Data Gathering From Educational User Devices: A Learning Framework for the Inicio Organisation

SIMON ÖHMAN
Abstract

Sweden is currently going through changes in curricula, syllabuses and subject plans for elementary school and upper secondary school in order to adapt to the growing need of digital competence in the society. Inicio is an organisation that strives to help schools adjust to these changes in strategy. Inicio arranges events where students can work with educational user devices, designed to educate the user in specific areas.

Inicio wants to understand how their users learn, while using the educational user devices. This report answers that question through the use of a learning framework that describes how usage data can be collected and analyzed. In addition, the framework allows analysis of both the devices and the events themselves. This gives Inicio the ability to measure the quality of what they provide and make improvements where necessary. The framework is built to be general enough to be applicable for future areas that Inicio may want to expand into.

The finished framework is the result of an iterative process where applicability, scalability and ease of use have been the main focus. This report provides results in the form of the framework, two dream scenarios, an implementation example for a current device, documentation and a visual aid to simplify the use of the framework. The dream scenarios are made up use cases designed to test the framework for future products in both hardware and software environments.

Keywords: Quality Assurance, Data Collection, Learning Analytics
**Sammanfattning**

Sverige går för närvarande genom förändringar i läroplaner, kursplaner och ämnesplaner för grundskolan och gymnasieskolan för att anpassa sig till det växande behovet av digital kompetens i samhället. Inicio är en organisation som strävar efter att hjälpa skolorna att anpassa sig till dessa förändringar i strategin. Inicio arrangerar events där eleverna kan arbeta med pedagogiska användaranordningar, utformade för att utbilda användaren på specifika områden.

Inicio vill förstå hur användarna lär sig, medan de använder de pedagogiska användaranordningarna. Denna rapport svarar på den frågan genom att använda ett inlärningsramverk som beskriver hur användningsdata kan samlas in och analyseras. Dessutom möjliggör ramverket analys av både enheterna och eventen i sig. Detta ger Inicio möjligheten att mäta kvaliteten på vad de tillhandahåller och utföra förbättringar vid behov. Ramverket är byggt för att vara generellt nog för att kunna tillämpas på framtida områden som Inicio kan vilja expandera till.

Det färdiga ramverket är resultatet av en iterativ process där anvendbarhet, skalbarhet och användarvänlighet har varit huvudfokus. Rapporten erbjuder resultat i form av ramverket, två drömscenarier, ett praktiskt exempel för en aktuell anordning, dokumentation och ett visuellt hjälpmedel för att förenkla användningen av ramverket. Drömscenarierna består av användarfall som är utformade för att testa ramverket för framtida produkter i både hårdvaru- och mjukvarumiljöer.

Nyckelord: Kvalitetssäkering, Datasamling, Learning Analytics
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1 Introduction

The first chapter begins with the reasoning behind this project. The background section describes the events that lead to the creation of the organization that owns the project. The problem section describes the problem that the organization needs help with. The purpose and goal sections defines and itemizes the deliverables for the project. The benefits, ethics and sustainability chapter explains who the benefactors are and shortly discusses the ethics and sustainability parts of the project. Finally, the methodology section describes how the project will be done.

1.1 Background

The 9th of March of 2017, the Swedish government decided on clarifications and reinforcements in curricula, syllabuses and subject plans for elementary school and upper secondary school[1]. The decision was based on the results of a mission given to the Swedish national agency for education, in order to adapt to the growing need of digital competence in the society [2]. The changes are to be applied by the first of July, 2018 at the latest.

Inicio is an organization that strives to help schools adjust to these changes in strategy[3]. Inicio designs educational user devices and arranges events where students can use these devices to achieve certain educational goals. These devices are designed to be simple enough to be used by children in various ages.

When the author of this report first came in contact with Inicio, they were looking for someone to ‘give them the ability to understand how users learn, while using their devices’. There were no specifics or delimitations set, but the use of data gathering from their devices was suggested. Through the initial phase of the project, the idea of a general framework came to light. One that works not only for current devices, but also for new devices and or services.

1.2 Problem

In order to improve their educational user devices, Inicio wants to understand how students learn while using them. There is currently no framework that analyzes how Inicio’s products are used and what the users are learning from it. What kind of usage data is relevant for learning? How do you measure how people learn?

1.3 Purpose

The purpose of this project is to give Inicio the ability to understand how students learn while using their products. In order to provide that ability, a framework will be set up to manage data on how the devices are used. What data is relevant, how to gather it and how to analyze it will form the framework.
1.4 Goal

In order to fulfill the purpose, the main goals are to:

- Set up a framework for what usage data is relevant and why
- Set up framework documentation to simplify its use
- Present the work in oral and written form
- Finish the project by September, 2017

1.5 Benefits, Ethics and Sustainability

The main benefactor of this project is Inicio. They will get the benefit of improved device understanding which will allow them to create better, more suitable devices.

Indirectly, the children in the Swedish elementary school and upper secondary school benefit from this project. As Inicio is able to produce devices more suitable for teaching, the children are given a better chance at learning.

The main ethical issue is that people may alter their behaviour if they know that they are being observed[4]. In order to get reliable data from the users experience with the devices, they need to be focused on what they are doing. At the same time, neglecting to inform the users that their activity is monitored can make them feel uncomfortable. There are articles discussing the ethics of this type of data collection [5]. This framework will not gather personal data about the users, in order to remain ethical.

In order to provide proper sustainability, the project aims to build a framework that not only can be applied to current devices at Inicio, but also to devices that will be developed in the future. That means that the framework needs to be sufficiently general, but also adaptable to changes in strategy.

1.6 Methodology

Building a framework requires a deep understanding of all the different parts that together form the framework. In order to achieve that, a literature study will be performed to provide an understanding of what needs to be done. The literature study will focus on the areas of the psychology of learning, data collection from electronics and framework design.

After the initial literature study, a first draft will be created to lay the foundation of the framework. Throughout the project, this first draft will be updated through an iterative approach as new information arises. The framework will then be polished and presented to Inicio.
The framework documentation will follow a similar approach as the framework. Alongside the first draft of the framework, documentation and visualization methods will be created, describing how the framework works. They will be iterated through alongside the framework iterations.
2 Background

When this project started out, there were no specifics set. Inicio wanted the ability to understand how their users were learning while using their products, but the 'how' of it all had many potential alternatives. After some research, two major choices remained.

The first choice was to continue working on one of Inicio’s existing products, 'The BubbleNode', granting it the ability to collect and analyze data on how it is being used. This project seemed prominent in that it could have a direct impact, delivering trustworthy information within a short period of time. The downside of this idea is that it would only apply to one current product.

The second choice was to build a general framework for all current and future products of Inicio. This would have no immediate impact on the Inicio organization, but rather lay the foundation for future products and potential modifications on current products.

Both projects were interesting to Inicio, but there would not be enough time to finish both. A compromise was reached where the second choice, the general framework, would be performed with a detailed example on how the framework could be applied to 'The BubbleNode'.
3 Methodology

This chapter defines the process behind the research study, framework and the documentation of the project.

3.1 Research Study

As stated in the introductionary methodology section, this project focused on three areas of research, namely:

- Psychology of learning
- Data Collection
- Framework Design

In addition, the area of User Experience (UX) was added to help understand the design behind Inicios products and to ensure that the framework gets a format that is suitable to Inicio.

Psychology of learning - Understanding how people learn is not an easy task. The experience differs between people depending on many factors. Therefore this study focused on understanding how to define reasonable goals for levels of understanding. This could for example mean that a person who has performed a certain level of a task, has learned what it means to perform that task. If for example the goal is to learn how to solder, then we can define the lesson as learnt if the user has finished soldering a certain amount of solder points. The area of learning analytics has been of great interest when performing this part of the research. The 1st International Conference on Learning Analytics[6] has provided a widely accepted definition of the area as:

Learning analytics is the measurement, collection, analysis, and reporting of data about learners and their contexts, for the purposes of understanding and optimizing learning and the environments in which it occurs.

Data Collection - Understanding how data is stored and how it can be extraced was key to making reasonably priced suggestions of implementation to Inicio. Therefore this study focused on looking at alternatives on how to manage data at as low a cost as possible. This part of the study relied heavily on looking at different technologies on the market, comparing their costs and effectiveness and discussing them with experts working in the area of electronics. Not all usage data can be gathered by the devices and some must be observed. According to multiple sources [4],[7], subjects behave differently if they know they are being observed, depending on the observer. In order for the data to be reliable, this must be taken into consideration for the observed data.

Framework Design - ‘Framework’ is a term used loosely to describe a packaged solution. This part of the research focused heavily on looking at various
existing frameworks for pros and cons. It was clear that Inicio wanted a simple framework that is easy to use, but also able to scale up for future markets. Which parts should build this framework was a priority of this research. The book *Observing the user experience* by Mike Kuniavsky[8] was very helpful when designing the framework. It details the how to set up, perform and analyze the results of a general usability test.

*User Experience (UX)* - It was suggested by an Inicio employee that the area of UX should be included in the research. Along with this recommendation was a book, *The Design of Everyday Things*, by Donald A. Norman[9]. Understanding the meaning and reasoning behind the book allowed for a deeper understanding on how Inicio design their products.

3.2 The Framework - An iterative process

In the early stages of the research study, several simplified framework ideas came to light. They were compared to each other in regards to applicability, scalability and ease of use. They were improved upon many times over. After some time, there were two remaining candidates.

The first candidate can be found in Appendix A. It featured a structure with three layers, starting out general in the top layer and going more specific in layers two and three. The idea was that the different parts of the structure would hold relevant functionality for that type of product. For example, if the product is a piece of hardware meant for self assembly by the user, it would inherit from the the ‘Self built’, ‘Hardware’ and ‘General’ parts. The biggest benefit from this type of structure is that it allows distinction between different types of products.

The second candidate can be found in Appendix B. It featured a structure with three stages: ‘Define’, ‘Gather Data’ and ‘Analyze’. The ‘Define’ stage was intended to be performed once per product, documenting who it was for, its purpose and a list of functions to measure. The ‘Gather Data’ stage was intended to describe the process of gathering data and observing issues with data collection. The ‘Analyze’ stage was intended to analyze the data collection from an event, along with the event itself. It suggested that any observed issues should be presented as goals for improvement. The biggest benefit from this type of structure is scalability.

After discussions with Inicio, it was decided that the second candidate was the best choice. The idea was that the first candidate would probably suit Inicio’s current products well, but prove problematic for future products. The second candidate was more general and built to be adaptable to future products.
3.3 Documentation

When there was just one framework idea remaining, a simple documentation was produced, covering the basic aspects of the questions and functions that built the framework. As the framework became more stable, so did the documentation. Along with the documentation, a visual aid was created to ensure simplicity and efficiency of the framework.
4 Results

This chapter contains the results of the project. 4.1 explains the various parts that together form the framework. 4.2 contains the documentation behind the framework. Finally, 4.3 describes the visual aid that supports the framework.

4.1 The Framework

The purpose of this framework is to design an environment that allows Inicio to understand how their users learn. The usage data subsection describes how usage data is defined within the framework, why it is relevant and how it can be used. The implementation subsection delves deeper into different project types and how usage data applies to each of those specifically. This is followed by three examples. One for a current Inicio project called The BubbleNode, followed by two so called ‘Dream Scenarios’. The Dream Scenarios are made up use cases to test the adaptability of the framework for future environments.

4.1.1 Usage Data

Usage data is all the data that can be gathered from the first to the last interaction a user has with a system. Search engines, for example, commonly analyze usage data to determine the relevancy of query results. In this framework, we use it to try and understand how the users learn. How much time a user spends with a certain task, what tasks they struggle with or maybe what tasks they return to. There is no simple universal answer to what usage data to gather. Depending on the type of product or event, different user data will need to be analyzed.

4.1.2 Implementation

The framework is built to be general enough to manage not only current projects, but also future potential projects. This report analyzes three different types of projects; hardware, software, and educational seminars. Inicio are currently focusing on hardware projects but are looking at expanding into more areas.

How usage data is managed differs a lot between the different project types. For each of these project types, methods for storing, gathering, extracting and analyzing usage data are looked into.

Hardware

Hardware projects are physical, users can see them, touch them and perform certain actions on them. They can be products that the users build during an event and then take home with them, or some kind of learning hardware that the users use during an event before returning them. In order to understand how users learn while using a piece of hardware, we need to get reliable data on how they are being used. It is difficult to gather data before the devices are
connected to a power source and activated. This means that if the hardware project contains an assembly phase before the device is usable, that one needs to be observed by a third party, as data won’t be automatically generated. Extraction of data from hardware devices can be done in different ways. If the device is permanently connected to a network over cable or wireless, data can be gathered automatically as the device is being used. More likely however is that the device only has basic networking capabilities.

Take for example the BubbleNode. For ease of analysis, let’s define the project as having two phases; the first one being assembly and the second phase being device usage. During the assembly phase, the users are given a plastic bubble containing various electronic components meant for assembly through soldering. Usage data can be stored on board and gathered as the device is being used. Before the battery is connected however, there is no way to store data. We can not ask the device to log the time it takes a user to solder a resistor or to determine how long it takes the user to put a certain chip on with the correct orientation, or how many ways they tried it. For this phase, we must rely on the perception of the soldering instructors who observe how the users react to the process of assembly. It is first when we reach the second phase that we can start automatically gathering reliable usage data. For the entire interaction phase, we can log usage data on how the device is being used. The automatic collection provides irrefutable numbers on the usage of each device.

Software
A software project is a computer program, run either at a local event or remotely, from any computer. The program can track usage data as the user uses the program, and automatically upload the information either while running or as part of the program’s shutdown sequence.

Seminars
Seminar projects cover the area of teaching seminars. This means there is no specific hardware or software that the attendees are using. This sort of project introduces problems when it comes to usage data gathering, as there is no easy automatic way to do it.

4.1.3 The BubbleNode Example
The full BubbleNode Example can be found in Appendix C.

The BubbleNode is one of Inicios' current projects. It’s a plastic bubble with various components (resistors, transistors etc.) that users can solder together into a finished BubbleNode. The BubbleNode interacts with other BubbleNodes via IR and shows a colored light depending on the type of BubbleNode it interacts with.
4.1.4 Dream Scenarios

Dream scenarios are made up use cases. In order to prepare the framework for future devices or services, semi-detailed use cases are made up. The purpose of the dream scenarios is to test the framework for different types of events to ensure that the framework is adaptable to new environments.

Make-The-Robot-Dance
The full Make-The-Robot-Dance dream scenario can be found in Appendix D.

The purpose of this dream scenario is to test the framework on a general hardware project. Being a hardware project, it is similar to The BubbleNode project, but there are some big differences. For one, The BubbleNode is meant to be taken home at the end of the event, where the Make-The-Robot-Dance project keeps all hardware. This allows for a bigger investment in the hardware cost, allowing more means of data collection and extraction.

Village Manager
The full Village Manager dream scenario can be found in Appendix E.

The purpose of this dream scenario is to test the framework on a general software project. This is not currently an area that Inicio is present in, but it is one that is possible to expand into. The Village Manager project strives to offer an example of a project that gives children the ability to try programming in a safe environment with very basic commands. It can be scaled to allow more levels of programming for more advanced studies, or to test how far students can understand.

4.2 Documentation

The full documentation can be found in Appendix F.

The framework documentation gives a detailed description for the parts that together form the framework. The Project definition, data gathering, data analysis and improvement sections are explained to give the reader an understanding on how to use the framework. The documentation can be used favorably together with the framework visual aid (described below) to provide an understanding of the framework.

4.3 Visual Aid

The full Visual Aid can be found in Appendix G.

The visual aid is meant to provide a quick overlook on the entire process that the framework is built for. The whole idea of the framework is that is is supposed to be easy to use. The visual aid provides the steps necessary to complete each
stage of the framework. It can also be helpful in cases where certain work is outsourced to people who are not entirely familiar with the framework, allowing them to take responsibility over certain tasks.


5 Discussion

In this chapter we will explain, analyze and discuss the results stated in chapter 4 and the approach to the results will be justified. The aim of this dissertation is to give Inicio the ability to understand how their users learn, while using their products. The results chapter provides us with the three pieces needed to give Inicio this ability.

The Framework is the collection of rules and definitions that together form the system that allows Inicio to measure the levels of understanding a user of a product has. It builds on the event based activities of Inicio. The framework has been built through iterations of improvements throughout the course of the project.

The Documentation explains the different parts of the framework, why they exist and how they should be approached. The documentation has been improved on through iterations alongside the framework itself.

The Visual Aid provides a quick overview of the process of understanding how to use the framework. The visual aid contains twelve tasks that can be delegated in order to efficiently plan work.

This solution is meant to work for Inicios target group, which is young people in Sweden. This thesis does not analyze whether or not it could be suitable for user groups outside this age range or geographical location. It could likely be used by similar organizations in countries where the educational level is on the same level as in Sweden, but that lies outside the scope of this project.

This solution could possibly be adapted to other projects where usage data could be gathered efficiently. The biggest change would be how the functions of a product should be measured. If for example older students of a higher education would use devices similar to those of Inicio, then the function measurements would need to be adjusted for that level of learning goals.
6 Conclusions and Future Work

This chapter provides the final conclusions of the project, along with future work made possible by this project.

6.1 Conclusions

This project started with the idea that Inicio wanted to understand how their users learned, while using their educational user devices. The work described in this report has given Inicio the ability to define clear learning goals, and measure how well these goals are being met.

By being able to define learning goals and measure how well they are being met, Inicio is able to measure their ability to help schools adapt to the changes in Swedish elementary and upper secondary schools. In addition, the ability to measure how their devices are being used, Inicio now has an improved ability to improve their devices. By being able to collect reliable measurements, Inicio can now compare the results of different events where their devices are being used. They are also able to make changes to their devices and compare the measurements from before and after the changes, to see their impact.

6.2 Future Work

This framework lays the groundwork for several future projects. Consider the framework a 'how-to' on understanding how users learn. The actual implementation on Inicio products remains. This report suggests 4 future projects that either Inicio themselves can perform, or another student for the master thesis.

Software Project Implementation
This project aims to expand the framework to accommodate software projects. This could for example mean creating some basic software to act as an example to work on. If the software could be worked on locally at an event, and remotely without mentor supervision, different usage data points may be needed. Defining common ground and differences between the two could lay the ground for future Inicio software projects to build on.

Teaching Seminar Implementation
This project involves a deeper analysis of how the framework can be applied to teaching seminars. Defining reliable usage data points and gathering trustworthy data is key here. It’s likely that the seminar attendees are more aware that their activity is being monitored than if a device or software is logging usage data in the background. A deeper analysis on how the seminar attendees react to the knowledge of being recorded may be warranted.
Current Hardware Product Implementation
This project suggests implementing the learning framework on one or more current device(s). This means defining data points, writing code for gathering the data, looking at data extraction method alternatives, implementing said extraction method and analyzing the results for feasibility.

Visualization System
When data has been gathered from a product, it needs to be analyzed. In order to be able to do that efficiently, the data needs to be easy to survey. Therefore a system needs to be implemented to present the data, automatically detect abnormalities and store information between iterations for later comparison.
References


Appendices
A  First Candidate
B Second Candidate

Framework Structure
Second Candidate

- Target Group
- Purpose
- List of functions

Gather Data
- For each function, how many users utilized it?
- For how long did users use the product?
- ... Observe issues

Analyze
- How did we feel it went as a whole?
- Did the gathered data match our expectations?
- ... Present observed issues as goals for improvement.
C The BubbleNode Example

This is an example of how the framework can be applied on the Inicio hardware product called BubbleNode. The BubbleNode device has the necessary hardware to implement the framework. One of the components of the BubbleNode is a chip that contains the software that allows the device to function. In order to implement this example, the software on that chip can be expanded to allow usage data gathering according to the suggested functions in the project definition. There are four suggested functions related to BubbleNode interaction in this example. In the software for each of those BubbleNode functions, code can be added to store information when a function has been performed. This allows us to measure what percentage of users have performed each specific function. At the end of the event, the collected usage data can be extracted manually via the on-board IR-sensor to a suitable source, such as an Inicio server. This example follows the 4-step process described by the framework.

The Project Definition suggests functions according to what the BubbleNode is programmed to do. Each function in the project definition corresponds to the functionality of the BubbleNode device. The estimates are expectations on the device, largely based on the authors experience with a previous BubbleNode event. A BubbleNode event is divided in two phases; assembly and product interaction phases. The assembly phase contains the functions that occur before the device has a connected power source. The device is not able to automatically collect data during this phase. The product interaction phase begins when the power source is connected and usage data begins recording.

Data Gathering gives an example of what the collected data could look like. The number of attendees at an event should be manually recorded for later comparison with the number of uploaded data sources. If the number of attendees differ much from the amount of devices that have uploaded their data, the data is less reliable. The collected data is presented in a table with green color for values inside the interval defined in the project definition, and red for values outside. After the table, example manual observations are presented.

Data Analysis is where we look at the data that has been collected during the data gathering step for all devices and compare it to our estimates from the project definition. In addition, we look at any important notes from our mentors about the event that can help us understand the data. For each function, we give a short explanation on how it went and why. A function that has performed inside the interval gets an OK status. A function that falls outside the interval sets its status to how far outside it is. There are some additional questions to evaluate the project as a whole. These questions are meant to help us evaluate if the event was successful and suitable for the target group.

Improvement contains suggestions for improvement. For each function in analysis where the status was not OK, an improvement should be suggested
to solve that problem. If the event was found unsuitable for the target group, suggestions should be made to either change to a more suitable target group or change the device to better suit the current target group. These improvements should be performed before the next event. If there are major changes to the device, the project definition may need to be changed accordingly.
Project Definition

Target group: Girls age 12-19

Purpose: Teach basic electronics and programming

List of functions:

- Assembly phase
  - Solder parts
  - Attach battery and test functionality
- Product Interaction phase
  - Interact with the same team
  - Interact with another team
  - Interact with mentor
  - Find unique twin

Function Estimates:

<table>
<thead>
<tr>
<th>Function</th>
<th>Function Name</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Solder parts</td>
<td>95-100%</td>
</tr>
<tr>
<td>F2</td>
<td>Attach battery and test functionality</td>
<td>95-100%</td>
</tr>
<tr>
<td>F3</td>
<td>Interact with same team</td>
<td>95-100%</td>
</tr>
<tr>
<td>F4</td>
<td>Interact with other team</td>
<td>85-90%</td>
</tr>
<tr>
<td>F5</td>
<td>Interact with mentor</td>
<td>95-100%</td>
</tr>
<tr>
<td>F6</td>
<td>Find unique twin</td>
<td>5-10%</td>
</tr>
</tbody>
</table>

Notes:

- F1-F2 needs to be managed manually as the device is not yet connected to a power source at this phase.
- F3-F6 can be automatically gathered by the BubbleNode. Remember that the participants get to keep their BubbleNodes so data extraction must be done before they leave the event.
- In order to incentivize the participants to upload their data, a drop-off station is introduced, The PartyTeddy. When the participants interact with The PartyTeddy, their BubbleNode repeats all the interactions it has done with a quick succession of blinking lights, creating a grand light show. In the background, the usage data is downloaded from the BubbleNodes to The PartyTeddy’s storage.
Data Gathering

Total number of participants: 96

Data collected from each function:

<table>
<thead>
<tr>
<th>F</th>
<th>Function Name</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Solder parts</td>
<td>98%</td>
</tr>
<tr>
<td>F2</td>
<td>Attach battery and test functionality</td>
<td>98%</td>
</tr>
<tr>
<td>F3</td>
<td>Interact with the same team</td>
<td>82%</td>
</tr>
<tr>
<td>F4</td>
<td>Interact with other team</td>
<td>25%</td>
</tr>
<tr>
<td>F5</td>
<td>Interact with mentor</td>
<td>95%</td>
</tr>
<tr>
<td>F6</td>
<td>Find unique twin</td>
<td>25%</td>
</tr>
</tbody>
</table>

Important Notes:

- Mentors in the soldering area noticed that there were not enough batteries for all participants, resulting in one device not being fully completed.

- A couple of the girls soldered the chip on the wrong way and none of the mentors knew how to correct the problem.
Data Analysis

Were there any major unexpected impacts on the event? If so, what?:
No. The event went according to plan, there were no power outages, no key personell missing or anything like that.

Look at each function, do the numbers match the expectations? If not, why?

<table>
<thead>
<tr>
<th>F</th>
<th>Function Name</th>
<th>Status</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Solder parts</td>
<td>OK</td>
<td>Soldering went as expected</td>
</tr>
<tr>
<td>F2</td>
<td>Attach battery and test functionality</td>
<td>OK</td>
<td>Small mishaps but nothing major, OK.</td>
</tr>
<tr>
<td>F3</td>
<td>Interact with same team</td>
<td>-13%</td>
<td>Instructions were unclear, some users didn’t know what to do.</td>
</tr>
<tr>
<td>F4</td>
<td>Interact with other team</td>
<td>-60%</td>
<td>Most users were not interested in interacting with others. They either did not feel it was rewarding or they were afraid to mingle.</td>
</tr>
<tr>
<td>F5</td>
<td>Interact with mentor</td>
<td>OK</td>
<td>Just about everyone interacted with a mentor.</td>
</tr>
<tr>
<td>F6</td>
<td>Find unique twin</td>
<td>+15%</td>
<td>More users found their unique twin than expected. It appears the chance is too high for these estimates.</td>
</tr>
</tbody>
</table>

Did we observe a behaviour of uncertainty in certain parts of the event? When?
There was some level of uncertainty during the soldering phase. There were instructions on paper at each work station, but they expected someone to tell them what to do rather than work on their own.

Was the project suitable for the target group?
Yes. The participants proved great at soldering, scared at first but most found it fun once they got started.

Was the purpose reached?
Yes.
Improvement

What parts of the event could be improved on?

Based on the analysis, there are 3 suggested improvements:

- Based on F3, instructions were not clear enough during the soldering event. After talking to the mentors on-site, it appears that there was no mentor designated to tell the users what to do, they were merely given the instructions on paper and expected to start. For the next event, we will make sure there is always one person responsible on-site to ensure things go according to plan.

- According to F4, the users were hesitant to interact with users from other teams. After talking to the mentors, it would appear that the users thought they were competing against the other teams and did not feel they should interact with them. This was not intended, in the future we can stop using the term “Team” and instead call them “Group”, and try pushing the idea of ‘finding their unique twin’.

- According to F6, a lot of users found their unique twin. The idea was to make it feel super rewarding and something to really work for. We can lower the chance of finding the twin to ensure our ideas remain.
D Make-The-Robot-Dance

The Make-a-robot-dance project features 20 robots that can be programmed to move their legs and arms in a number of set movements. There is a sandbox environment set up for the children to write simple code in to make the robot perform these moves. The environment does not allow coding outside of artificial limb-movement, ensuring the children only work on dancing and can safely work without fear of ‘messing up’.

The project allows groups of up to 5 per robot, resulting in 100 children per event. The robots log usage information that can be extracted after an event is finished.

**Target group:** Children age 12-19

**Purpose:** Teach basic programming and electronics

**List of functions:**

- **Start Robot (Flip the on-lever)**
  - Launch robot movement demo (The robot does a quick dance to show possible movements)

- **Programming**
  - Connect development environment to the robot (The robots voices ‘Connected’ when the connection has been made)
  - Send instructions to robot (Send any movement instruction to the robot to perform)
  - Send a loop-instruction to the robot (Make the robot perform a sequence of instructions a specific number of times)
  - Include all movements in one dance routine
  - Do the ‘stinky-leg’ (Find the easter egg movement!)

- **Error handling**
  - Send faulty instructions to the robot (Misspelled words or trying to send the robot on a murderous killing-spree. That’s not dancing.)

- **Shutdown robot**
  - (Send shutdown-instruction, robot voices ‘Goodbye, human’)
### Table 4: Function Estimates Make-The-Robot-Dance

<table>
<thead>
<tr>
<th>F</th>
<th>Function Name</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Launch robot movement demo</td>
<td>95-100%</td>
</tr>
<tr>
<td>F2</td>
<td>Connect development environment to robot</td>
<td>95-100%</td>
</tr>
<tr>
<td>F3</td>
<td>Send instructions to robot</td>
<td>95-100%</td>
</tr>
<tr>
<td>F4</td>
<td>Include all movements in once dance</td>
<td>5-10%</td>
</tr>
<tr>
<td>F5</td>
<td>Do the ‘stinky-leg’</td>
<td>1%</td>
</tr>
<tr>
<td>F6</td>
<td>Send faulty instructions to the robot</td>
<td>90%</td>
</tr>
<tr>
<td>F7</td>
<td>Shutdown robot</td>
<td>50%</td>
</tr>
</tbody>
</table>

**Notes:**

- Collection of data is done automatically over wifi to a server. Since the participants do not get to keep the robots, they can be fitted with slightly more expensive networking capabilities.

- For this type of project, it is important that the project mentors are projecting happy and positive thoughts to the users as programming may seem difficult, or scary even. Confident participants try more - and learn more.
E Village Manager

The village Manager project features a software game that allows users to write code for a small village. In its default state, the village has a number of idle villagers awaiting instructions. The users can then start ordering the villages to perform certain tasks. Each villager can be told to perform a set of tasks in a pattern; a loop. One villager could for example be ordered to chop wood and drop it off at the warehouse. Another villager could collect wood from the warehouse and create furniture or buildings with it. This teaches the user about resource management and touches a bit on parallel programming.

This project allows one or more users per computer to write code. The maximum number of users depends on the amount of available computers. An introductory tutorial allows users to work from home. The project separates on-site data from off-site data to allow analyzing of differences between mentor-led teaching and self teaching. This could provide a basis for understanding the importance of mentors.

**Target group:** Children age 12-19

**Purpose:** Teach basic programming

**List of functions:**

- **Basic**
  - Order a villager to perform any task
  - Give a villager a task loop (chop wood, drop off wood, repeat for example)
  - Create a new villager (Requires collected food. Almost just like in real life.)
  - Create a new building using collected resources
  - Upgrade a building using collected resources

- **Programming**
  - Put a wait condition on a task (Wait until there is wood in the warehouse for example)

- **Resource Management**
  - Have at least 5 villagers working task loops at the same time
  - Have at least 20 villagers working task loops at the same time
  - Stockpile a total of 25 resources
  - Stockpile a total of 100 resources
Table 5: Function Estimates Village Manager

<table>
<thead>
<tr>
<th>F</th>
<th>Function Name</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Order a villager to perform any task</td>
<td>100-100%</td>
</tr>
<tr>
<td>F2</td>
<td>Order a villager to perform task(s) in a loop</td>
<td>100-100%</td>
</tr>
<tr>
<td>F3</td>
<td>Create a new villager</td>
<td>90-100%</td>
</tr>
<tr>
<td>F4</td>
<td>Construct a new building</td>
<td>85-100%</td>
</tr>
<tr>
<td>F5</td>
<td>Upgrade a building</td>
<td>75-100%</td>
</tr>
<tr>
<td>F6</td>
<td>Put a wait condition on a task</td>
<td>80-95%</td>
</tr>
<tr>
<td>F7</td>
<td>Have at least 5 villagers working task loops at the same time</td>
<td>80-90%</td>
</tr>
<tr>
<td>F8</td>
<td>Have at least 20 villagers working task loops at the same time</td>
<td>20-40%</td>
</tr>
<tr>
<td>F9</td>
<td>Stockpile a total of 25 resources</td>
<td>50-80%</td>
</tr>
<tr>
<td>F10</td>
<td>Stockpile a total of 100 resources</td>
<td>20-40%</td>
</tr>
</tbody>
</table>

Notes:

- Collection of data done automatically over wifi to a server. The software can upload usage data as the participants play the game.

- By measuring how many users perform certain tasks, we get an understanding of what they understand. If there are not enough users utilizing wait conditions for example, it is a probable sign that it is either too advanced in its current state, or it does not seem rewarding enough.
F Documentation

Framework Documentation

This is the documentation for the Inicio Learning Framework. It contains implementation instructions for the framework and the four framework sections: Project Definition, Data Gathering, Data Analysis and Improvement. Each section gives a detailed description for the parts that build it.

The documentation is meant to be used alongside the Framework Visual Aid, explaining the steps and stages further. Together, they form the knowledge base needed to implement the framework.
Framework Implementation Instructions

Implementing the framework means defining the structures that allows the framework to work. Functions that match the teaching goals defined in the purpose of the project needs to be included. There may be multiple functions that match a specific teaching goal.

Looking at the Villager Manager example in Appendix E, F1 and F2 are required tasks to match the purpose of teaching basic programming. The functions that follow serve other purposes. F3-F5 are meant as control functions to check if the users are using the basic functionalities provided by the project. F6-F7 introduces a higher level of programming and is not expected to be understood by everyone. F8-F10 are meant to see just how far the users are able to go.

In hardware and software projects data gathering can be defined by writing additional code to say whether a function has been performed or not. By setting all functions to begin in a status of not having been performed yet, we can update their status to has been performed when the function is performed. If the function is performed again, we do not need to update the status.

Implementation differs between different types of projects in regards to usage data storing and extracting. Storing timing values for example differs in implementation between hardware and software projects. A piece of hardware can calculate the time it takes to perform a task based on the hardware clock. Software can time tasks using the operating system clock. Extracting the data depends on the networking capabilities of the project as well. A hardware device may be fitted with a wide variety of networking hardware that functions in different ways. A software product can upload usage data as it is being used if it is connected to the extraction location, otherwise it can be stored on the device that is running the software for later extraction.
Project Definition

When starting a new project, understanding the audience and defining a clear purpose allows for creating clear, measurable teaching goals. By making these definitions, Inicio can ensure a high quality in their products and provide reliable proof that their events teach what they are supposed to.

**Target Group** Understanding the target group is crucial. Different ages and levels of education demand different approaches to teaching. If the audience finds the tasks too difficult, they will be discouraged and will have trouble learning. If the tasks are too easy, the audience will not learn as much as they could have and may find the event boring.

**Purpose** Each product should have a clear purpose. It could for example be to introduce children to the areas of electronics or programming. By defining a purpose, Inicio will have the ability to create a portfolio of products to match specific needs.

**List of Functions** This is where we define the functions from which data will be collected. The functions are binary (either a user has completed a function, or they have not). It is possible to collect non-binary data from users, but it would be more difficult to analyze. This project uses binary functions for easier analysis.

One way of finding these functions is to break the purpose up in various sub-purposes. For example, if the goal is to teach basic electronics, then functions for soldering, understanding parts and using the assembled product could be relevant.

We can now define functions for each of these sub-purposes that, if completed, means that the user has understood that lesson. For example, if the user successfully finishes soldering, the user has achieved a basic understanding of how to solder.

Furthermore, certain functions can have multiple levels, in order to measure difficulty or how well something has been understood. In the Village Manager dream scenario (Appendix E of the report), there are multiple levels on certain functions. These functions have a basic level to prove understanding, and a higher level to measure if the users are outperforming the goals by a lot. These higher level functions are not meant for everyone to complete, but rather to check the level of difficulty. If most users are able to reach the higher level, then the difficulty can be raised in order for the users to learn more in the future.

**Function Estimates** Now that we have our list of functions, we need to define our estimates for completion. Functions that are required for a topic to be
considered as understood should be performed by near 100% of the users, as without these a lesson can not be considered as learned. Other functions that rather measures the performance of the event or device itself should have an appropriate estimate for the expectations. In the BubbleNode example (Appendice C), one function mentions finding the unique twin. When the users finish soldering their devices, they are instructed in how interaction works. One feature is that each device has a unique twin that will respond in a special way, if they are able to find it. This is meant to be something that drives the users, rather then serving as a specific learning goal. Therefore this function should have a very low estimate so that the users have something that keeps them going.

**Definition Notes** This is where Inicio can write important notes about the project. In the BubbleNode example (Appendice C), these notes concern reminders about how certain functions must be managed manually and information about how data collection will be performed. These notes help Inicio remember specifics about products and simplifies preparing events.
Data Gathering

This section covers all aspects of data gathering. In addition to the three steps shown in Stage 2 of the Framework Visual Aid (Appendix G), this chapter covers a more detailed description of data management and data gathering notes.

**Data management** There are many alternatives to how data can be collected, stored and extracted. Depending on the type of product, the focus could shift between the most economical or the most efficient way.

On hardware products, storage components have the ability to store different amounts of data. In general, the amount of data stored by this framework is very small and does not require a big investment. Collection varies depending on the device itself. The BubbleNode (Appendice C) for example can implement collection through the addition of programming code in a chip to collect usage data. Furthermore, the BubbleNode is fitted with IR-sensors with the capability of transmitting data, allowing the device to extract the data without further investment.

In the case of the dream scenario Make-The-Robot-Dance (Appendice D), data storage and collection works in a similar way but extraction has a different focus. Since the devices stays with Inicio, they do not have to be as economical. Instead, the devices can be fitted with more expensive wifi-connectivity components that allow usage data to be extracted as the devices are being used. This allows for the framework to work entirely in the background so that Inicio can focus on the teaching aspects.

Software products can manage usage data storage and collection to an Inicio server directly by having the clients connected to the server, either locally at an Inicio event or by the Internet. Extraction can be done as the user uses the software, or all at once as the user shuts down the program.

**Number of participants** In order to ensure reliable results, data needs to be collected from all users. Therefore it is important to check the collected data against the total number of users to ensure that data has been collected from everyone. Additionally, if there are several groups of users at once, the number of participants can be divided between the sub groups to get more reliable results for each group and allow comparison between them.

**Ensure participants ability to unload device data** If there is need for manual drop-off by the users, as in the BubbleNode example (Appendice C), we need to make sure that the users go through that activity. If they do not, we will not receive the usage data from everyone and the end result will be less reliable. It is still highly preferable that the participants are not aware that they usage is being logged, as that most likely will affect the way they use the devices.
Collect the data  Data is gathered for each function defined in the project definition. The data is compared to the number of participants to produce a percentage for how many of the users completed certain tasks. If those percentages are inside the estimates, the field will be marked green. If the percentage is outside the estimates, the field will be marked red. This step is entirely about collecting the data, without analysis.

Data Gathering notes  During the event, take note of events that occur that affect the gathered data. Maybe some participants had to leave, there were batteries missing or anything that should be known when analyzing the results. Do note that this information comes from talking to mentors about how they perceived situations they were put in. To make this information more reliable, ensure that there is someone responsible for each part of an event. That way it is clear who to contact for that information.
Data Analysis

This section explains how to answer the analysis questions and how to analyze usage data and the event in whole. In addition to the analysis of usage data functions, there are four major questions that help define the outcome of the event.

**Analysis questions and event feedback** The questions are there to give an overview of a finished event, allowing comparison between events or a quick overview of a specific event. They are meant to complement the usage data and explain reasons for possible errors.

The last two questions regard the event itself. They are there to make sure that the event is at a reasonable level and that the purpose of the event has been reached.

**Usage Data** Analyzing the collected data is done by looking at each function and trying to explain the outcome. If the usage data does not match the estimates, explain why. Look at the notes from the project definition and from the gathering itself. If there are uncertainties, speak with the people responsible for related parts and find out the reasons. If there were no major disruptions to the event itself, take an extra look at the expectations and make sure that they are reasonable. Everything that does not match the expectations should be brought up for improvements.
Improvement

This section covers the areas that are in need of improvement and defines what improvements should be performed.

**Event Improvement** If there are structural problems with the event, such as poorly defined responsibilities, unstable working environments for participants or other impactful problems, changes need to be made.

**Device Improvement** This is where you suggest improvements for the analyzed functions that were outside the estimates. Define the problem, explain the reason and plan the steps that should be taken to solve the issues.

**Perform improvements** If there are no changes to be performed, the device is stable and the event structure is working the way it should. That means that more events can be arranged without making any changes. If there are improvements scheduled, then they should be implemented before the next event is held. If changes are made to the device, update their version number for future comparison.
G The Visual Aid

**Inicio Learning Framework**

**Visual Aid**

- **Project Definition**
  - Stage 1
  - Determine the target group and purpose of the project
  - List the functions to be measured
  - Enter function estimates

- **Gather Data**
  - Stage 2
  - Collect the data
  - Ensure participants ability to unload device data
  - Document number of participants and age span

- **Analyze**
  - Stage 3
  - Answer the analysis questions
  - Analyze the results of the function data
  - Analyze the results of the event in whole

- **Improvement**
  - Stage 4
  - Perform improvements
  - Determine if and how to improve the device
  - Determine if and how to improve the event

If major changes have been performed, re-evaluate Stage 1 for changes.

When the improvements from Stage 4 are finished, return to Stage 2 to gather data from the updated version.