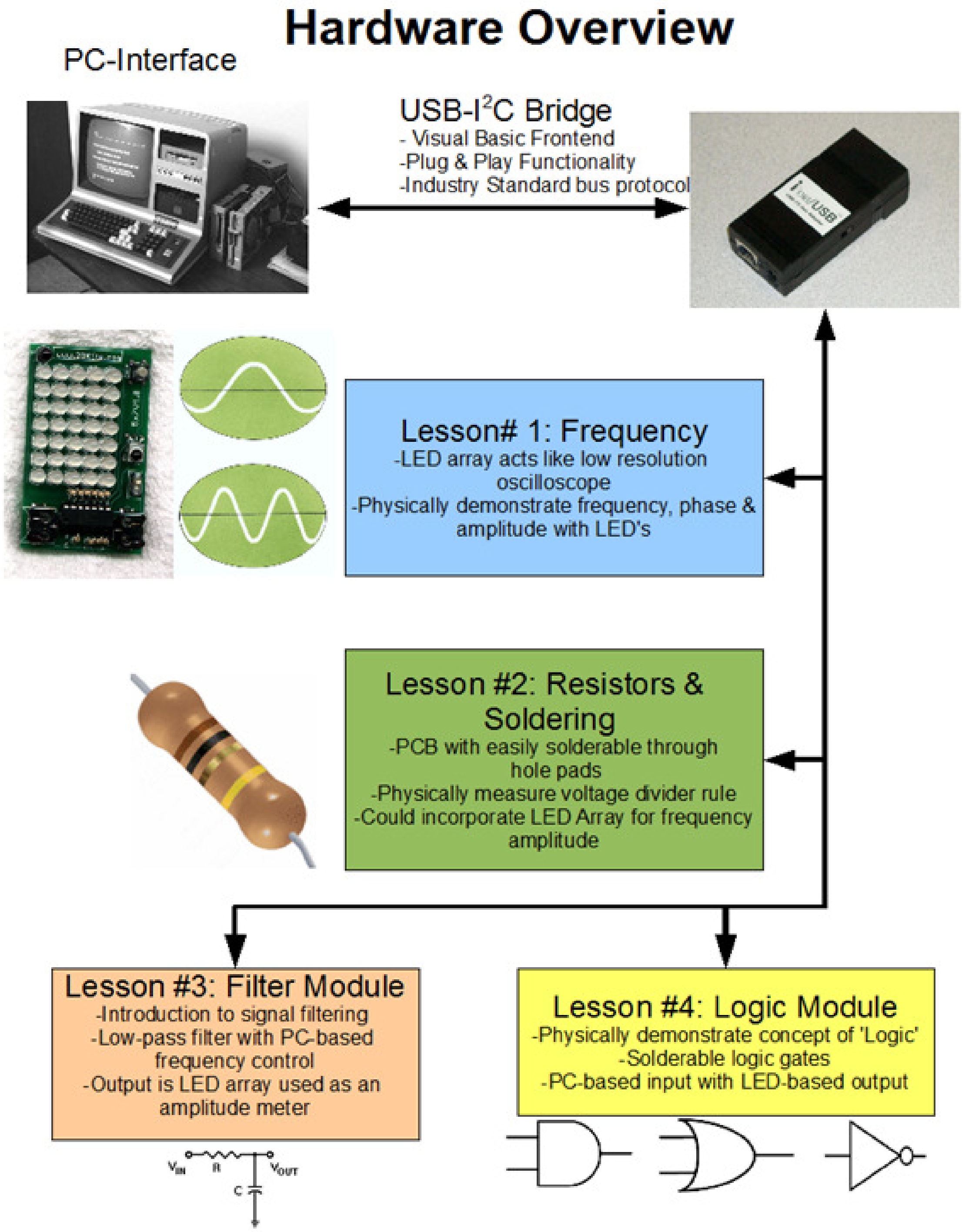

Figure 2 Hardware overview of Novus Tabula

Images used from: (MMC, 2007), (LaRosa, 2005), (DKImages, 2005), (2DKits, 2008), (DragonMods, 2008), (Play-Hookey, 1996), (Dahan, 2008)

3 Design Solutions

3.1 Possible Solutions

To reinforce fundamental circuit concepts we will develop an array of learning modules designed to interface with a Windows-based PC. A software component will allow students to interface with a simple VisualBasic-based front-end to control system dynamics in an insightful fashion. Each of these modules will emphasize and strengthen some area of the student's knowledge base, allowing for real world verification and investigation into the concepts covered in class.

LabVIEW is a software package that facilitates data acquisition and instrument control. It is compatible with a broad range of devices (including function generators), and provides several resources to develop complete interactive-interfaces. Besides the ease of hardware communications between compatible devices, the use of LabVIEW would be convenient for development of the initial prototype as SFU already possesses an educational licence. However, since the licensing of production units would represent a significant cost, a different software solution must be used in order to achieve affordable and marketable products.

Should production costs prove to be a critical factor, there are extremely low-cost methods of signal generation available. A simple solution involving zero hardware cost would be utilizing the sound cards found in every modern PC. Since the learning modules will be based on LED indicators, signal frequencies greater than 1 kHz will be totally unnecessary, allowing our desired range to be easily generated using any sound card. Additionally, the communication protocols between a PC and its sound card are already functional, an attribute that would save us considerable effort. There is a variety of freeware options to control the generation of sinusoidal functions in sound cards that are readily available. Some of the programs found were siggen.exe and sine.exe, both of which are extremely straightforward and simple to emulate. The obvious disadvantage of such a solution is that the PCI bus would have to be utilized to control the card and additional software complexity would result.

3.2 Proposed Solutions

As the nature of such a system necessitates a high degree of flexibility and robustness in both the inter-module and PC-module communications, we feel that the I^2C bus presents an ideal solution. The straightforward bus protocols and ease of implementation will allow an array of learning modules based upon differing requirements (e.g. clock speed, power supply, noise tolerance, etc...) to seamlessly interface through a proven, industry standard, communications protocol. The limited time in which we wish to implement this project also dictates that a simple inter-chip communications solution is needed, as it is the design of the individual modules that is our focus.

To allow a PC to participate in I^2C bus interactions, it is necessary to provide a bridge circuit between the I^2C bus and an available PC communications port. The "plug and play" qualities and ubiquitous nature of

USB technology indicate that a USB/ I^2C adaptor board would be the ideal solution. Such bridges are available at relatively low cost and can be utilized with minimal effort.

In terms of software, we are planning to use a front-end VisualBasic application to run the I^2C controller and retrieve data through a serial port. With this application we will communicate with various devices such as the DAC and perform data acquisition when users interact directly with the board. We will also use VisualBasic to design an interface that helps students familiarize themselves with electronics and computer languages. For example, instead of implementing user-friendly applications such as GUI's, users would be required to control the DAC from a commands terminal. Retrieving data from the board will be performed in the same way, introducing students, in a more realistic way, to basics of computing communication.

The next hurdle will be a method of basic function generation necessary to serve as inputs for some of the proposed modules. A commercially available function generator is unacceptable for our purposes due to the high cost (>$3000) and relative simplicity of the functions desired for our purposes. The generation of sinusoids of varying frequency is the principle requirement for such a circuit and a commercially available DAC IC would be suitable for the task. As I^2C compatible DACs are readily available, this functionality can be implemented in a cost-effective and timely fashion. The realization of multiple output channels would be a matter of utilizing a simple and widely available de-multiplexing IC.

Once basic communication and signal generation sub-systems have been developed it will be easy to develop and integrate a wide variety of I^2C ready learning modules. The verification of basic circuit theory will afford the student an intuitive understanding that can only be realized with hands-on experience. Simple circuit structures can be developed to demonstrate a wide array of basic electronics concepts such as: frequency, phase, amplitude, DC biasing, capacitance, inductance, KVL, KCL, voltage division, current division, filters, logic and more. Low cost implementation will ensure that such modules can be competitively priced and basic systems will fall within the strict budget requirements found at the secondary school level.

3.3 Potential Risks

Although we cannot identify *every* possible risk, we feel that certain elements of our project warrant particular consideration. There exist ambiguities around obtaining proper licensing for a commercially available product. Further research into open-source and licensing agreements is being conducted for our software interface and I^2C controller. Another potential risk is the failure of components, especially our expensive I^2C controller. To mitigate these risks, we will double our inventory when possible. In the event our hardware controller should fail, we have the potential to borrow an identical controller from a founder's previous co-op employer.

Lag-time in ordering parts is also a worry for our prototype development. We have contacted the sales department of the company that sells our desired controller, MMC. They have assured us that the MIIC

204 controller is regularly stocked. We plan to buy our other components from quick-turn companies such as DigiKey.

Another concern is the difference in achieving software and hardware milestones. We chose this particular I^2C controller since it allows us to control the I^2C bus at a level lower than our final design. Essentially, we can develop our software and hardware in parallel.

Lastly, since our product is intrinsically modular, we are able to adjust the development throughout our term. If we encounter unforeseen issues within a particular project element, our design allows us to modify the project as needed. This feature ensures that we will have an operating product by April, 2008

4 Information Sources

In designing the Novus Tabula, we considered various information sources. One possible source is the Faculty of Education at SFU, which can provide valuable insight in the field of teaching. This would include research on how to create an interface that effectively teaches students the fundamentals on electronics. Members of the Engineering faculty will also assists us during the project. Initially we will consult Patrick Leung, Brad Oldham and Steve Whitmore for documentation and technical concerns.

One of the team members has previously worked with the proposed I^2C controller during a work-term. We have already contacted the employer to find further information about the design of our I^2C bridge component. We are also discussing the possibility of borrowing their I^2C controller such that we can immediately begin development while we await our parts. Other conventional information sources include, but are not limited to: SFU library, manufactures' datasheets (Philips, 2000) and the Internet (NXP).

5 Budget & Funding

5.1 Budget

A tentative budget has been established to approximate the design and manufacturing costs of the prototype. Our largest cost will be the I^2C bridge, which accounts for 75% of the total cost. We also estimated the cost of the learning board in terms of components and manufacturing as shown in the following table. Lastly, a miscellaneous cost has been added to the budget to account for contingencies, which represent 15% of the overall cost. A brief overview of our budget is shown in Table 1 below:

Table 1 Budget Estimation

Equipment		Estimated Cost (USD)
I^2C Controller		$425
Board	Components: LEDs, multiple ICs, Thru hole components, Wall Mount power supply	$40
	Manufacturing: Board soldering and equipment assembly	$30
Miscellaneous		$75
Total		$570

5.2 Funding

We considered several funding sources for the fabrication of our prototype. The first alternative will be to apply to the Engineering Science Student Endowment Fund (ESSEF) as a category C project. We also considered the contribution of $50 that every team receives in ENSC440. The remaining costs will be shared equally within the team members, starting with an individual contribution of $25. This initial contribution will allow us to start immediately without having to wait for the other sources of funding.

Other alternatives have also been considered to minimized costs. Online auctions and other resources such as *eBay* and *Craigslist* will be searched for less expensive equipment. Moreover, the ESSEF resource pool is an important option which could make the I^2C controller SFU property. This alone would reduce our budget considerably.

6 Schedule

A Gantt chart outlining our project schedule is demonstrated in Figure 3 below:

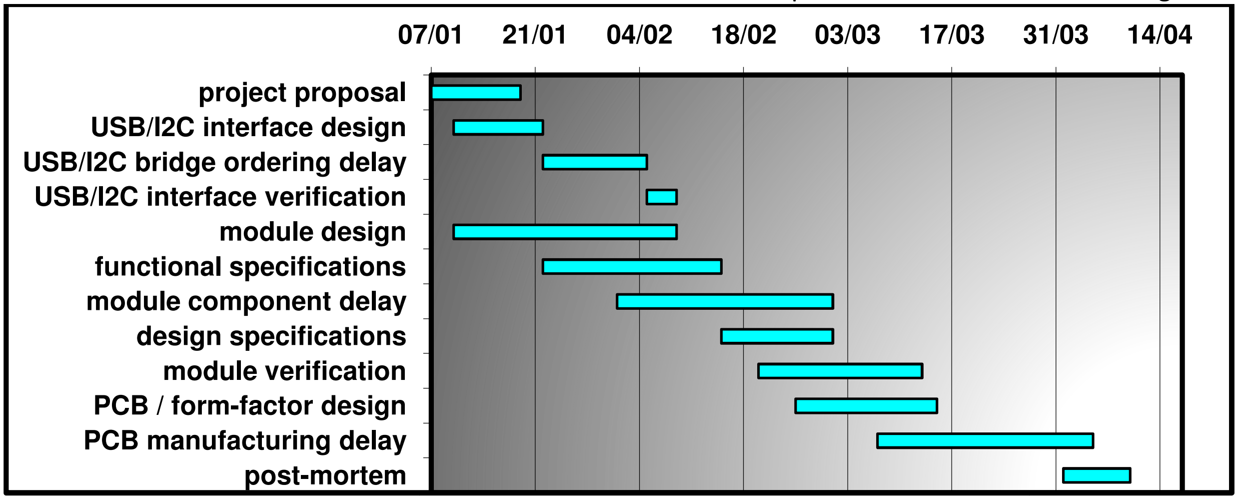

Figure 3 Gantt Chart - Project Timeline (2008)

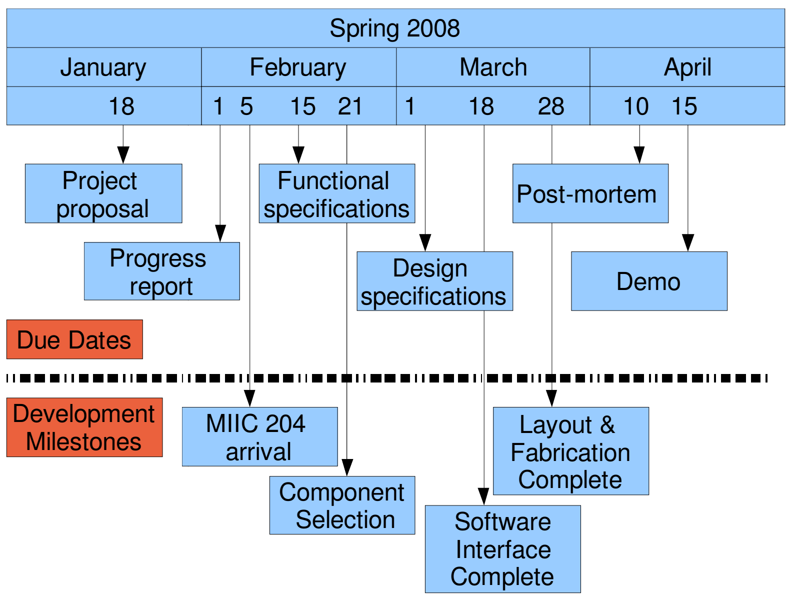

Figure 4 Project Milestones

7 Company Profile

7.1 Team Organization

Perceptum Technologies has been organized by considering each member's strengths and interests. Since each member of the team has hardware and software coding experience, members with the strongest skills in each area have become the project managers. The managers, Ben Shewan and Daniel Galeano, will oversee the two the major project elements: the physical hardware on the Novus Tabula learning board and the user interface software, respectively. Paul Carriere and Kyle Huffman will also be partaking in the design and implementation of the product but will also oversee many of the administrative tasks. A breakdown of this structure is given in Figure 5 below:

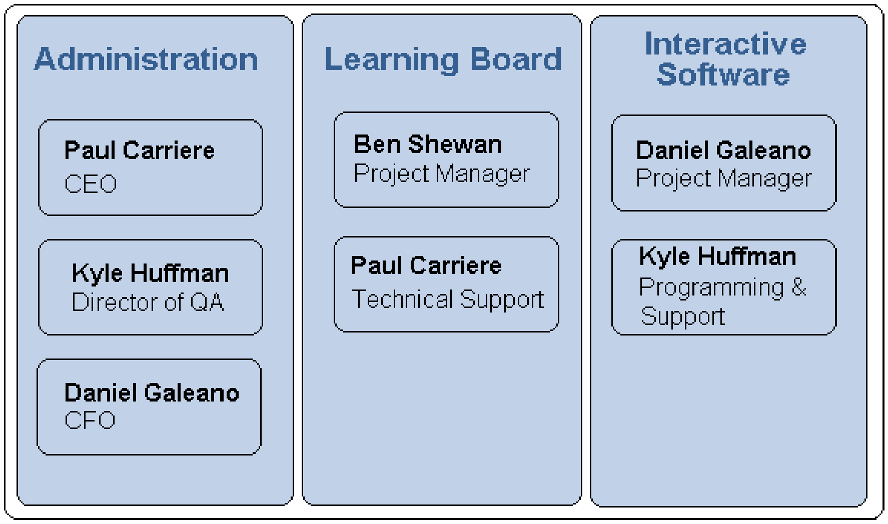

Figure 5 Perceptum member organizations

Although we each have titles within the company, decisions and tasks are often shared or passed to individuals where beneficial. To stay current with the status of the project, we are using Central Desktop (www.centraldesktop.com). This website is a free, wiki-based software package specifically for members of a project team. Currently, we meet on a need-to basis. The automatic updating of group members by Central Desktop allows for any minor issues to be resolved easily and for major issues to be resolved via meeting notifications. A master schedule is kept on Central Desktop showing everyone's available meeting times. Meeting minutes are taken by Paul Carriere and posted immediately afterwards on our account.

7.2 Member Profile

A brief outline of each member is presented in the following table:

Table 2 Perceptum Technologies Company profile

	**Kyle Huffman, Director of QA** I am a fifth year Electronics Engineering student at Simon Fraser University. Previously I have worked as an electrical technician in a diesel power plant located in the Caribbean, a lab assistant at Simon Fraser University investigating Surface Plasmon effects, and test engineer at Icron Technologies in Burnaby, BC. I am an experienced tutor and can supply knowledge of effective teaching methods. In the past I have developed nano devices via clean room processes. I am also skilled in writing image processing algorithms in C++. My experience in business plan competitions and public speaking will undoubtedly prove useful in launching Perceptum. In my spare time I enjoy guitar and volleyball.

	**Ben Shewan, Director of Hardware** I am a fifth year Electronics Engineering student currently enrolled at Simon Fraser University. With previous co-op experience at VTech Telecommunications, I have a strong grasp of theoretical and practical aspects of the consumer-end telecommunications industry. My area of study is focused on hardware applications and implementation and I have a keen interest in the field of high frequency electronics. With practical experience in PCB layout and distributed system analysis, I have a strong sense of system requirements and potentially problematic areas. Besides engineering related topics, I am also interested in English literature and have significant experience with both technical and non-technical writing styles.
	**Paul Carriere, CEO** I am a fifth year Engineering Physics student at Simon Fraser University. Currently, I have one year's worth of industry experience working at D-Wave Systems and Lighthaus Logic. During my work terms, I developed integrated testing and prototype systems. My expertise is electronic hardware with experience in schematic and PCB layout; PCB fabrication; advanced electromechanical assembly; noise reduction techniques; I^2C bus protocols; analog electronic theory, design and measurement; component ordering and software simulation. During my second work term at D-Wave Systems, I was the principal tester and designer for a new cryogenic IO system. I consider myself a quick learner with a keen sense of project development. I have a considerable network and presentation experience which I have developed through volunteering with Engineers without Borders. My career goal is to become a research engineer in the field of superconducting electronics.
	**Daniel Galeano, CFO** I am a fifth year Electronics Engineering student at Simon Fraser University. I have important work experience in the SFU robotics department, which helped me developed strong programming and documenting skills. I also worked with storage devices at PMC-Sierra. As part of the product validation team, I became proficient at performing and documenting regressive and structural tests. By volunteering with Engineers Without Boarders and the SFU residence, I gained valuable leadership and organizational experience to bring to Perceptum. Last but not least, my participation in competitions such as the Western Engineering Competition, allowed me to acquire efficient project management skills and a dynamic team-work spirit.

8 Conclusion

Novus Tabula is simple and robust. It is an easy-to-use device with challenging lessons in circuitry which introduce the essentials of electronics. The learning module approach allows for flexibility in integrating new technologies into the system. This novel product is being developed by four outstanding engineers with broad hardware and software experience.

In order to make knowledge of technology as easily accessible as technology itself, better education tools are necessary and must be introduced at the secondary level. Technology is evolving at a break-neck pace and the methods of teaching must keep up. To achieve these goals, Novus Tabula can and will provide the necessary environment for students to adapt and thrive in our modern society.

9 Appendix

9.1 Glossary

DAC: Digital to Analog Converter
ESSEF: Engineering Science Student Endowment Fund
GUI: Graphical User Interface
IC: Integrated Circuit
I^{2}C: Inter-Integrated Circuit bus protocol
KCL: Kirchoff's Current Law
KVL: Kirchoff's Voltage Law
LED: Light Emitting Diode
PCI: Peripheral Component Interconnect

9.2 References

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