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DTU Compute
Department of Applied Mathematics and Computer Science

Investigating the understandability of the fragment-based case management approach

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Abstract

Business process management (BPM) uses various methods to discover, model, analyse, measure, improve, optimise and automate business processes. The BMP community has concentrated on modelling and executing processes that have a known structure and processes with a high degree of variability have limited support. Case management is a promising approach to overcome that deficiency. One variation of case management is to dynamically combine process fragments at runtime (also referred to as fragment-based case management approach). That hybrid approach allows for more flexible case modelling. However, so far research on how people read, understand, and engage with the models created following the fragment-based case management approach is in its early stages. This project aims at investigating how people approach and engage these kinds of models using an eye-tracker, and what the advantages and inconveniences of such a representation are.

The results show that fragment-based case modelling is seen to reduce complexity and improve the readability of business process models. Results also show that the models are clear and understandable to people with no prior knowledge to BPM. The conclusion is that fragment-based case modelling with Gryphon is on the right path and with further improvements to Gryphon and Chimera such as full support of BPMN 2.0 it is well suited to model variable business processes.

Preface

This thesis was prepared at the department of Applied Mathematics and Computer Science at the Technical University of Denmark in fulfilment of the requirements for acquiring a M.Sc. degree in Computer Science and Engineering. The thesis was supervised by Professor Barbara Weber with additional help from PhD student Amine Abbad Andaloussi. This work summarises the thesis project that was carried out in the period of January to April 2019.

April 17, 2019

Skúli Skúlason

Acknowledgements

The process of this thesis has been long and difficult. It has taught me a lot about my self and showed how I am surrounded by good people. People that are willing to help and assist in any way so I can follow my dreams. There are a lot of people that I ow gratitude to.

I want to think my supervisor Barbara Weber for all the support and feedback. I also want to think Amine Abbad Andaloussi for his help in every aspect of this project, all the feedback and guidance he gave to me during this project.

My deepest gratitude to the consultant company Efla and specially to the manager Einar Andrésson for giving me an office space, coffee, and most important companion and friendly environment to work in. With out the help from you I would not have been able to finish this project from Iceland.

And lastly I want to think my family for their love and support through out this journey. This would have been impossible with out your help.

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Skúli Skúlason

Contents

CHAPTER 1

Introduction

Business Process Management (BPM) is a way to oversee how work is done in an organisation, to make sure that the desired outcome is consistent, and to realise improvement opportunities[5]. BPM uses various methods to discover, model, analyse, measure, improve, optimise and automate business processes[13]. Those improvements include, e.g. reducing costs, reducing execution times, and reducing the error rate. BPM is not about improving only activities. Instead, it is about managing all individual components that together built up a process. Those components are, e.g. events, activities and decisions[5]. The BPM community has been focusing on developing tools to model and execute business processes that have a known structure and limited variation[9]. A highly variant process, e.g. event-driven processes are challenging to model in a structured way because there is no certainty when or if an event occurs. The BPM model quickly becomes large and complex when trying to model variable processes.

To make up for the shortcomings of BPM regarding variable processes a case management system that uses process fragments and dynamically combines them at runtime has been developed. This approach is also known as fragment-based case management (fCM) and the main difference from traditional workflow approaches is the dynamical combination of fragments at runtime[9]. The fragments are meant to be simple and easy to add, but there can be many fragments. The fragments are combined with data objects. Each data object has a lifecycle that is built up like a state machine to ensure that the progress rules of the process are followed. Knowledge workers then handle the progression of the process. The Business Process Technology Group has developed a formal method that uses fCM at Hasser Plattner Institut in Potsdam Germany[1]. The formalisation of the approach has also helped to develop tools to model and execute fCM models, Gryphon[2] is a modelling tool and Chimera[3] is a case engine where the models modelled in Gryphon are executed, for details see Chapter 2. Researches about models that are modelled with fCM are still in its early stages. With the help of an eye-tracker, this project aims at investigating how people read, understand, and approach these types of models. The research question thus is:

[1] https://hpi.de/
[2] https://bpt.hpi.uni-potsdam.de/Gryphon
[3] https://bpt.hpi.uni-potsdam.de/Chimera

How do people read and understand fragment-based case models?

A scenario that is variant-rich, goal-oriented, and data-driven was designed for this exploratory study. Those kinds of scenarios are well suited to be handled by knowledge workers [9]. The scenario is explained in (cf. Section 3.2). From the scenario, questions were developed for the participants to answer while they were monitored by eye-tracking equipment and a galvanic skin response sensor (GSR). The questions were designed to grasp all the major components of fCM as well as be suitable for people with no prior knowledge of BPM. The data gathered in the exploratory study is analysed with process mining tool and with qualitative data analysis. The results from the questions together with the data analysis show that fCM is on the correct path, the participants found it understandable and some of them thought it could be useful to reduce complexity and add clarity to the models of business processes. It is suitable for experienced as well as inexperienced engineers who want to model a business process.

1.1 Report structure

The report is structured as follows, in Chapter 2 the background and the necessary technologies and tools to create a fCM model and analyse data are explained. In Chapter 3 the exploratory study design is described, a scenario is introduced, and the model and questions that were created based on the scenario are outlined. It also describes how data was collected, prepared, and analysed. In Chapter 4 the results of the exploratory study are outlined and the results are discussed. Finally Chapter 5 concludes the thesis with a discussion about the results as well as future work.

CHAPTER 2

Background

This section gives an overview of the fragment-based Case Modelling (fCM) approach as well as the components used to perform this exploratory study. It starts by explaining the fCM approach and lists an overview of the concepts used by fCM. It then explains the tools used to execute the scenario. Three main tools are used for that, an event processing and monitoring platform called Unicorn (cf. Section 2.2.3), an engine for executing fragment-based case models called Chimera (cf. Section 2.2.1) and a case modeller tool called Gryphon (cf. Section 2.2.2). It then explains the components used for the eye-tracking exploratory study, it has two fundamental components, an eye-tracker called Tobii (cf. Section 2.3.2), and a Galvanic Skin Response (GSR) (cf. Section 2.3.3) tool from Shimmer. Finally it briefly explains the tools (cf. Section 2.5) that are used to analyse the data as well as preparing the data for the exploratory study.

2.1 Fragment-based Case Modelling

Case models are specified by several process fragments, which are structured pieces of work that are dynamically combined during case execution based on data objects and their states[9]. This approach is suitable for the flexible nature of knowledge work and at runtime multiple valid executions paths of a process can be executed from case instantiation to case termination[9].

2.1.1 Case Model

Business scenarios are captured in a case model that consists of a domain model, process fragments, object lifecycles, and a goal state[9]. A case model is instantiated into a case. The case represents the scenario at runtime and case exhibits the notation case state that changes over time, mainly through knowledge workers performing activities[9]. Cases are like process instances in traditional workflow systems. The difference is cases are made up of several fragments instances and data objects[9].

2.1.2 Data and Lifecycles

The data in this approach is encapsulated in data objects. These data objects make up the domain model. The domain model is then a part of the case model. The data objects all have a data class. The associations of the data classes can be depicted in an UML diagram. When the relation of the data classes is organised one of the data classes will become the so called case class and hold reference to all the other data classes[9]. The behaviour of the data classes is then handled by a transitioning system called lifecycle. The lifecycle of each data class specifies the valid states the data class can be in and transition to and from. The graphical notation of lifecycles is represented by the usual notation for state transition systems.

2.1.3 Fragments and Activities

The main difference from traditional workflow approaches is to split the process into smaller fragments and then combine them at runtime[9]. Each fragment consists of events, gateways, activities, and data objects just like BPMN process models. The fragments are controlled by pre-conditions. The pre-condition is then met by changing the states of data objects. Many instances of the same fragment can run in parallel. Individual fragments are meant to be simple and straight forward and then their interplay allows for complex behaviour[9]. Activities perform the work in the processes. When activities are executed they manipulate the data objects by switching their states. Activities can also have a pre-condition and they are not enabled until the pre-condition is met. A case finishes when particular data objects have reached the desired state.

To better explain how the concept and components of fCM work together lets look at an example. The example comes from the paper A Hybrid Approach for Flexible Case Modeling and Execution[9]. The example is built up on organising seminars at a university. The example shows two data objects and two fragments. The data objects are Seminar and Topic. The first fragment is for the seminar setup and uses the data object Seminar. The other fragment is for topic proposals and uses the data object Topic. Based on the different states of the Seminar data object the topic fragment can be instantiated and it can be instantiated multiple times so multiple topics can be suggested for each seminar. Figure 2.1 depicts the seminar fragment.

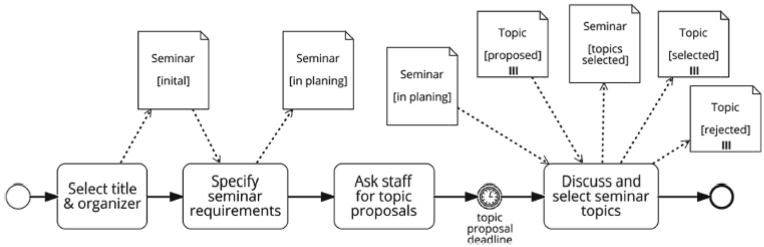

Fig. 3. Fragment for seminar setup

Figure 2.1: The seminar fragment. Source: [9].

The boxed paper items in the figure are the data objects. It shows the name of the data object and the state of the data object on the square bracket. The arrows in and out of the data objects show if it is a pre-condition or a post-condition. If it is a pre-condition the activity that has the arrow in is not enabled for execution until the data object is in the state specified in the square brackets. If it is a post-condition the activity that has the arrow out will alter the state of the data object to the state specified in the square brackets.
When the Seminar data object is in the state ”in planning” the topic fragment can be instantiated because Seminar in ”in planning” state is the pre-condition for the topic fragment. When the topic fragment starts and the Topic data object gets to the state ”proposed” the seminar fragment can continue and the ”discuss and select seminar topics” activity can be executed. Figure 2.2 depicts the topic fragment.

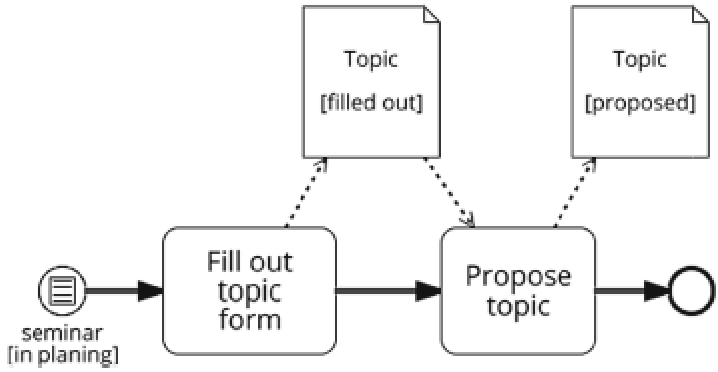

Fig. 4. Fragment for topic proposals

Figure 2.2: The topic fragment. Source: [9].

The possible states and transitions of the data objects in the example are depicted in Figure 2.3.

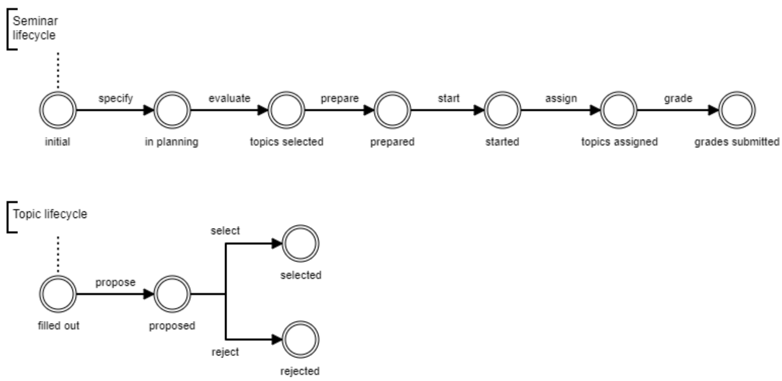

Figure 2.3: The lifecycles of Seminar and Topic data objects.

2.2 Modelling tools

This section briefly explains the tools used to create the model from the scenario, the execution engine used to execute the model, and the platform used to create the events so the model could be tested in a real life scenario.

2.2.1 Chimera

Chimera is an engine for executing fragment-based case models. These case-models are modelled using Gryphon. Once a case-model has been deployed to Chimera the case-model can be instantiated into a case. Cases can be started with events and they can also be started manually. Chimera offers a case overview page. In that page you can follow the case that was deployed to Chimera. The page has three panels, "Processing status" panel, "Log" panel, and "Case Conditions" panel. Those panels are displaying necessary information to the user such as active data objects and their current state, state transitions of tasks and data objects, changes in attributes, and the termination condition for the case. When that condition has been reached the case can be terminated with a "Terminate" button[7]. Figure 2.4 depicts an example of the case overview page in Chimera.

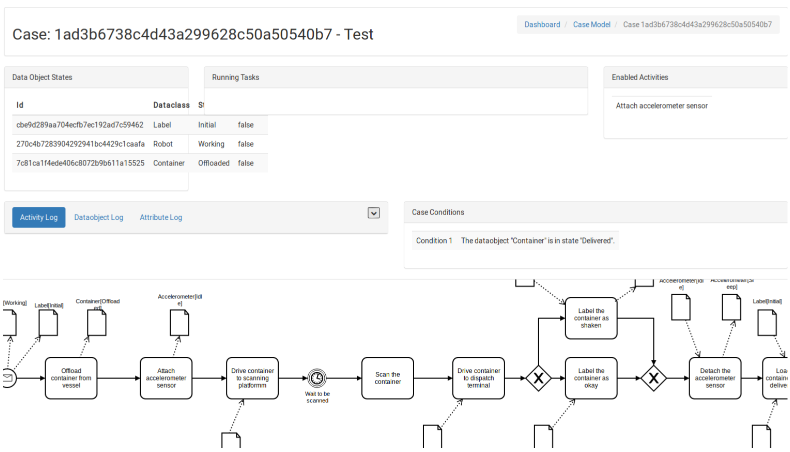

Figure 2.4: Case overview page in Chimera.

2.2.2 Gryphon

Gryphon is a tool to create the fragment-based case models that are used in Chimera. It is powered by bpmn.io[1] to model business processes. Gryphon has its own seman-

[1] `https://bpmn.io/`

tics, definitions, and rules that can differ from other BPMS systems. The formalisation of Gryphon is only a subset of the BPMN specification, the formalisation can be found in [9]. Being a subset of BPMN there are limits to what Gryphon has to offer, e.g it does not support all types of events or gateways. The basics of the case models that Gryphon creates are fragments that hold the execution steps, a domain model that holds the data definitions, a start conditions that defines the beginning of the case, and termination condition that defines the end of a case[8]. Figure 2.5 depicts the user front page for a case in Gryphon.

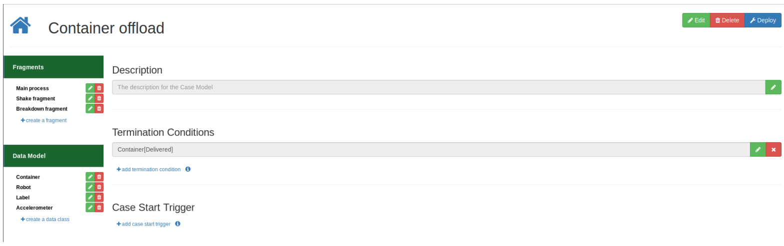

Figure 2.5: Gryphon user interface.

The front page of Gryphon shows the fragments and the data model that have been created for the case in the left panels. In the middle you can add a description, a termination condition, and start triggers. The start triggers can, e.g. be events that are generated from Unicorn. In the upper right corner you can deploy the model to Chimera.

2.2.3 Unicorn

Unicorn[2] allows one to capture real-world events from different sources. It processes those events from unstructured raw events to process events with aggregation or transformation rules that the user defines. The user can then set rules to those process events to correlate them to process instances. Furthermore, Unicorn can monitor processes. The user creates process models with BPMN that includes monitoring points. Those monitoring points then allows the monitoring processor of Unicorn to keep track of running process instances and their progress. Another part of the monitoring capabilities of Unicorn is the query processor. It utilises complex event processing (CEP) to monitor streams of events, and it can detect query patterns that have been specified by the user using an event processing language (EPL) called Esper Query Language[3].

[2] `https://bpt.hpi.uni-potsdam.de/UNICORN/EventGenerator`
[3] `http://www.espertech.com/esper`

2.3 Eye tracking

This section briefly explains the methodology behind eye-tracking, what eye-tracker was used in the exploratory study as well as how Galvanic Skin Response (GRS) was incorporated.

2.3.1 Eye-tracking

Eye tracking is the recording of eye position (gaze point) and movement on a 2D screen or in 3D environments based on the optical tracking of corneal reflections. Eye tracking reflects visual attention as it objectively monitors where, when, and what respondents look at. Eye tracking defines different types of eye movement to help with the analysis of the data collected with the eye tracking equipment. Algorithms with in the eye tracking software calculate and define these eye movements. One of those eye movements are fixations. They are the most common feature of looking at when performing an eye tracking experiment. Fixations are defined as when our eyes stop scanning and we start to take in the detailed information about what we are looking at[1].
For further analysis the stimulus showed to the participants is often split into areas of interest (AOIs). It defines regions in the stimulus allowing for events to be created such as: dwells, transitions, and AOI hits. Dwell time is defined as the time one visits an AOI, from entry to exit. Dwell time is known by many names one of them being gaze duration. Dwell time can only be calculated if the stimulus has been divided by AOIs. Often the definition of a dwell time is the sum of all fixation durations during a dwell in an AOI [10].

2.3.2 Tobii eye-tracker

The eye-tracker used in the exploratory study was Tobii Pro TX300. It is a screen-based eye-tracker that captured the gaze data at 300Hz. The exploratory study itself was then created in Tobii Pro Lab, a software that supports the entire research process from test design and recording to analysis[17]. The collected eye-tracking data can be analysed individually as well as aggregated and exported for quantitative analysis and visualisation. It is also possible to combine other data streams such as a GSR for physiological data.

2.3.3 Galvanic skin response

Galvanic skin response (GSR) is one of the most sensitive measures for emotional arousal[11]. GSR response reflects the variation in the electrical characteristics of the skin. Identifying skin conductance responses (SCRs) and take out their main characteristics is a well known procedure in GSR research[20]. SCRs are responses to a stimulus onset known as event-related skin conductance responses (ER-SCR)[20].

GSR is measured in micro-Siemens (μS) and it is a strong predictor of attention and memory because it can capture emotional arousal or the level of stimulus[20].

2.3.4 Shimmer

Shimmer is a GSR sensor and because it is a non-invasive device it requires little preparation or calibration[19].

Figure 2.6: Shimmer GSR sensor. (Source: https://www.ashokcharan.com/Marketing-Analytics/images/image312-18.png).

Figure 2.6 depicts how the Shimmer sensor looks and how the measurement electrodes are put on the fingers. Low voltage is applied and the electrodes measure the current between them so the skin conductance can be computed[19].

2.4 Qualitative data analysis

Coding is a technique to make data quantifiable, codes in qualitative research can give as vital information as quantitative numbers in a study[18]. When raw data is coded the goal is to identify concepts and finding relationships between them[21]. The codes then allows one to organise the data so it can be examined in a structured way[21]. From the raw data one can start to identify preliminary codes which then results in a final code that is a combination of all the preliminary codes.

2.5 Disco

Disco is a process mining tool. Process mining aims to discover, monitor, and improve processes. Using event logs from organisations it can extract knowledge easily. By doing that it is possible to detect and diagnose problems with in processes based on facts[14]. Disco creates process maps directly from raw data that displays activities with information such as absolute frequency, max repetitions, and max duration if the data includes those attributes. With Disco it is also easy to visualise the data so the users can spot bottlenecks in their processes. Disco also shows statistical data about the raw data that was imported. With the filters that are built into Disco you can filter out unwanted data as well as categorised the data for better analysis[6].

CHAPTER 3

Method

In this chapter, the exploratory study is outlined and explained. It starts by giving an overview of the eye-tracking experiment, what the experiment was and how it was performed. It then describes the scenario that was used throughout this project and then how the model is created from the scenario. Then it explains how the questions were designed from the model. It then describes how the model and the questions were used as a stimulus in the experiment. Then it talks about the pre-experiment form so background information could be gathered about the participants. It then shows the familiarisation task to get participants familiar with fCM. Then the think-aloud is outlined. It then explains how the data gathered had to be processed to make the analysis more manageable, and lastly, it shows how the data collected in the experiment were analysed.

3.1 The experiment

To investigate how people read and understand fragment-based case models an eye-tracking experiment was designed and performed. The experiment was held at the Department of Applied Mathematics and Computer Science at the Technical University of Denmark (DTU). It was conducted from the 14Th of February until the 19Th of February 2019 at building 322 room 211.

3.1.1 Participants

To get participants to participate in the experiment few approaches were used. First, a small text about the experiment and what background participants had to have to participate was created. Then an invitation to participate in the experiment was sent out to groups of people, former business process management students as well as to other groups in my network such as the Icelandic student community at DTU. To get some participants with a knowledge in business process management people from the Software and Process Engineering department at DTU were also invited. The background of the participants did no matter as long as they were or had been studying some field of Engineering or Computer Science. The aim though was to get some experienced participants within the BPM field so they could be compared to the participants that had no prior knowledge. Before the participants could participate, they all had to sign a consent form. Twelve participants participated in the experiment.

3.1.2 Experimental procedure

The experiment was built up with an eye-tracking software that collected the eye-tracking data. In the software the experiment is designed by adding stimuli to a timeline which is then presented to the participants in the same software. The stimuli in the experiment included a model that was modelled from the scenario in (cf. Section 3.2) and a question about the model that was mostly created from the constraints that were added to the scenario. The experiment displayed twelve questions to the participants; three of them had a and b part so in total it was fifteen questions. The participants would then answer the questions out loud, and that was recorded with a voice recorder. The answer to the questions could be found by looking at the different sections of the model. After the participants gave a solution, they could progress to the next question by pressing a key on the keyboard. Some participants accidentally pressed a key, or they pressed a key before answering the b part of a question which leads to some questions being invalid in the analysis. The questions came in a random order to avoid that the participants could learn from previous questions. Participants were also asked to put on a GSR (cf. Section 2.3.3) sensor to collect data about their cognitive load regarding the questions.

3.1.3 Instrumentalization

The software that was used in the experiment is designed to handle all aspects of an eye-tracking experiment. The experiment is first designed, then it is recorded, and then it can be analysed and the recording data can be exported. Tobii Pro Lab (cf.Section 2.3.2) provides all these features.

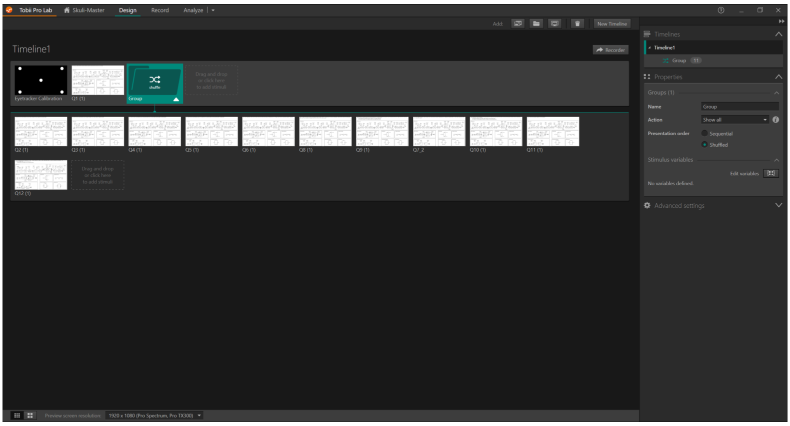

Figure 3.1: The design panel in Tobii Pro Lab.

Figure 3.1 depicts how the experiment was designed in Tobii Pro Lab. A new timeline is created and stimuli is added. The first stimuli in the experiment was the calibration of the eye-tracker, then question one because that question always had to be first as it asked the participants to describe the scenario that the model was showing, and then a group stimuli [3] was added so the questions could be shuffled. Each question is then added to the group stimuli.
After the experiment has been designed it can be recorded. In the record section of Tobii Pro Lab a participant is created and the eye-tracker that is connected is selected and the GSR sensor as well if that is used. It is also possible to record another recording for the same participant.

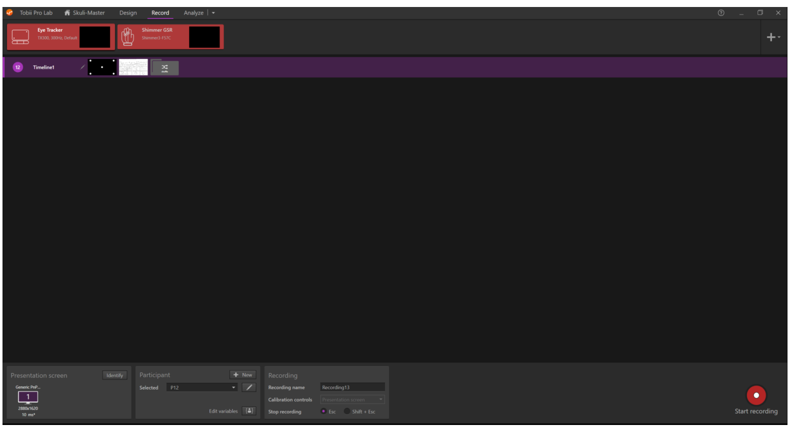

Figure 3.2: The record panel in Tobii Pro Lab.

Figure 3.2 depicts how record panel in Tobii Pro Lab looks. The timeline that was created it the design panel is shown as well as the eye-tracker and the GSR sensor. The final panel of Tobii Pro Lab is the Analyse panel. In the Analyse panel all the data from the recording can be analysed and exported. The analysis offers an area of interest tool (AOI) (cf. Section 3.9.1), a visualisation with heat maps and gaze plot, a metrics export, and data export.

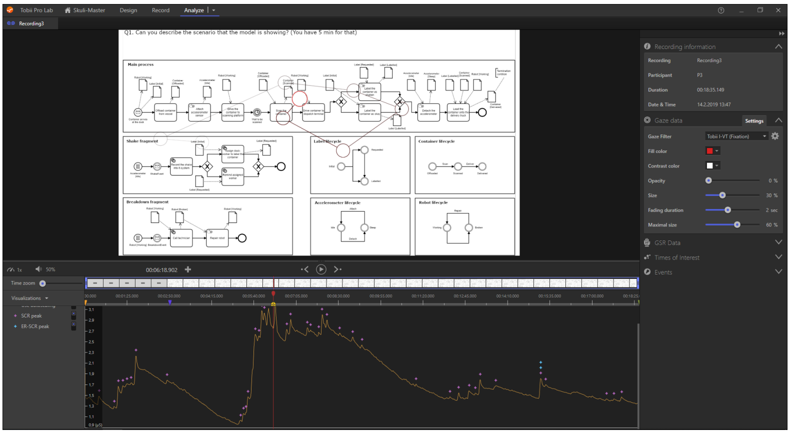

Figure 3.3: The analyse panel in Tobii Pro Lab where a recording can be analysed.

Figure 3.3 depicts an example of how the analyse panel allows one to visualise the recording after it has been recorded. It shows where the participant looked at the stimuli, it shows a red circles connected with lines. The circles represent the point where the participant was looking and the line shows how they connect so one can see the path of the participants eye movement. The Analyzis panel also shows a graph of the data collected with the GSR sensor, that graph is explained in (cf. Section 3.10.7).

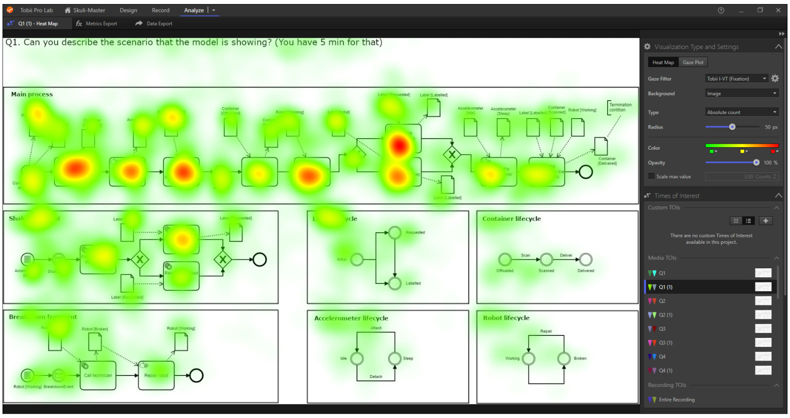

Figure 3.4: The analyse panel in Tobii Pro Lab where heat maps of recordings can be analysed.

Figure 3.4 depicts an example of how the analyse panel allows one to visualise a recording by showing heat map of the gaze data. In the right upper corner one can also select to see the gaze plot of the same data.

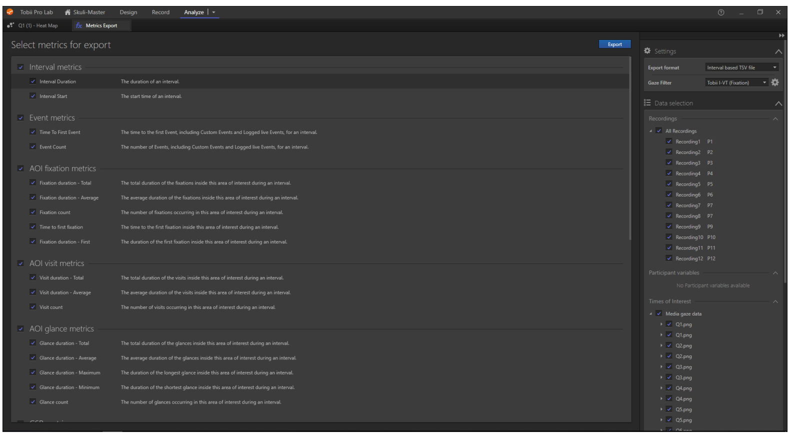

Figure 3.5: The analyse panel in Tobii Pro Lab where metrics of a recording can be exported.

Figure 3.5 depicts an example of how the metrics export looks in the analyse panel of Tobii Pro Lab. The metrics can be exported for all or a single recording as well as for all or a single stimuli. The metrics export allows one to export different measures from the recording data[2].

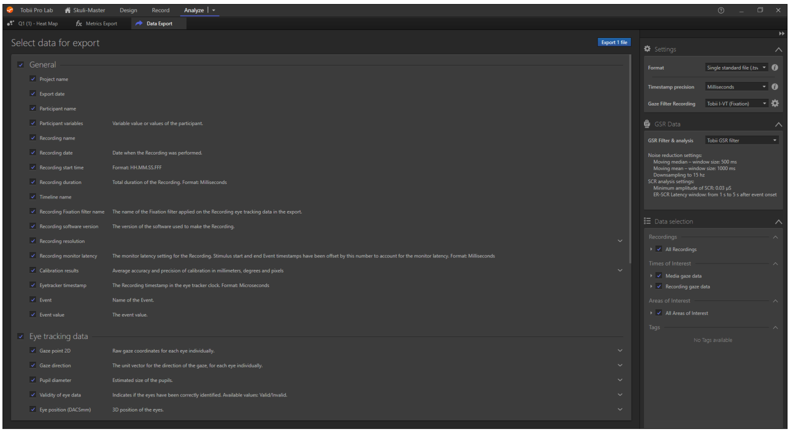

Figure 3.6: The analyse panel in Tobii Pro Lab where recording data can be exported.

Figure 3.6 depicts an example of how the data export looks in the analyse panel of Tobii Pro Lab. The data can be exported for all or a single participant as well as for all or a single stimuli. What data was exported and how it was analysed can be seen in (cf. Section 3.10).

3.2 The Scenario

The Scenario is inspired by container ships that carry all of their load in truck-sized intermodal containers from port to port. When the container ship arrives at the port the containers have to be offloaded and scanned for illegal substances such as drugs or illegal firearms. The scenario is as follows:

When a vessel arrives at a foreign port, each container is offloaded from the vessel using a quay crane. Containers often carry fragile goods, so an accelerometer (sensor) is attached to each container. After the accelerometer is attached, a Robot drives the container to a scanning platform. The container waits in a queue before being scanned by the customs for contraband, explosives, weapons, etc. After the container has been scanned, a robot drives the container from the scanner to the dispatch terminal. The container is then labelled if the accelerometer detected a shake. The accelerometer is then removed from the container. Finally, the container is loaded onto a delivery truck before leaving the port.

The constraints are as follows:

A shake can happen at any moment after the accelerometer has been attached to *the container until the accelerometer is detached. If a shake occurs, the event is recorded in the information system, and a dock-worker is assigned to stick a label on the container to mark it as being shaken. If a labelling request has been sent out and another shake is detected the dock-worker receives a reminder to label the container. In case a shake event is recorded in the information system, the container cannot be loaded for delivery before being labelled by a dock-worker. The robot responsible for driving to the scanning platform, to the dispatch terminal, and loading the container to the delivery truck can break down at any time. In case the robot breaks down, a technician is called to repair the robot. A breakdown event cannot happen if the robot is already in a broken state.*

3.3 From a scenario to a model

A challenge was to design the model so it was simple to understand but still fulfilled all the constraints that were set. Activities, events, and constraints are identified in the scenario (cf. Section 3.2). After analysing the scenario eight activities, two fragments, and four Data objects are detected. The model is split into three major parts. The Main process is the most critical part that is then supported by two fragments to handle the events that can happen. Those fragments are called Shake fragment and Breakdown fragment. It then has the lifecycles of the data objects to help the user to see valid states and state transitions. The data objects are Container which is the case class, Label, Accelerometer, and Robot. The end goal, so called termination condition is that the Container is in a delivered state. These components are all created in the modelling tool Gryphon (cf. Section 2.2.2). How the different parts are built can be found in Appendix G. The model is then deployed to the case engine Chimera (cf. Section 2.2.1) where it can be executed. Figure 3.7 depicts the final version of the model with all the components together.

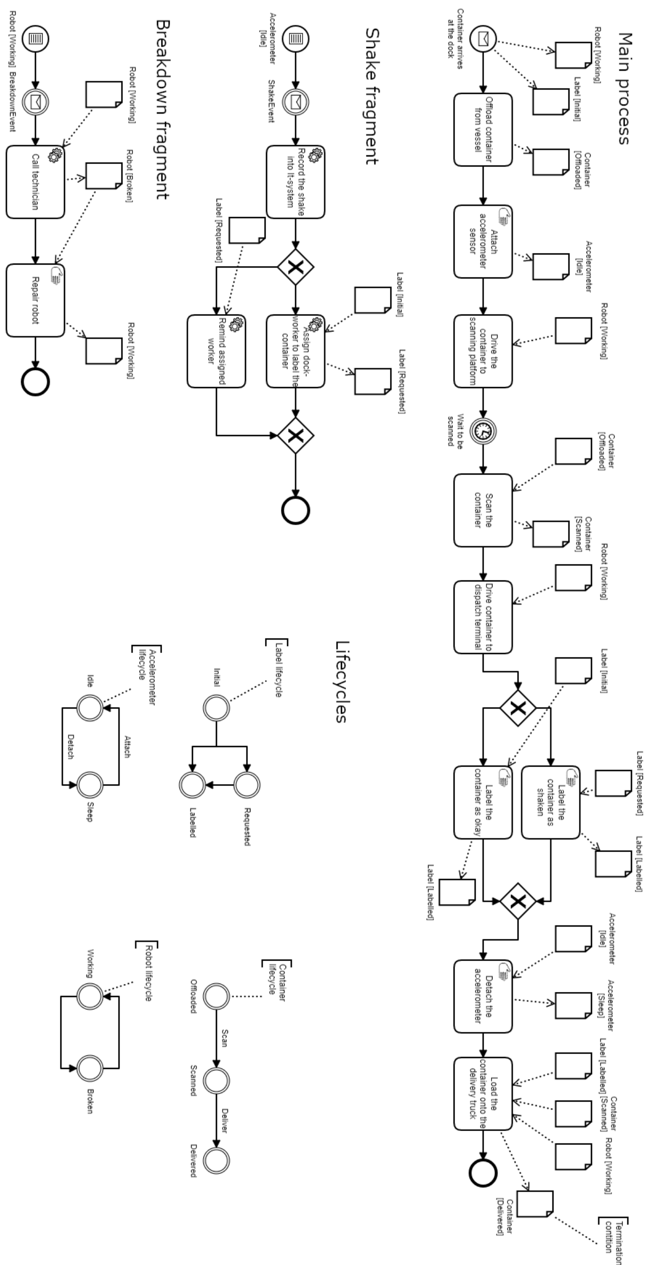

Figure 3.7: The final version of the model.

When the model had been deployed to Chimera it was ready for testing. To simulate the events from the Shake or the Breakdown, Unicorn (cf. Section 2.2.3) was used. The execution of the model was then tested in Chimera with and without events. After the tests the model was sound, that means that it applies with the formal definition of Gryphon and now the questions for the experiment could be created.

3.4 Experiment questions

When the model is ready questions about the model can be developed. To make full use of all the benefits of fCM the questions had to touch on all major parts of fCM. Those parts are mainly the Data Objects and their states. Combining those two parts can produce complicated conditions, and it is interesting to see how people read and understand those conditions. Four types of questions classes were created, those are:

- Single state change
- Combinational state change
- Condition
- State

The first question was different and did not follow the classification. That question was created to see if participants were able to figure out the scenario just by looking at the model. The questions were twelve but three of the questions had a sub question so they were fifteen in total. The questions and their class in parenthesis after each question is listed below:

- Q1. *Can you describe the scenario that the model is showing? (You have 5 min for that)*
- Q2. *Under which circumstance(s) can a Robot change from working state to broken state?* (Single state change)
- Q3. *Under which circumstance(s) cab the Label change from initial state to requested state?* (Single state change)
- Q4. *Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?* (Combinational state change)
- Q5. *Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?* (Combinational state change)
- Q6. *In all fragments, what is the minimum set of activities that should be executed prior to "Assign dock-worker to label the container" activity?* (Condition)

- Q7. *In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?* (Condition)
- Q8. *No shake event has occurred, a breakdown event occurs and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity in the Main process?* (Condition)
- Q9. *A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the Container is in a "Scanned" state.*
  - a) *What activities are executed until the Container is in the state "Delivered"?* (Condition)
  - b) *What are the state(s) of the Label during the Main process after the scan?* (State)
- Q10. *A Container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed.*
  - a) *What are the state(s) of the Robot, Label, Container, and the Accelerometer?* (State)
  - b) *In order for the Main process to continue, what activity has to be executed next?* (Condition)
- Q11. *What are all possible states for the Container?* (State)
- Q12. *The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot".*
  - a) *What states are the Label and the Robot in?* (State)
  - b) *What activity is executed next in the Shake fragment?* (Condition)

After the questions had been created the expected reading pattern for each questions was outlined. It is based up on the knowledge I had gained when working with the fCM approach. After the experiment was conducted an analysis that compared the expected reading pattern to the actual reading pattern was done and the results from that analysis can be seen in (cf. Section 4.2).

3.5 Experiment stimuli

When the model and the questions had been created the images that were used as the stimuli in the experiment could be constructed. To construct the stimuli a drawing tool called Gimp[1] was used to create an image that showed the question, the model, and boxes around the different sections of the model along with text label displaying the name of the section. An example stimuli of question twelve that is ready for the experiment is depicted in Figure 3.8.

[1] https://www.gimp.org/

Q12. The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot".

a) What states are the Label and the Robot in?

b) What activity is executed next in the Shake fragment?

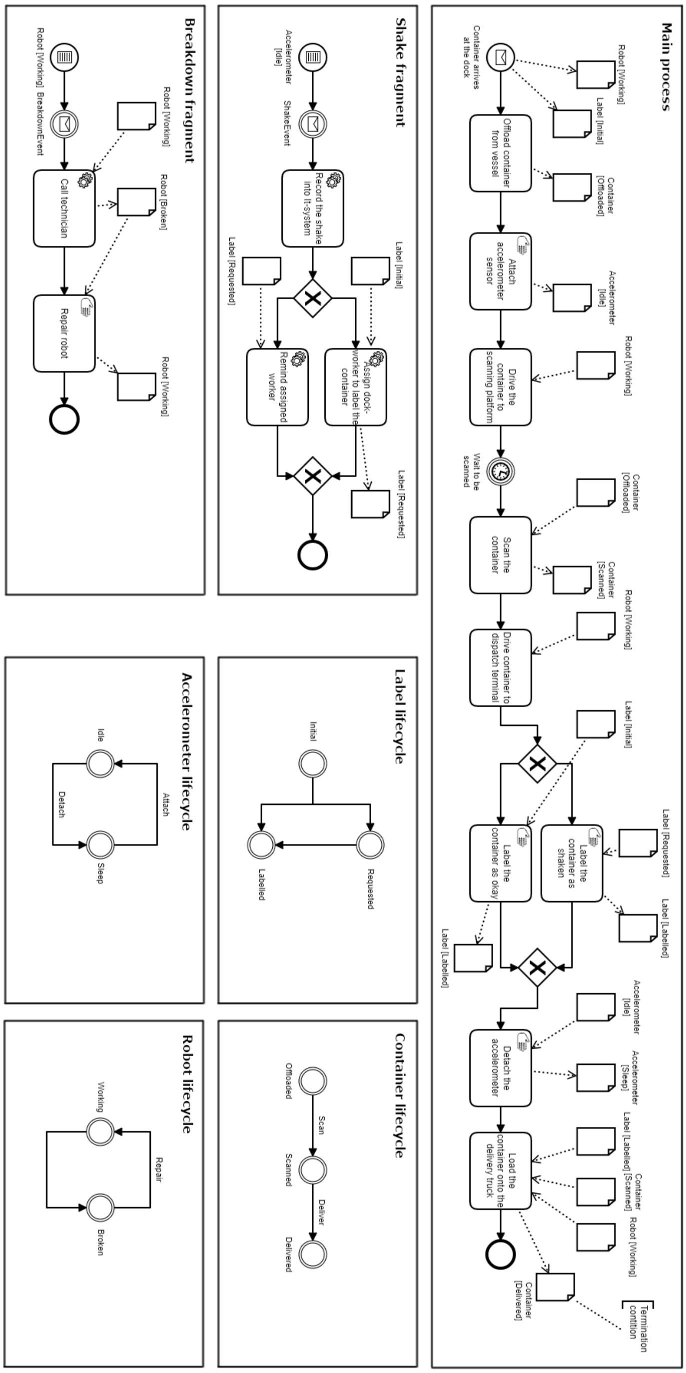

Figure 3.8: Stimuli of question 12.

All the images can be seen in Appendix A

3.6 Pre-experiment form

Before the experiment participants would fill out a pre-experiment form, the form is used to collect data about the participants to gain knowledge and insight about them. That knowledge can then be used in the analysis both for statistical measures as well as for categorising and grouping. The form was split into three sections. The first section was necessary information, background, profession, and experience. The second section was for screening the participants to asses their physical ability to participate in the eye-tracking experiment. That section asked mostly about their vision, if they used glasses, were colour blind, and so on. The third section was about participants familiarity with the subject. It asked about their knowledge and experience with business process management as well as their modelling experience within the business process management field. The full pre-experiment form can be seen in Appendix B. The answers from the participants can the be found in the online Appendix F in a CSV file called Pre experiment form.

3.7 Familiarisation task

Because fragment-based case modelling (fCM) is a new approach to handle business scenarios no prior knowledge of fCM was required of participants. Some participants did not have any knowledge about business process management as well. For this reason, a familiarisation task was introduced to all the participants before starting the experiment. The task started by showing a simple example of a business process; the process was explained to the participants. It then introduced BPMN [2] sequences that showed different types of start nodes, activities, and end nodes. Next came the introduction of control flow; it only showed XOR and AND gateways. The XOR gateway was the only control flow relevant for the experiment, and the AND gateway was used to have a comparison to the XOR. Next part of the task displayed an image of a rather complicated business process. Figure 3.9 depicts that process.

[2] `http://www.bpmn.org/`

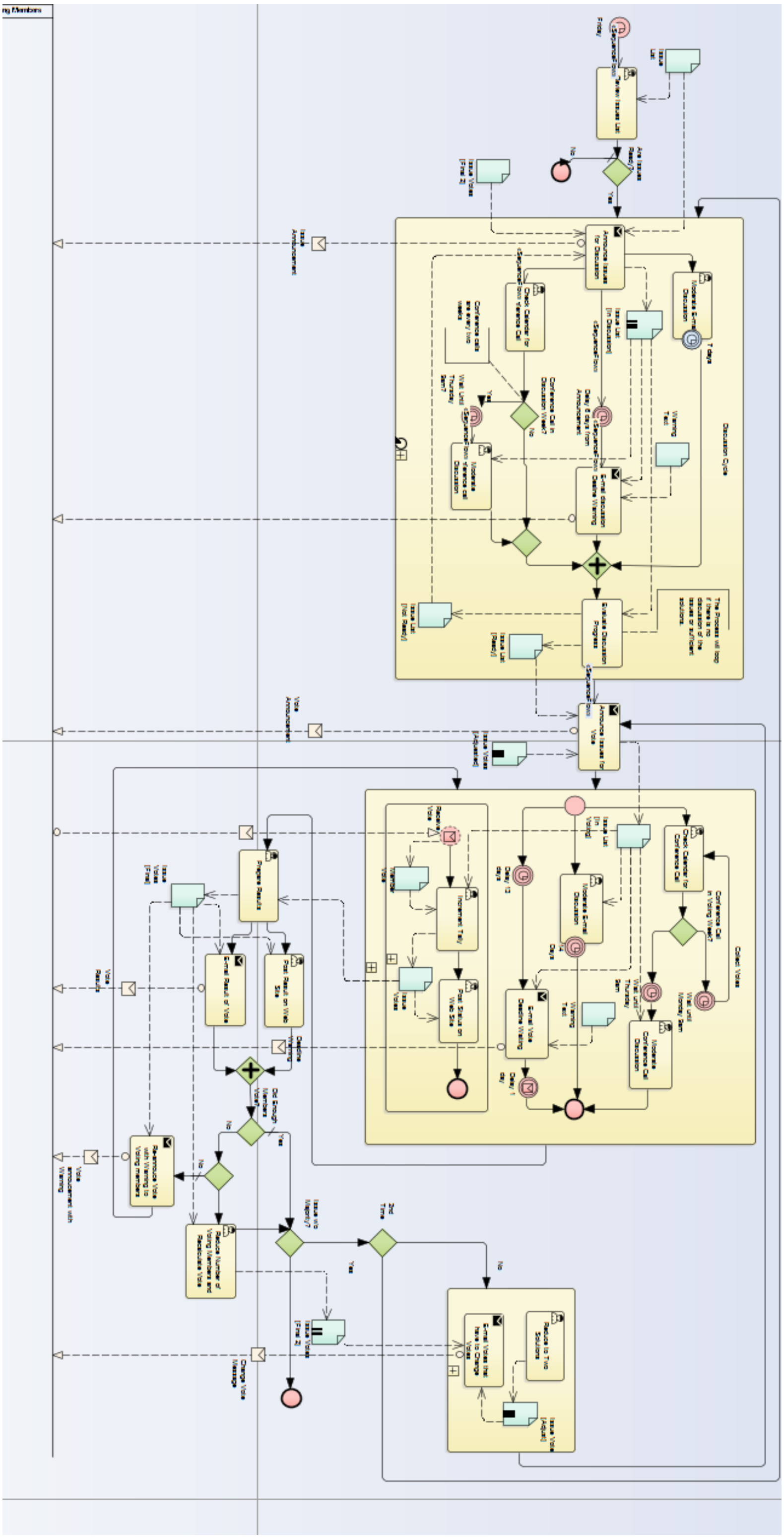

Figure 3.9: Example BPMN process in familiarisation task. Source [15].

The participants were told that this is how a business process quickly becomes large and unreadable when he is modelled with conventional business process workflow software. The task then showed an example of the fragment-based approach emphasising about that splitting a complex process like they just saw into smaller fragments was the main idea of fCM. After that more details about fCM followed. Those details included the introduction of Data objects (cf. Section 2.1.2) that would be used for control flow. The pre and post conditions of data objects as well as how the arrows work when they point in or out of the data objects were explained. The control flow by data objects was then further explained, and an image showed an example of how they can start new fragments. After the introduction of data objects their lifecycles (cf.Section 2.1.2) were explained, how they display the possible states and state transitioning of each data object. Lastly, the task had a small example that looked like the model in the experiment. It had four trial questions, and the participants were helped with answering the first question and then they had to answer the following three questions them self. Figure 3.10 depicts the familiarisation question model.

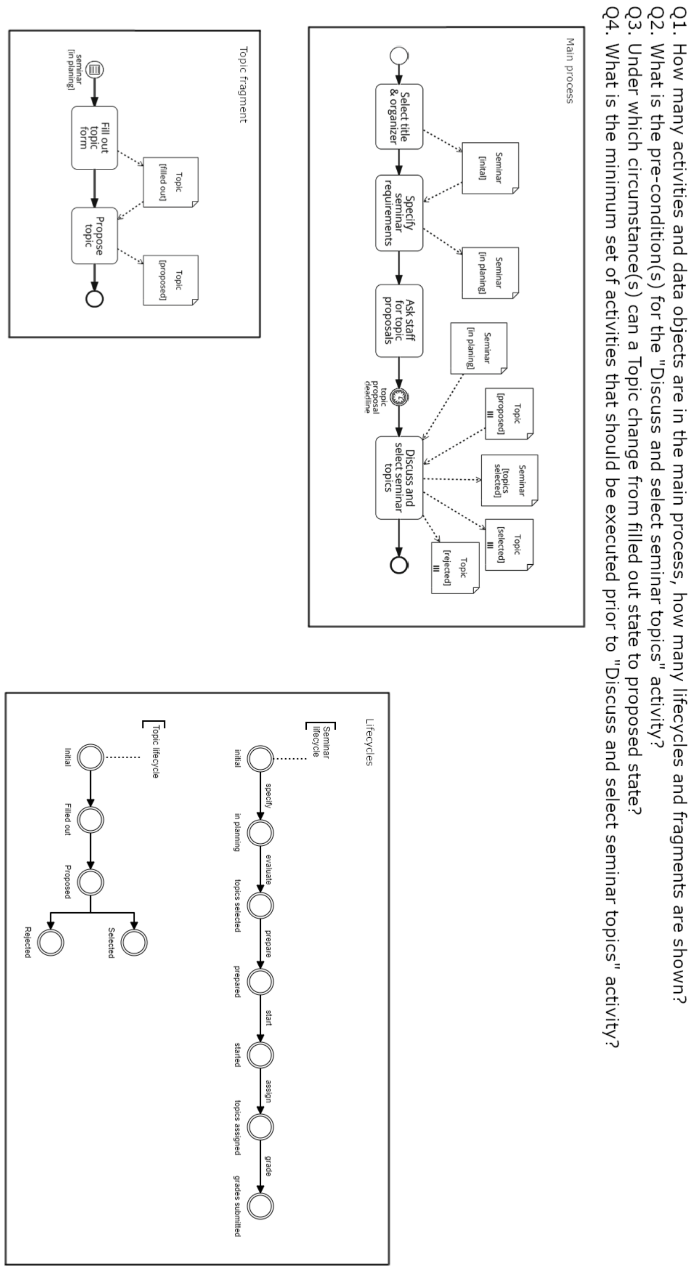

Figure 3.10: Trial questions with a model. Source: [9].

The full familiarisation task can be seen in a power point presentation file called ”Familiarisation task.pptx” in the online Appendix F

3.8 Think-aloud

To gain insights from the participants about the model a think-aloud dialogue was performed after the experiment. The think-aloud asked questions about all the aspects of fCM such as fragments and lifecycles. The information gathered from the think-aloud can then be analysed, and it can become a vital part of understanding how people make sense of fCM. The think-aloud was presented as a power point slide show to the participants, one slide with six questions and one slide with the model so they could reference what they were talking explaining in their answers. The questions were:

- Can you describe the strategy you have followed to answer the questions?
- Was the main process enough to get an understanding of the process?
- For what purpose have you used the lifecycles?
- For what purpose have you used the different fragments?
- Do you see any benefits in combining the main process, with fragments and lifecycles?
- Do you see any challenges in combining the main process, with fragments and lifecycles?

And the image of the model from the think-aloud is depicted in Figure 3.11.

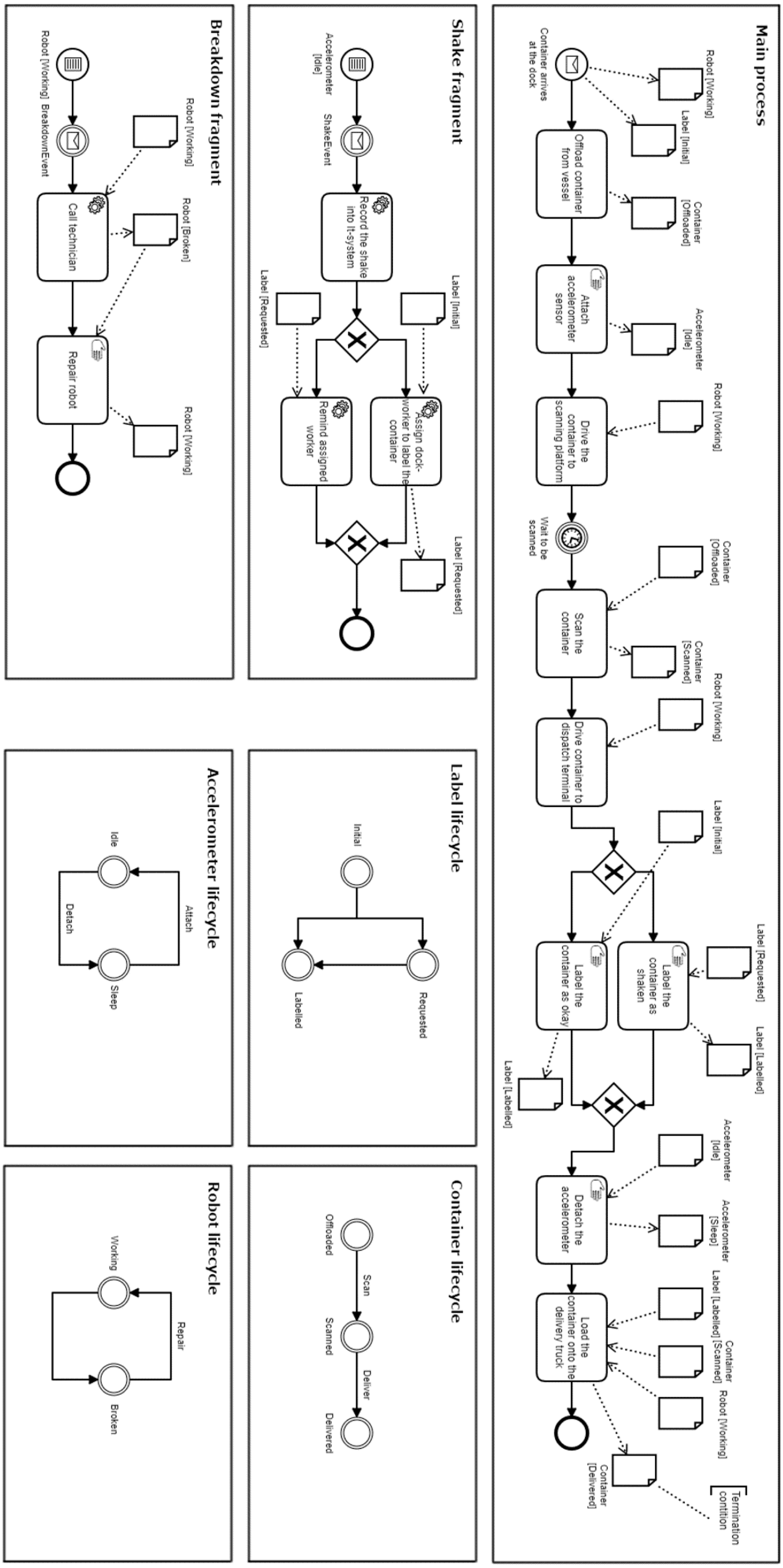

Figure 3.11: Trial questions with a model.

3.9 Preparing the data for analysis

In this section the preparation of the data before it could be analysed is explained. It starts by explaining where the data came from. It then explains how and why areas of interest were created. And finally it explains how the participants were split into groups and how their background was analysed.
The experiment collected a lot of data. The data came from the pre-experiment form, the think-aloud, the eye-tracking software, and the recordings of participants answering the questions. To make use of some of the data it had to be transformed, and the voice recordings had to be transcribed, those are the think-aloud and the participants answering the questions.
Participant four (P4) is not included in the transcription of the questions. The recording for the participant failed but was realised before the think-aloud, so the transcription for that is included. The answers to the questions were marked while the experiment was ongoing, so the solutions for the participants are valid, but they could not be confirmed with the transcription data like for the other participants. The transcribed data of the participants answering the questions can be found in the Appendix H and the transcribed data from the think-aloud can be found in the Appendix I.
To be able to use Disco (cf. Section 2.5) to analyse the gaze data the data exported from Tobii Pro Lab (cf. Section 2.3.2) had to be processed with a script that generated Extensible Event Stream (XES)[3] log files. The data from Tobii came as a tab-separated value file (TSV) file. The script was a modified version of tsv2xex[4]. The modification that I did was to add a new attribute to the log file so the questions could be analysed separately with Disco and to get the gaze event duration working I had to sum up the duration from the data. The attributes that the script extracted from the TSV file and into the XES log file was the gaze event duration, the participant name (id), and the question. The script can be found in the Appendix C. From the XES log file, it is possible to filter the data for each attribute. Figure 3.12 depicts how the groups were filtered with Disco.

[3]http://xes-standard.org/

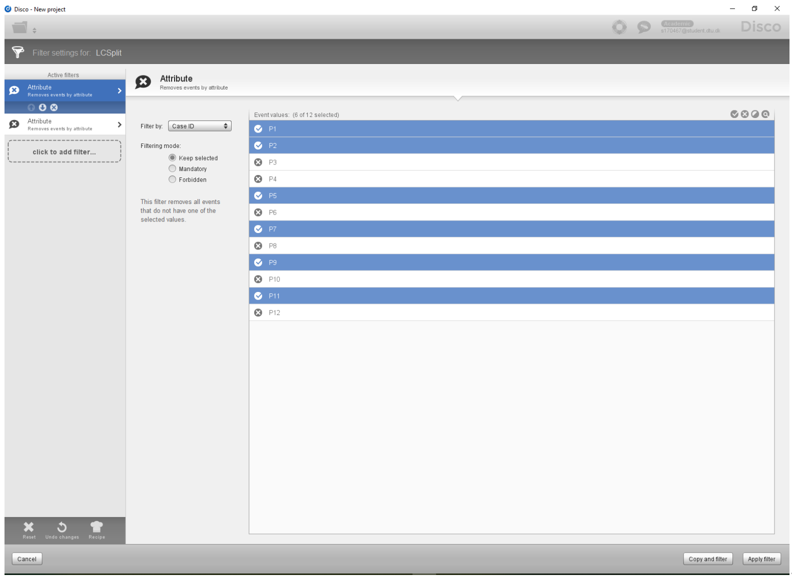

Figure 3.12: Filtering participants in Disco.

This filter is filtering the participants by using the Case ID. The Case ID is the participants id. After applying this filter disco will only show data for the selected values (highlighted in blue) thus only showing the participants selected. To also filter out the question that I wanted to analyse another attribute filter was added. Figure 3.13 depicts how that filter is added.

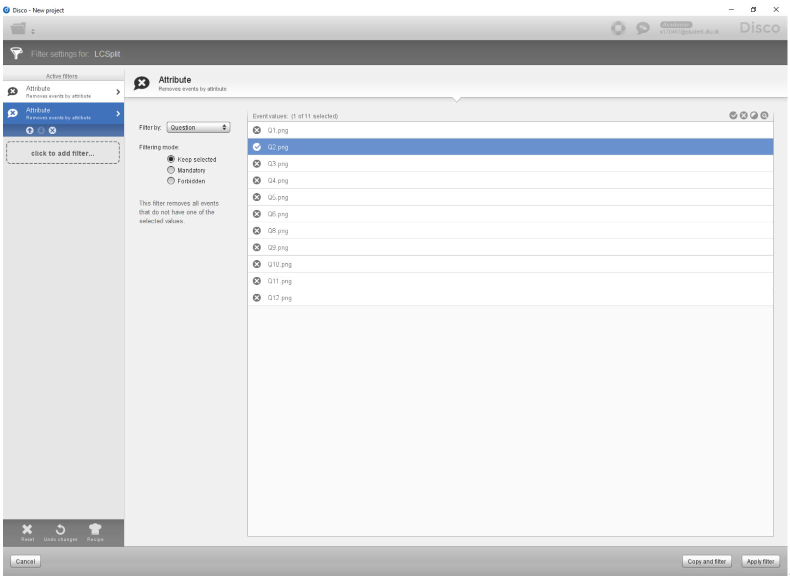

Figure 3.13: Filtering by each question in Disco.

This filter is filtering out the data by the question attribute. That allowed me to see data for one question at a time.

More of the data had to be processed before it could be analysed. The Tobii Lab Pro software that collected the gaze data for each participant did not group all the areas of interest (AOI) so, for each AOI hit on each question data was exported. The AOI is explained in (cf. Section 3.9.1). In Excel the AOI hits were merged into one. The eye movement type Fixation was the only eye movement type that was used to the exported data was filtered by that as well. The eye movement type index then allowed for removing all the duplicated data that was exported. The final and ready for processing file then had fifteen headers, those are:

- Participant name
- Recording start time
- Presented Media name
- Eye movement type
- Gaze event duration
- Eye movement type index
- AOI hit [Accelerometer LC]

- AOI hit [All LC]
- AOI hit [Breakdown fragment]
- AOI hit [Container LC]
- AOI hit [Label LC]
- AOI hit [Main process]
- AOI hit [Question]
- AOI hit [Robot LC]
- AOI hit [Shake fragment]

All the files can be found in the online Appendix F . They are named after the participant name (P1-P12) and are in TSV format in a folder called TSV files.
After the script had processed the TSV files for all the participants one XES file had to be created. The XES file is a XML file so in a text editor all the files were opened and merged to one large XES file. The final XES files can be found in the online Appendix F, they are named AllLC.xes and LCSplit.xes. Figure 3.14 depicts a snapshot of the XES log file that was used in Disco.

```
<log xes.version="1.0" xes.features="nested-attributes" openxes.version="1.0RC7">
    <extension name="Organizational" prefix="org" uri="http://www.xes-standard.org/org.xesext"/>
    <extension name="Time" prefix="time" uri="http://www.xes-standard.org/time.xesext"/>
    <extension name="Lifecycle" prefix="lifecycle" uri="http://www.xes-standard.org/lifecycle.xesext"/>
    <extension name="Concept" prefix="concept" uri="http://www.xes-standard.org/concept.xesext"/>
    <string key="concept:name" value="P1.tsv - AllLC"/>
    <trace>
        <string key="concept:name" value="P1"/>
        <event>
            <string key="Question" value="Q1.png"/>
            <string key="concept:name" value="Main process"/>
            <string key="lifecycle:transition" value="start"/>
            <date key="time:timestamp" value="2019-03-12T11:36:17.000Z"/>
        </event>
        <event>
            <string key="Question" value="Q1.png"/>
            <string key="concept:name" value="Main process"/>
            <string key="lifecycle:transition" value="complete"/>
            <date key="time:timestamp" value="2019-03-12T11:36:18.303Z"/>
        </event>
        <event>
            <string key="Question" value="Q1.png"/>
            <string key="concept:name" value="Question"/>
            <string key="lifecycle:transition" value="start"/>
            <date key="time:timestamp" value="2019-03-12T11:36:17.000Z"/>
        </event>
        <event>
            <string key="Question" value="Q1.png"/>
            <string key="concept:name" value="Question"/>
            <string key="lifecycle:transition" value="complete"/>
            <date key="time:timestamp" value="2019-03-12T11:36:18.706Z"/>
        </event>
        <event>
```

Figure 3.14: XES log file snapshot.

The XES file is built up by traces and events. Each participant had a trace that then included a lot of events. The final file thus included twelve traces, one for each participant. The events were then built up by the presented media name (Q1.png), the AOI (Main process), a start or a complete transition, and a time stamp so the gaze event duration could be seen in Disco.

3.9.1 Area of Interest

To prepare the data that the eye-tracker recorded the model was split up by to AOIs. The AOIs are artefacts that can give valuable statistical data to analyse. The data that it gives is the fixation duration (cf. Section 3.10.2) and the repetitions (cf. Section 3.10.3).
The Tobii Pro Lab software has a built-in tool which allows you to create AOIs. Figure 3.15 depicts how the tool looks in Tobii Pro Lab.

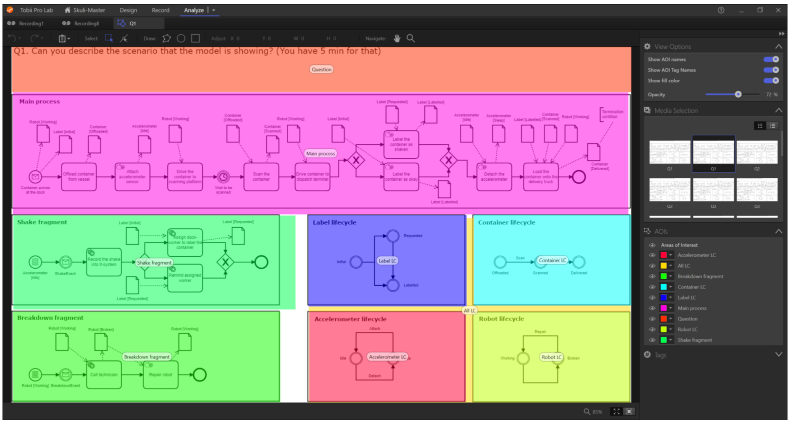

Figure 3.15: The AOI tool in Tobii Pro Lab.

The AOI split is twofold, the difference is that in one of them the lifecycles are divided and in the other, the lifecycles are together. The AOI split with lifecycles together is depicted in Figure 3.16.

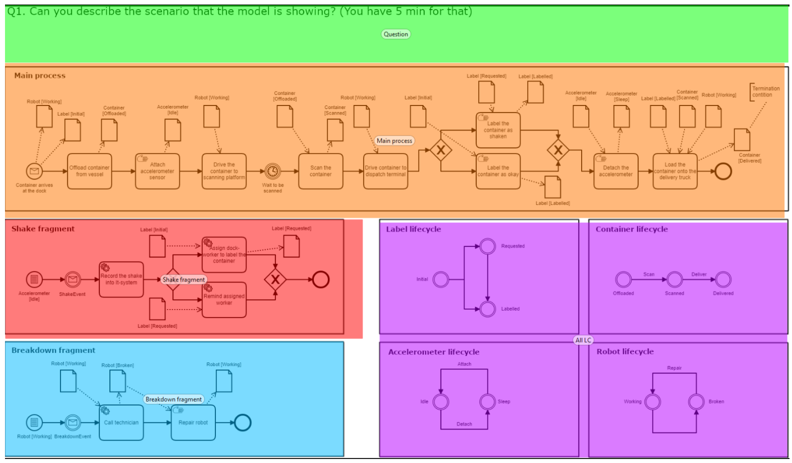

Figure 3.16: The AOI split with the lifecycles combined.

The artefacts for the AOI split with the lifecycles combined are:

- Main process
- Question
- Shake fragment
- Breakdown fragment
- All LC

Figure 3.17 depicts the AOIs where the lifecycles are split.

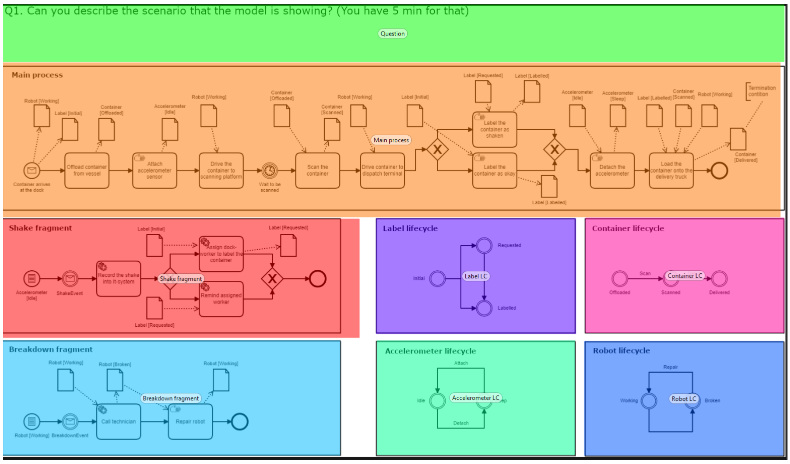

Figure 3.17: The AOI split with the lifecycles divided.

The AOI split with the lifecycles combined gave an overview of the fixation duration as well as the repetitions for each artefact of the model but to get more detailed analysis the AOI split with the lifecycles divided was used. The artefacts for the AOI split with the lifecycles divided are:

- Main process
- Question
- Shake fragment
- Breakdown fragment
- Container LC
- Accelerometer LC
- Robot LC
- Label LC

3.9.2 Groups

The performance of the the participants was used to split them into two groups. How the performance was evaluated is explained in (cf. Section 3.10.1). By examining the behaviour of the two user groups, we can understand the reasons why those who did well, did well. From the performance, a score for each participant was calculated. One point was given for correct answer, a half point was given for correct answer with a hint, and no point was given for incorrect or invalid answers. Based on the median score participants are either added to group A or group B. Figure 3.18 depicts the table where the score is calculated, and the groups are formed.

Participant	Q2	Q3	Q4	Q5	Q6	Q8	Q9a	Q9b	Q10a	Q10b	Q11	Q12a	Q12b	Score	Group	Stats	Score
P01	1	1	0	0	0	0	0	0	0	1	1	0	1	0.38	B	STD	0.18
P02	1	1	0	1	0	0.5	0	0	1	1	0.5	1	1	0.62	B	Median	0.65
P03	1	1	1	0	1	1	0	1	1	0	1	1	1	0.77	A	AV	0.65
P04	1	1	1	1	0	1	1	1	0.5	1	1	0.5	1	0.85	A	Group A AV	0.81
P05	0.5	1	1	0.5	0	0	0	0	1	0	1	0	1	0.46	B	Group B AV	0.50
P06	0.5	1	0.5	0.5	1	1	1	1	1	1	1	1	1	0.88	A		
P07	1	0	1	1	0	0	0	0	1	1	1	1	0.5	0.58	B		
P08	1	1	1	1	1	1	1	0	1	1	1	1	1	0.92	A		
P09	0	1	0	1	0	0	1	0	0	1	1	1	1	0.54	B		
P10	1	1	0.5	1	1	0	0	0	1	1	1	1	1	0.73	A		
P11	1	0	1	1	0	0.5	0	0	0	1	1	0	0	0.42	B		
P12	1	1	1	1	0	0	0	0	1	1	1	1	1	0.69	A		
AV score	0.83	0.83	0.67	0.75	0.33	0.42	0.33	0.25	0.71	0.83	0.96	0.71	0.88	0.65			

Figure 3.18: Calculation of the score to split the participants in groups.

Figure 3.18 shows that the median score was 0.65, group A had an average score of 0.81 and group B had an average score of 0.50. You can also see the participants who performed best by looking at the Score column on the right. The AV score row then shows what question was answered most often correctly. For both of these statistics the green colour indicates a positive value.

3.9.2.1 Background

I analysed the pre-experiment form (cf. Section 3.6) to gain more background knowledge of the two groups. The background and experience can be a big factor in the difference in performance of the groups. The information I wanted to extract from there is the participants age, gender, profession, experience, and familiarity with the subject. This information could be give some indication of why participants in group A performed better in the experiment. Figure 3.19 depicts the average age of the participants in each group shown in years.

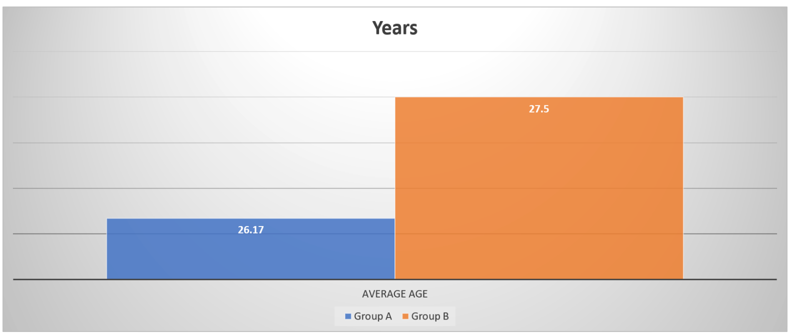

Figure 3.19: The average age of each group in years.

The average age of the participants is very similar, group B is slightly older, about one year. When I look at the gender split of the groups the results are not similar at all. Figure 3.20 depicts the gender split for each group.

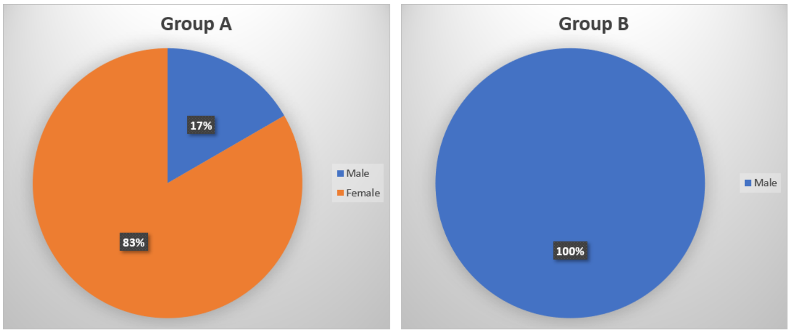

Figure 3.20: The gender split for both groups.

Group A has 83% females but group B is 100% males. This is an interesting insight that is further discussed in (cf. Section 5.1).
Next thing to analyse is the groups profession and the experience in that profession. Figure 3.21 depicts a pie chart of the professions for both groups.

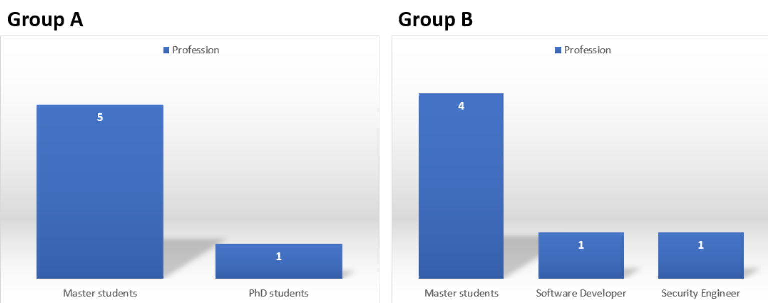

Figure 3.21: The profession of both groups.

In group A there are only students, five master students and one PhD student. Group B has four master students, a software developer and security engineer. Because the majority of the participants are students I also analysed their study line. In group A two participants are studying Mathematical Modelling and Computation, and the other four participants are split to; Computer Science and Engineering, Biomedical Engineering, Industrial Engineering and Management, and Software Process Engineering. In group B the participants study line is as follows; two Software Engineering students, two Digital Media Engineering students where one is graduated, one Computer Science graduate, and one Mechanical Engineering student. Both groups have a strong background in Engineering related fields. The experience with in a field is also important. Figure 3.22 depicts the profession experience for each group shown in years.

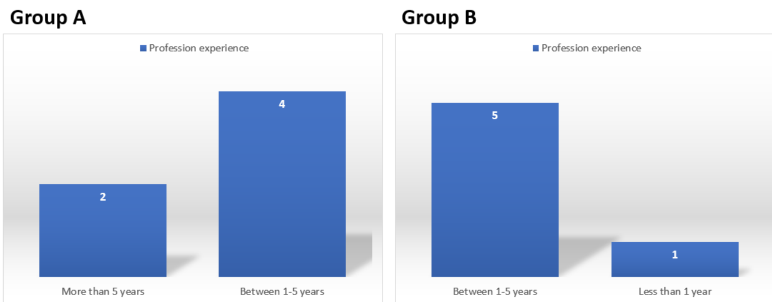

Figure 3.22: The profession experience of both groups in years.

The profession experience is slightly higher for group A, two participants say that they have more than 5 years of experience in their profession. In general the experience of both groups is similar and can not be considered as a clear indication of the difference in performance of the groups.
Next step is to look at the familiarity of the subject. The first thing to look at is if the groups were familiar with BPMN 2.0 before they participated in the experiment. Figure 3.23 depicts the results for that question.

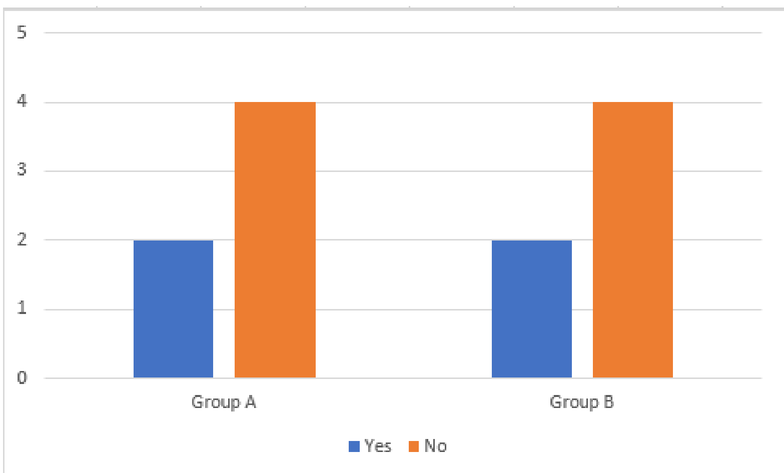

Figure 3.23: The familiarity of BPMN 2.0 before the experiment.

Like the graph shows the participants in the groups were equally divided when asked if they were familiar with BPMN 2.0 before starting the experiment. Group A had two participants that were familiar with BPMN 2.0 and group B had two participants as well.
To further see the familiarity the participants were asked to answer approximately how many BPMN 2.0 models they had read in the last 5 years. Figure 3.24 depicts the results from that question.

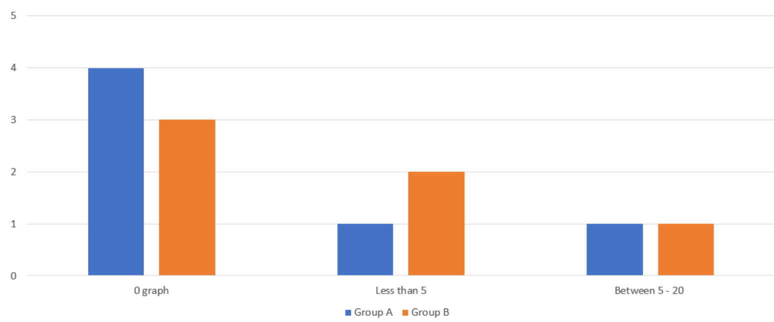

Figure 3.24: How many BPMN 2.0 models the participants have read in the last 5 years.

Although the inexperience of BPMN models in general is high for both groups, group B states that he has a slightly more experience of reading BPMN 2.0 models.

After analysing the background of the participants in both groups there is no clear difference that could be influencing the fact that the participants in group A performed better. The background knowledge and experience is almost the same for both groups and group B is even showing a little more experience with BPMN in general but still performed worse.

3.9.2.2 Three group split

The participants were also split into three groups to focus more on those who performed good and to those who performed poorly. Leaving out the middle will hopefully show a more detailed difference in how the participants read and understood the fCM approach. I used the interquartile range to make three groups, group A, group B, and group C. In group A participants that had a score above the third quartile, group B had participants that scored lower than then the third quartile but higher than the first quartile, and finally, group C had participants that scored lower than the first quartile. Following this procedure made the groups uneven, group A had 3 participants, group B had 6 participants, and group C had 3 participants. To even out the groups the highest scored participant from group B was moved to group A, and the lowest scored participant from group B was moved to group C. Figure 3.18 depicts the table where the score is calculated, and the three groups are formed.

Participant	Q2	Q3	Q4	Q5	Q6	Q8	Q9a	Q9b	Q10a	Q10b	Q11	Q12a	Q12b	Score	Group	Quartile	Score
P01	1	1	0	0	0	0	0	0	0	1	1	0	1	0.38	C	Quartile 1	0.52
P02	1	1	0	1	0	0.5	0	0	1	1	0.5	1	1	0.62	B	Quartile 3	0.79
P03	1	1	1	0	1	1	0	1	1	0	1	1	1	0.77	A	IQR	0.27
P04	1	1	1	1	0	1	1	1	0.5	1	1	0.5	1	0.85	A	Upper bound	1.19
P05	0.5	1	1	0.5	0	0	0	0	1	0	1	0	1	0.46	C	Lower bound	0.12
P06	0.5	1	0.5	0.5	1	1	1	1	1	1	1	1	1	0.88	A	Group	AV score
P07	1	0	1	1	0	0	0	0	1	1	1	1	0.5	0.58	B	A	0.86
P08	1	1	1	1	1	1	1	0	1	1	1	1	1	0.92	A	B	0.65
P09	0	1	0	1	0	0	1	0	0	1	1	1	1	0.54	C	C	0.45
P10	1	1	0.5	1	1	0	0	0	1	1	1	1	1	0.73	B	All	0.65
P11	1	0	1	1	0	0.5	0	0	0	1	1	0	0	0.42	C		
P12	1	1	1	1	0	0	0	0	1	1	1	1	1	0.69	B		

Figure 3.25: Calculation of the score to split the participants in three groups.

3.10 Analysing the data

This section explains how the data gathered in the experiment was analysed. To help the investigation of how people read and understand fCM models the analysis starts by answering how the overall participant's performance was. Then it shows how the questions were analysed between the groups. After that the fixation duration and repetitions on the areas of interest is analysed. It then shows the analysis of the think-aloud data. Then the performance of the participants based on the question classification is analysed. It then shows the analysis of the data gathered from the galvanic skin response sensor and finally it shows the result from the expected vs actual reading pattern analysis.

The analysis part excludes question 1 and question 7. Question 1 did not have a quantitative answer, it asked the participants to describe the scenario that the model showed so the answer from that question can be used for qualitative research and that is discussed in (cf. Section 4.10). Question 7 was excluded because the experiment had a bug in the beginning and it displayed question 6 two times instead of displaying question 7.

3.10.1 Performance

The performance of the participants in the experiment can give an indication of how understandable the fCM approach is. I noted down the participant answers in the experiment and I used the transcribed data from the voice recordings to confirm the results that I had noted down. Figure 3.26 depicts the document that I used to note down while the experiment was on going.

Question/Parti	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
2	Q6	Q11	Q2	Q4	Q3	Q3	Q7	Q11	Q11	Q12a	Q6	Q11
3	Q5	Q9a	Q8	Q10a	Q10a	Q9a	Q3	Q3	Q6	Q12b	Q5	Q5
4	Q11	Q9b	Q4	Q10b	Q10b	Q9b	Q4	Q5	Q10a	Q9a	Q10a	Q12a
5	Q9a	Q6	Q11	Q9a	Q5	Q4	Q5	Q4	Q10b	Q9b	Q10b	Q12b
6	Q9b	Q2	Q12a	Q9b	Q2	Q5	Q8	Q2	Q2	Q8	Q11	Q8
7	Q8	Q4	Q12b	Q8	Q4	Q2	Q2	Q7	Q3	Q3	Q8	Q3
8	Q12a	Q10a	Q9a	Q6	Q7	Q10a	Q6	Q10a	Q5	Q6	Q12a	Q6
9	Q12b	Q10b	Q9b	Q3	Q9a	Q10b	Q9a	Q10b	Q7	Q7	Q12b	Q4
10	Q4	Q5	Q10a	Q7	Q9b	Q6	Q9b	Q12a	Q12a	Q2	Q2	Q10a
11	Q2	Q12a	Q10b	Q2	Q6	Q12a	Q10a	Q12b	Q12b	Q10a	Q7	Q10b
12	Q10a	Q12b	Q5 (Skipped)	Q12a	Q12a	Q12b	Q10b	Q6	Q4	Q10b	Q3	Q2
13	Q10b	Q8	Q6	Q12b	Q12b	Q8	Q11	Q9a	Q8	Q4	Q4	Q7
14	Q3	Q7	Q7	Q5	Q8	Q11	Q12a	Q9b	Q9a	Q11	Q9a	Q9a
15	Q7	Q3	Q3	Q11	Q11	Q7	Q12b	Q8	Q9b	Q5	Q9b	Q9b

Figure 3.26: The question order for each participant.

I coloured the cells with different colours to see how the participant answered the question. Their answers are split into four categories; *Correct*, *Correct with hint*, *Wrong*, and *Invalid*. *Correct* is the category where the participants answered correctly, *Correct with hint* is the category where the participant was hinted about where he could find the answer, *Wrong* is the category where an incorrect answer was given to a question, and *Invalid* is the category where the participant did not answer a question. The blue colour is for question 1 because that question did not have a correct or wrong answer. After I had validated the answers, I added all the participant's responses together in one table. That table is depicted in Figure 3.27.

Question	Correct	Correct with hint	Wrong	Invalid
Q2	9	2	1	0
Q3	10	0	1	1
Q4	6	2	4	0
Q5	8	2	1	1
Q6	4	0	8	0
Q8	4	2	6	0
Q9a	4	0	8	0
Q9b	3	0	8	1
Q10a	8	1	3	0
Q10b	9	0	2	1
Q11	11	1	0	0
Q12a	7	1	4	0
Q12b	10	1	1	0
Total	93	12	47	4

Figure 3.27: Answers for all categories by question.

The green colour in the table always shows the positive outcome. In the correct column it is good to have a high score but in the wrong column it is positive to have a low score.

3.10.2 Fixation Duration

The fixation duration analysis is summing up the dwell time of each AOI hit (cf. Section 2.3.1). I want to see what AOIs the participants were spending most of their time looking at, that can give some indication about how they read and understand the model. The fixation duration is split into two tables based on the groups. Figure 3.28 depicts the total duration for each AOI by different question for group A.

Question	Main process	Question	Shake fragment	Breakdown fragment	All lifecycles	Total
Q2	40	23	3.6	78.4	0.273	145.27
Q3	62.3	38.1	63.2	5.1	17.8	186.50
Q4	234	52.2	22	3.7	12.7	324.60
Q5	246	48.4	9	6.9	34.8	345.10
Q6	88.8	45.5	51.5	3.5	3.7	193.00
Q8	94.7	51.4	7.2	16.5	0.977	170.78
Q9	156	84	19	1.75	4.65	265.40
Q10	66	45.7	5.65	18.8	0.65	136.80
Q11	34.3	20.5	1.3	1.3	37.9	95.30
Q12	28.5	46.1	45.6	8.45	0.458	129.11
Total	1050.60	454.90	228.05	144.40	113.91	1991.86
AV	105.06	45.49	22.81	14.44	11.39	199.19
STV	80.22	17.50	22.48	23.24	14.40	84.93
Median	77.40	45.90	14.00	6.00	4.18	178.64

Figure 3.28: Total fixation duration for group A.

Figure 3.29 depicts the total fixation duration for each AOI by different question for group B.

Question	Main process	Question	Shake fragment	Breakdown fragment	All lifecycles	Total
Q2	61.7	40	12.4	120	21.3	255.4
Q3	186	47.1	117.3	5.3	17.8	373.5
Q4	306	72.7	6	2.2	16.1	403
Q5	222	49.7	7.5	2.5	10.9	292.6
Q6	198	100.7	174	17.9	5	495.6
Q8	252	174	20.2	87.7	1.7	535.6
Q9	186	180	50.75	8.5	25.75	451
Q10	84	81	30	91.2	30.4	316.6
Q11	54.3	9.4	3.7	1.3	19.95	88.65
Q12	119	198	156	59.6	11.5	544.1
Total	1669	952.6	577.85	396.2	160.4	3756.05
AV	166.90	95.26	57.79	39.62	16.04	375.61
STV	84.48	66.25	65.93	45.58	8.95	142.20
Median	186.00	76.85	25.10	13.20	16.95	388.25

Figure 3.29: Total fixation duration for group B.

For a better visualisation and easier visual comparison the values have been coloured. Red means the highest duration and green means lower duration. Disco was then used to see the total fixation duration for all questions combined for both groups. Figure 3.30 depicts the total fixation duration for group A.

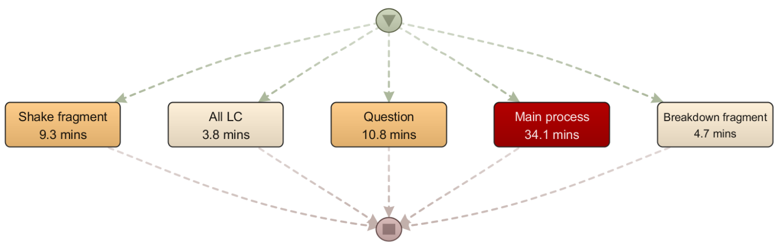

Figure 3.30: Total fixation duration with questions combined for group A.

Figure 3.31 depicts the total fixation duration for group B.

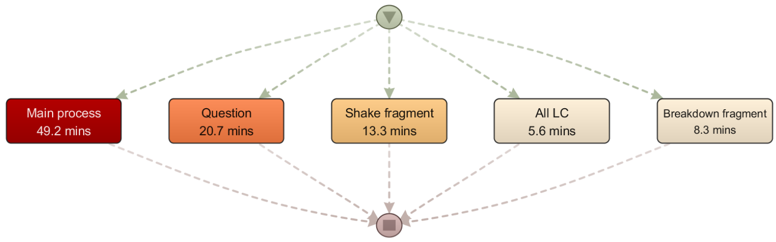

Figure 3.31: Total fixation duration with questions combined for group B.

The comparison of the total duration between the groups shows that Group B spent 32.6 minutes more on the artefacts than group A did. Table 3.1 shows the fixation duration in minutes for all questions between group A and group B and the difference also in minutes.

Artefact	Group A	Group B	Difference
Main process	34.1	49.2	15.1
Question	10.8	20.7	9.9
Shake fragment	9.3	13.3	4
Breakdown fragment	4.7	8.3	3.6
All LC	3.8	5.6	1.8

Table 3.1: Fixation duration difference in minutes between group A and group B.

3.10.3 Repetitions

Disco also gives another parameter to analyse, repetitions. “The max repetitions numbers give us an idea how many times the most frequently churned or reworked case looped through a particular activity or path”[16]. What the analysis of the repetition can show is how the participants read the model. If the repetition is high it means that participants were looking again and again at the same AOI. That can give an indication of how participants understand and understand the model. Figure 3.32 depicts the repetitions for each AOI by each question for group A.

Max repetitions for each activity for Group A						
Question	Main process	Question	Shake fragment	Breakdown fragment	All lifecycles	Total
Q2	10	9	3	9	1	32
Q3	15	12	5	4	10	46
Q4	22	14	14	5	4	59
Q5	29	20	6	5	13	73
Q6	24	12	16	3	4	59
Q8	11	10	5	6	1	33
Q9	37	30	19	3	7	96
Q10	27	18	16	11	2	74
Q11	10	9	2	1	13	35
Q12	21	18	20	9	2	70
Total	206.00	152.00	106.00	56.00	57.00	577.00
AV	20.60	15.20	10.60	5.60	5.70	104.91
STV	9.08	6.53	7.03	3.17	4.76	157.86
Median	21.50	13.00	10.00	5.00	4.00	59.00

Figure 3.32: Repetitions for group A.

Figure 3.33 depicts the repetitions for each AOI by each question for group B.

Max repetitions for each activity for Group B						
Question	Main process	Question	Shake fragment	Breakdown fragment	All lifecycles	Total
Q2	14	13	7	13	11	58
Q3	19	10	28	5	6	68
Q4	16	14	3	2	4	39
Q5	21	18	3	2	6	50
Q6	40	21	33	9	8	111
Q8	41	34	17	16	2	110
Q9	54	44	22	13	23	156
Q10	50	46	21	36	11	164
Q11	11	8	3	1	11	34
Q12	54	48	37	24	10	173
Total	320.00	256.00	174.00	121.00	92.00	963.00
AV	32.00	25.60	17.40	12.10	9.20	175.09
STV	17.47	15.82	12.93	11.14	5.79	266.25
Median	30.50	19.50	19.00	11.00	9.00	89.00

Figure 3.33: Repetitions for group B.

The analysis of the repetitions show that group A has fewer repetitions for all the AOIs (Total row) and the total repetitions are almost twice as high for group B. With the values coloured the comparison is more comfortable to visualise, the red colour is for the higher values meaning more repetitions. The colour distribution is very similar between the groups. But it can be noticed that group B has more repetitions on each AOI.

3.10.4 Question analysis

The question analysis is based on the two-group split, and it uses the AOI data where the lifecycles are divided. Trying to understand the difference how participants read through the model I have been attempting to analyse each question both with Disco (cf. Section 2.5) and with heat maps from Tobii Pro Lab (cf. Section 2.3.2). By analysing the reading pattern of the participants I can see how they approach fCM models. To be able to create the images in this analysis the log files (cf. Section 3.9) were imported to Disco, and then two filters were applied. Both filters are Attribute filters, one that filters out participants so the groups can be examined individually, and one that filters out the question that I currently want to analyse. The heat maps that are used in this analysis come from Tobii Pro Lab, the software that was used to create the eye-tracking experiment. When the heat maps are exported from Tobii, they can be exported for each question based on data from multiple users, so they were exported based on the groups.

The analysis involved comparing images taken from Disco of the Fixation duration for each AOI and comparing the exported heat maps from Tobii. Figure 3.34 depicts how the comparison image looked for comparison with Disco for question 2. This section only shows an example of how the questions were analysed. All the images from the analysis can be seen in Appendix D.

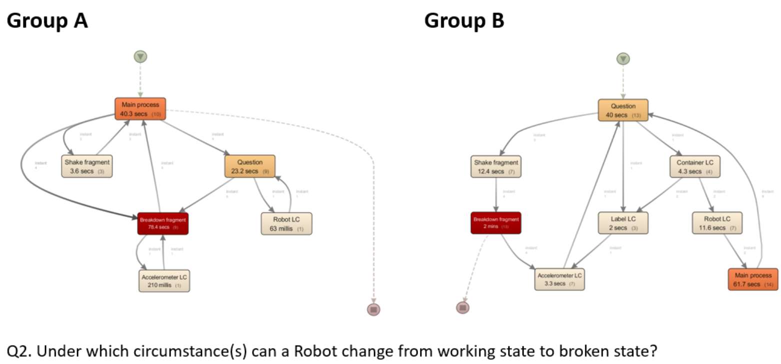

Figure 3.34: Comparison of images from Disco of question 2.

And Figure 3.35 depicts the heat map for question 2 split between the groups.

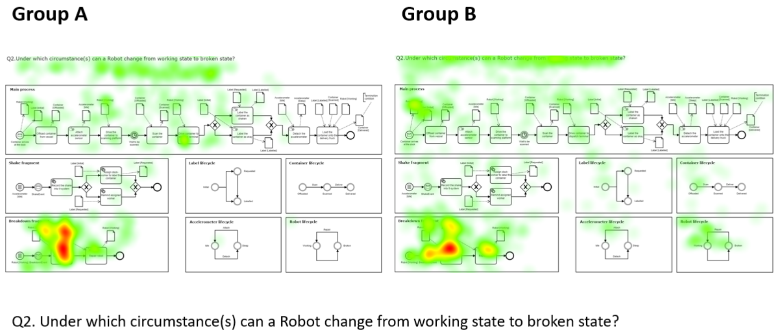

Figure 3.35: Comparison of heat maps from Tobii for question 2.

Figure 3.34 shows a snapshot of the process map that Disco created from the data. Data from participants in both groups for question 2 is displayed. It shows the fixation duration for each activity and the max-repetitions is revealed in the parenthesis after the time. Figure 3.35 then shows the same data displayed as a heat map for both groups. The red colour indicates areas where the participants were looking the most at it then fades out to yellow and green for lower viewed spaces.

3.10.5 Think-aloud

The analysis of the think-aloud uses the three group split (cf. Section 3.9.2.2). That means it only includes the top four best performers and the bottom four performers. The data from the Think-aloud (cf. Section 3.8) is qualitative data. By using the coding technique (cf. Section 2.4), I analysed the think-aloud data. The transcription of the recordings is coded, and categories or themes are identified. The coding is done in a word document (Think-aloud coding first step.docx) and an excel sheet (Think aloud analysis.xlsx), these documents can be found in the online Appendix F. The outcome of the coding analysis is shown in a findings summary table for each think-aloud question, where the category, the meaning of the category, and the evidence from the data is outlined. The evidence from the data is only an example. The full data from the think-aloud can be found in the documents mentioned here above.
Table 3.2 shows the findings for think-aloud question 1.

Category or theme	**Meaning**	**Evidence from data**
Clear strategy	Answered with a clear strategy.	P4. "First, I looked at the lifecycles to figure out where it was in relation to the questions then if it was anything breakdown or shake related, I cross-referenced them with the current state"
No clear strategy	Did not give a clear strategy	P9. "I didn't´t really have a strategy, I tried to follow the words in the questions and to follow the process".

Table 3.2: Findings summary table for think-aloud question 1.

For think-aloud question 1 two categories identified and used as the final codes. The first one is *Clear strategy*, that is identifying those that had a strategy. The second one is *No clear strategy*, that is identifying those that did not say a clear strategy or said that they did not have a strategy at all.

Table 3.3 shows the findings for think-aloud question 2.

Category or theme	**Meaning**	**Evidence from data**
Enough	Participants thought the main process was enough	P3. “Yes, it was, at least that is what I think”.
Not enough	Participants that thought the main process was not enough	P11. “No, I don’t think so”.
Information missing	Missing some information from the fragments that are important	P4. “The main process is a good way to get a rough understanding of the process”.

Table 3.3: Findings summary table for think-aloud question 1.

for think-aloud question 2 three categories are identified and used as the final codes. The first is *Enough*, that code identifying those who stated that the Main process was enough, some participants in that category also said that some information could be missing. The second is *Not enough*, that is identifying those who thought that the Main process was not enough with out giving any reason why. And the third code is *Information missing*, that identifies those who said something about information could be missing from the fragments if they would not be shown regardless of what they stated about the previous codes.

Table 3.4 shows the findings for think-aloud question 3.

Category or theme	**Meaning**	**Evidence from data**
Used them	Stated that they used the lifecycles	P8. "Yes, I used them when I was searching for something". P4. "I specifically used them to see how the transitioning works and I used them to figure out the default states".
Did not use them	Stated that they did not use the lifecycles	P11. "Honestly nothing". P5. "I didn't´t really use them at all... yeah I didn't´t use them".

Table 3.4: Findings summary table for think-aloud question 3.

For think-aloud question 3 two categories are identified and used as the final codes. The first is *Used them*, that is identifying those who stated that they used the lifecycles, some participants gave more details about how they used them as well. The second is *Did not use them*, that is identifying those who stated that they did not use the lifecycles at all.

Table 3.5 shows the findings for think-aloud question 4.

Category or theme	Meaning	Evidence from data
Question related	If a question asked about them or participants said "only when question asked about them"	P9. "To answer questions about them". P11. "Mainly when a question asked specifically about the fragments".
See more details	To see more activities and execution of them, to see what happens when event occurs	P1. "To see what activities were executed". P2. "To realise what happens if the robot breaks down or if there is a shake event".

Table 3.5: Findings summary table for think-aloud question 4.

for think-aloud question 4 two categories are identified and used as the final codes. The first is *Question related*, that code is identifying those who only stated that they used the fragments if a question asked about them. The second is *See more details*, that code is categorising those who stated that they used the lifecycles for more details about some part of the overall process.

Table 3.6 shows the findings for think-aloud question 5.

Category or theme	**Meaning**	**Evidence from data**
Beneficial	Participants that said fCM was beneficial in some way	P1. “It helps to break it down into fragments, it would be much more crowded if it would all be in the same process, it makes it clearer, it is cleaner and better organised”. P7. “You can get a better understanding about the main process and how it works and how it connects to the data objects. You can get more details this way”.
Negative mentions	Participants that said something negative about fCM	P11. “It can be quite disorienting to use them all”. P4. “But you lose some information “.

Table 3.6: Findings summary table for think-aloud question 5.

For think-aloud question 5 two categories are identified and used as the final codes. The first is *Beneficial*, that code is identifying those who said something related to fCM being beneficial in some way or another. The second code is *Negative mentions* that code is identifying those who mentioned a negative thing about fCM.

Table 3.7 shows the findings for think-aloud question 5.

Category or theme	Meaning	Evidence from data
Event challenges	Challenging to integrate events when not using fCM	P3. "It could also get complex and the events can happen at any time so that is a challenge to make it fit with the main process".
Integration challenges	Challenging to see how and where fragments connect to the main process	P5. "it could be difficult to understand where and what fragments connect to the main process".
Information loss	Some information could be lost	P4. "You could lose some information".

Table 3.7: Findings summary table for think-aloud question 6.

For think-aloud question 6 three categories are identified and used as the finale codes. The first is *Event challenges*, that code is identifying those who said something about that it would be challenging to model the events into the main process. The second code is *Integration challenges*, that is identifying those who said something about that it is challenging to see in the main process where and how the fragments connect to the main process. And the third code is *Information loss*, that is identifying those who said that it could be challenging to not lose information when the processes are combined.

3.10.6 Question classification

When analysing the questions classes, I want to be able to figure out what class is the most difficult one by knowing that suggestions for improvements of fCM could be focused on those classes. I grouped the questions together in the classes and summed up the correct answers, correct answers with hint, wrong answers, and invalid answers for each question in each class. Then I divided the sum with how many questions each class had to get a final score for all the outcomes of the answers. Table 3.8 shows the questions in each class and the final score for each outcome of answers.

Question	Class	Correct	Correct with hint	Wrong	Invalid
Q2, Q3	Single state change	9.5	1	1	0.5
Q4, Q5	Combinational state change	7	2	2.5	0.5
Q6, Q8, Q9a, Q10b,Q12b	Condition	6.2	0.6	5	0.2
Q9b, Q10a, Q11, Q12a	State	7.25	0.75	3.75	0.17

Table 3.8: The question classification and their scores.

3.10.7 GSR data

When looking at the GSR (cf. Section 2.3.3) data, the focus was on event-related SCRs (ER-SCR). They can be interpreted as direct measures of arousal and engagement[12]. That can mean that if an ER-SCR peak event occurred the participant showed symptoms of stress that could indicate that he found the question difficult. The GSR data, the analysis of the performance, and the analysis of the performance based on question class could give a more concrete answer of what questions and classes the participants found most difficult.
The analysis was done by using the GSR data chart that Tobii Pro Lab software has built in. The graphical view shows SCRs events, ER-SCR events, and Figure 3.36 depicts an example images from Tobii showing the GSR data graph.

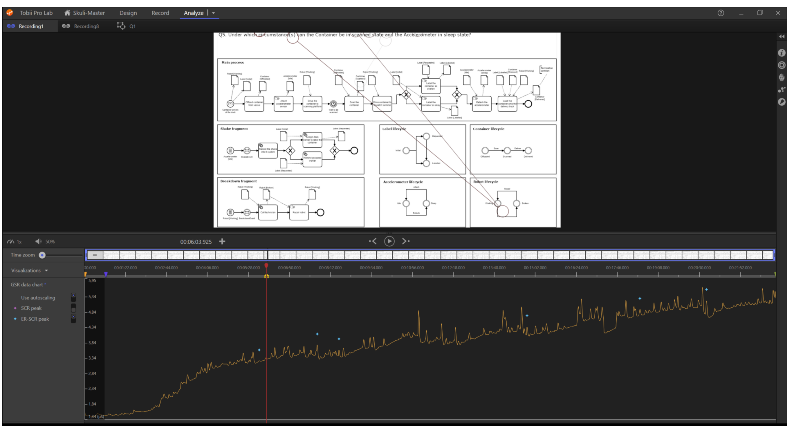

Figure 3.36: GSR data chart from Tobii Pro Lab.

The ER-SCR peak events are shown in blue just above the GSR sensor signal line in the graph. The ER-SCR peak events always happened when a participant got a new question in the experiment.

I also analysed the signal line from the data chart. I exported the GSR data from Tobii and created tables for each participant that shows the average value, the maximum value, and the minimum value of the signal from the GSR sensor.

P7			P8			P9			P10		
AV	MAX	MIN	AV	MAX	MIN	AV	MAX	MIN	AV	MAX	MIN
0.39	0.81	0.16	10.24	10.76	9.92	0.94	1.15	0.82	2.31	2.73	1.97
0.29	0.43	0.23	10.28	10.70	10.16	1.58	1.85	1.44	2.79	2.88	2.74
0.84	1.03	0.66	10.36	10.70	10.21	1.93	2.02	1.79	2.65	2.70	2.60
0.87	1.16	0.71	10.24	10.46	10.16	2.29	2.61	2.14	2.82	3.12	2.55
0.80	1.00	0.70	10.26	10.57	10.05	1.94	2.04	1.88	2.43	2.52	2.33
0.24	0.29	0.21	9.71	9.88	9.60	0.84	0.86	0.82	2.63	2.83	2.54
0.65	0.94	0.23	10.11	11.25	9.68	2.59	2.95	2.43	2.71	2.86	2.64
0.24	0.28	0.13	9.57	10.31	9.30	2.79	3.31	2.56	2.86	3.03	2.65
0.21	0.22	0.20	10.03	10.54	9.69	0.91	1.51	0.83	2.78	3.16	2.68
0.21	0.21	0.20	10.24	10.33	10.19	0.85	0.87	0.84	2.56	2.60	2.51
0.18	0.27	0.08	9.91	10.51	9.73	2.13	2.40	1.96	2.72	3.02	2.56
4.90	6.63	3.51	110.93	116.01	108.69	18.79	21.58	17.50	29.27	31.44	27.77
0.45	0.60	0.32	10.08	10.55	9.88	1.71	1.96	1.59	2.66	2.86	2.52
0.28	0.38	0.24	0.26	0.34	0.30	0.73	0.82	0.68	0.17	0.21	0.21
0.29	0.43	0.21	10.24	10.54	9.92	1.93	2.02	1.79	2.71	2.86	2.56

Figure 3.37: Table of GSR signal for four participants. Displayed in micro-Siemens (μS).

Figure 3.37 depicts an example table for four participants. The full table can be found in a document called GSR_Data.xlsx in the online Appendix F. The values in the table are micro-Siemens (μS), and they are shown for each question but excluding question seven. The non-coloured values at the bottom show the total, average, standard deviation, and median. Participant eight (P8) was the most stressed participant, and participant seven (P7) was with another participant the least stressed. After I had created those tables, I could calculate the same values for the groups to compare them with each other.
Both the ER-SCR peak event data and the GSR signal data is shown for each question that allowed me also to analyse what questions were the most stressful for the participants, and then I compared that analysis with the performance for each question.

3.10.8 Expected vs actual reading pattern

When I designed the questions, I wrote down the expected reading pattern based on my own experience with fCM. By doing this, it helped me to see if the question I was going to present to the participants would make sense, cover all the different parts of the model, and touch up on all the crucial components that fCM has to offer. When I had written down the expected reading pattern for each question an expert with extensible knowledge of fCM validated the expected reading pattern. The approach I used to analyse the reading patterns was similar to the method I used when analysing the questions. I used process maps from Disco (cf. Section 2.5) and heat maps from Tobii (cf. Section 2.3.2). The difference is that there is no group split just question split. Question four, seven, and question twelve are excluded from the analysis of the expected reading pattern because those questions were changed after the expected reading pattern was created for each question and I forgot to update the expected reading pattern after I changed these questions.

The second question in the experiment was: *Under which circumstance(s) can a Robot change from working state to broken state?*. The expected reading pattern was: *Here I expect the participant to skim through the whole model, looking at the data objects, read the robot lifecycle and stop at the breakdown fragment where they will answer, after "Call technician" activity.* To analyse the reading pattern process map from Disco was analysed. Figure 3.38 depicts an image of that model.

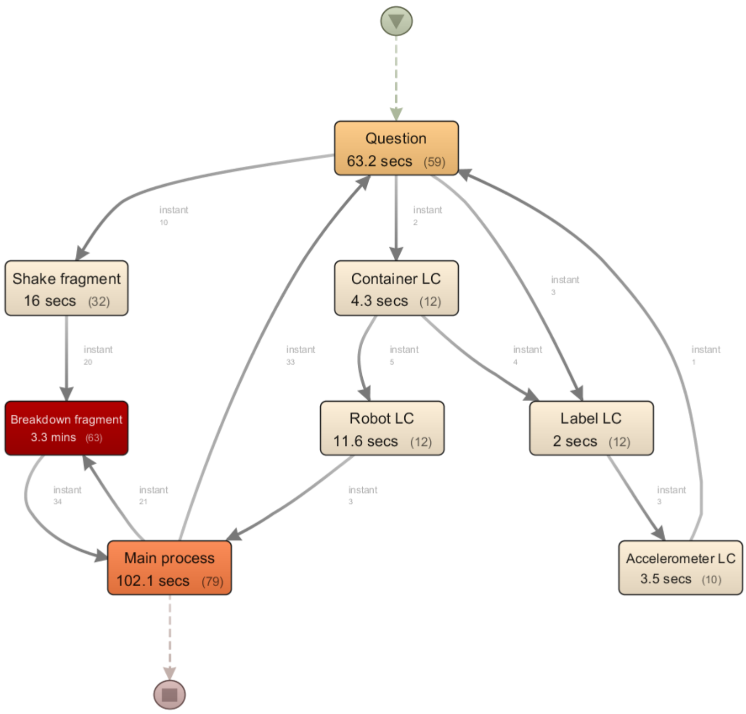

Figure 3.38: Total duration and absolute frequency for question two.

Figure 3.39 depicts the heat map for question two.

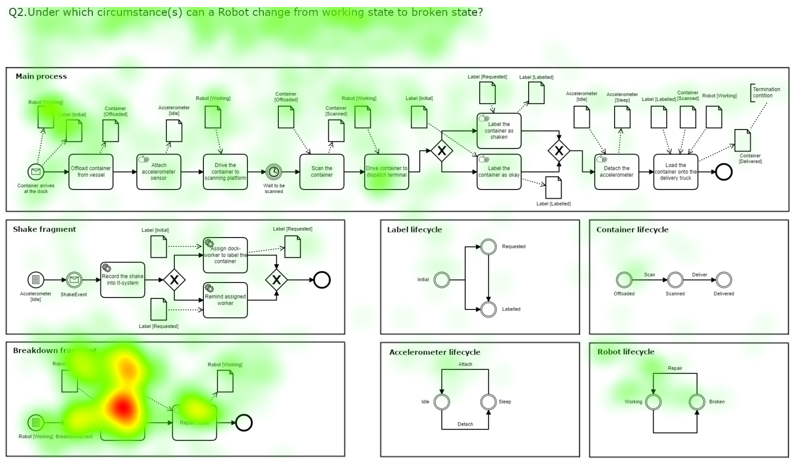

Figure 3.39: Heat map of question two.

By analysing these two images and comparing the actual reading pattern to the expected reading pattern I can see that the expected reading pattern was accurate, the fixation duration was highest for the Breakdown fragment, second highest for the Main process, third highest for the question and the Robot lifecycles had the most extended length of all the lifecycles. The most top repetitions also were between the Main process and the Breakdown fragment.

Question nine in the experiment had two parts. It started by giving a trace. The trace was: *A container is in a queue to be scanned, a shake event occurs, the "Record the shake into the it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state.* It then first asked: *What activities are executed until the Container is in the state "Delivered"?* And then it asked *What are the state(s) of the Label during the main process after the scan?* The expected reading pattern for both parts was: *Here participants should be looking at the main process after the scan, stopping at the XOR and read the Label data object state, then continue until the end where they see the Delivered state for the container.* To analyse the reading pattern process map from Disco was analysed. Figure 3.40 depicts an image of that model.

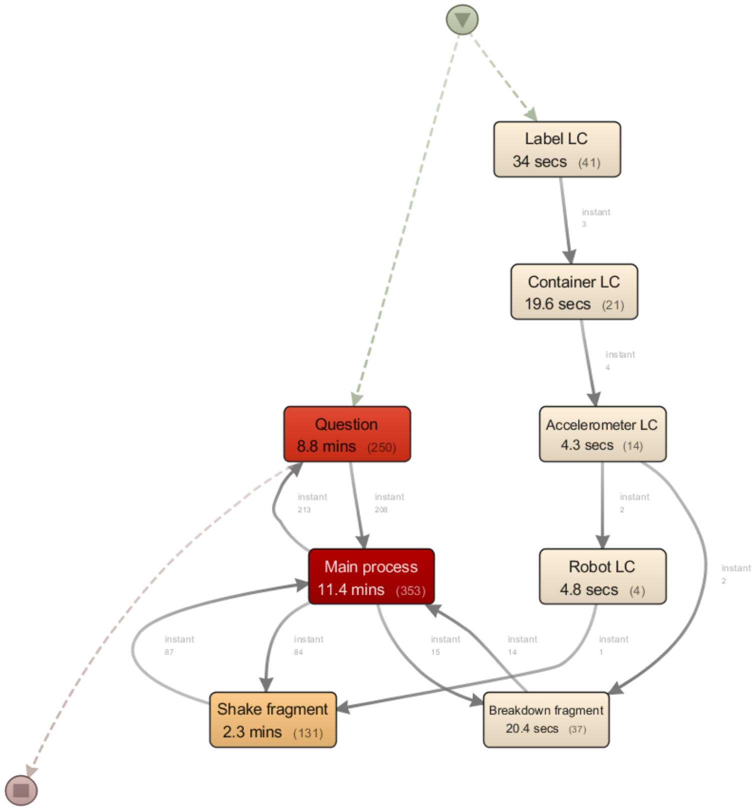

Figure 3.40: Total duration and absolute frequency for question nine.

Figure 3.41 depicts the heat map for question nine.

Figure 3.41: Heat map of question nine.

By analysing these two images and comparing the actual reading pattern to the expected reading pattern I can see that the expected reading pattern was accurate to some extent. If the prediction had mentioned the Shake fragment, it would have been very accurate. The primary fixation duration was spent in the Main process and almost all of it after the scan activity. The second most was the question, and that can be explained by the question having a and b part, as well as the question, was difficult for participants to answer correctly, only four out of twelve had this question correct. The heat map of question nine further confirms that the predicted reading pattern was accurate. You can see that the Main process after the scan has a lot of weight as well as the activities after the XOR.

This is only an example of the expected vs actual reading pattern analysis, the analysis for the other questions can be found in the Appendix E.

CHAPTER 4

Results

In this chapter, the results from the different analysis are reported. It first shows the results from the performance of the participants. It then shows the duration of the fixation on each are of interest. It then shows the results of the repetitions between the areas of interest. Next it explains the results from the question analysis and then it shows what question class participants found the most difficult one. Then the results from the galvanic skin response sensor is outlined. It then explains the results from the think-aloud and the results from the expected vs actual reading patterns. And finally the results are summarised and then they are discussed.

4.1 Performance results

The results from the analysis of the performance shows that the participants did a good job overall. Approximately 60% of the questions asked were answered correctly and approximately 68% were correct if we count the *Correct with hint* category as well. To better visualise how the overall performance was the outcome is depicted in Figure 4.1 as a pie chart.

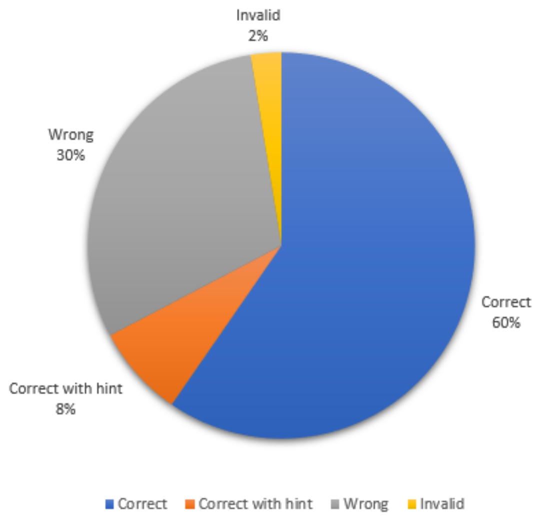

Figure 4.1: Total answers for each category.

The good overall performance and the fact that the majority of the participants had no experience in business process management is an indication of that fCM is understandable and people can be taught the basics in a short time.

4.2 Question analysis results

The question analysis results show that group A had *a more focused view* and group B had *a more distributed view*. The focused view of group A can be seen by comparing the hottest areas in the heat maps to the components that are asked in the questions, e.g. question two asks about how the Robot can change from working to the broken state. If the heat maps 3.35 are compared for question two it shows that group A is focused on the Breakdown fragment where the answer to the question is but group B is looking at the lifecycles as well as at the data objects in the Main process a lot. The distributed view of group B can further be seen in the heat maps of question 10 D.14, question 11 D.16, and question 12 D.18.

4.3 Fixation duration results

With the focused view of the participants in group A, they spent less time figuring out the answers to the questions which the fixation duration analysis confirms. Table 4.1 shows the fixation duration sum and total from all the questions on each AOI and the difference between the groups in percentage.

AOI	Group A	Group B	Difference
Main process	1050.6	1669	58.86%
Question	454.9	952.6	109.41%
Shake fragment	228.05	577.85	153.39%
Breakdown fragment	144.4	396.2	174.38%
All lifecycle	113.91	160.4	40.82%
Total	1991.86	3756.05	88.57%

Table 4.1: Fixation duration sum of all questions in seconds on each AOI for both groups.

Group B spent 88.57% more time overall on answering the questions in the experiment. Because group B had such a long fixation duration on the question, they were looking more distributed around the model and since they performed worse that indicates that the participants in group B were guessing more than participants in group A.

4.4 Repetition results

The same pattern is seen when the results from the repetition analysis are outlined. Table 4.2 shows the repetition sum from all the questions on each AOI and the difference between the groups in percentage.

AOI	Group A	Group B	Difference
Main process	206	320	55.34%
Question	152	256	68.42%
Shake fragment	106	174	64.15%
Breakdown fragment	56	121	116.07%
All lifecycles	57	92	61.40%
Total	577	963	66.90%

Table 4.2: Repetition sum of all questions on each AOI for both groups.

Group B had 66.90% more repetitions in total. The fixation duration difference and the repetition difference is related in a way. The highest values are for the question AOI and the fragments AOIs. Most of the difference is in the fragments, and it seems like participants in group B had a difficult time figuring out how the fragments work and how they connect to the main process. The results from the think-aloud analysis support that by showing that participants in group A talked about the importance of the fragments but participants in group B said that they were not as important.
These results show participants in group B were looking more around the whole model searching for the answer and possibly guessing while group A seems to have had a better understanding of where to find the answers in all of the AOIs.

4.5 Think-aloud results

This section reports the results from the analysis of the think-aloud data. The data from the think-aloud was in the form of qualitative data. The recorded think-aloud was transcribed and coded to extract usable knowledge from it.

The first question in the think-aloud was: *Can you describe the strategy you have followed to answer the questions?*.
The results of the coding gave two codes. The codes were *Clear strategy* and *Not clear strategy*. All participants from group A stated that they followed a strategy, but two participants from group C stated that they did not have a strategy or it was not clear to them what their strategy was. That indicates that it is better to have a strategy when reading through the fCM models. The strategy group A mentioned they used was to read the question carefully and try to locate the things mentioned in the question and to have a clear overview of the states and how the states change from one state to another and how that affects the process. One participant also from group A specifically mentioned that it was good to think about the scenario in real life.

The second question in the think-aloud was: *Was the main process enough to get an understanding of the process?*.
The results of the coding give three codes. Participants that state that the Main Process was *enough*, participants that state that it was *not enough*, and participants that state it was *enough, but some information was missing*. When analysing the answers, participants in group A specifically mentioned that it was missing the fragments for crucial information. That indicates that the fragments are an essential asset of the process, they hold vital information about how the Main process progresses based on changing data object states and they should not be left out when fCM models are explained.

The third question in the think-aloud was: *For what purpose have you used the lifecycles?*.
After coding this question, two codes are used. The first code is *Used them* and the second is *Did not use them*. It was interesting to see that participants from group A all stated that they used them and some of them mentioned what they used them for but the participants from group C except for one stated that they did not use them at all or only for one question that specifically asked about states (Q11). Its an indication of how useful the lifecycles are and how they can simplify the process of understanding and reading fCM models. They are not just beneficial when one must know all possible states for a given data object, they provide an overview and are a quick way to see if some transactions in the process are possible or not.

The fourth question in the think-aloud was: *For what purpose have you used the different fragments?*.
From the coding of this question, two codes are identified. They are *Question-related*

and *See more details*. The first code identified three participants from group C. They all stated that they only used the fragments when a question asked about them. The second category had all participants from group A, they stated that it was not just for answering questions, it is also for seeing more details and that they are used when the Main Process needs them. It indicates that the fragments are a vital part of the model and they are necessary not just to answer questions about them but also for an overall understanding of the scenario.

The fifth question in the think-aloud was: *Do you see any benefits in combining the main process, with fragments and lifecycles?*.
The results of coding this question gave two codes, *Beneficial* and *Negative mentions*. Overall participants found fCM beneficial compared to conventional BPM. In the familiarisation task 3.7 I showed participants a complex BPM model so they would have something to compare too. All the participants said that it was beneficial in some way and only two participants said a negative thing. Those two participants came from separate groups, the participant from group A stated that you could lose some information by using fCM and the participant from group C states that it could become disorienting to use all the fragments. Since all the participants said that fCM is beneficial, I further coded that down. The results from that show that three participants from group A stated that it reduces the complexity of modelling business processes and participants from group C stated that it is clearer and more understandable than the model I showed them in the familiarisation task. What this analysis indicates is that in general, all participants saw a benefit from using fCM, so the development of this new approach is on the correct path.

The sixth and the final question in the think-aloud was: *Do you see any challenges in combining the main process, with fragments and lifecycles?*.
After coding this question, the codes I found were *Event challenges*, *Integration Challenges*, and *Information loss*. Two of the participants from group A talked about that it would be difficult to model the events into the Main Process, they can only happen at a particular stage in the process as well as they can happen at any time when the process is in that specific stage. The participants from group C were a lot less informative about why it would be challenging, and two of them stated that they could not see any challenges. It indicates a deeper understanding of modelling business processes from group A despite that most of the group had no previous experience with BPM or BPMN in fact group C had members that had previously worked with BPM and BPMN. It indicates that fCM is simple enough for people that have a general engineering background; they can understand and make sense of the fCM approach with ease.

4.5.1 Think-aloud results summary

To summarise the results from the think-aloud these are the main parts that I found out:

- It is better to have a strategy when reading through the fCM models
- The fragments are an important asset of the process, they hold vital information about how the main process progresses based on changing data object states and they should not be left out when fCM models are explained.
- Lifecycles are useful and they can simplify the process of understanding and reading fCM models.
- Lifecycles are not just beneficial when one must know all possible states for a given data object. They provide an overview and are a quick way to see if some transactions in the process are possible and valid.
- The fragments are a vital part of the model and they are needed not just to answer questions about them but also for an overall understanding of the scenario.
- In general all participants saw a benefit from using fCM, so the development of this new approach is on the correct path.
- In general fCM is simple enough for people that have a general engineering background, they can understand and make sense of the fCM approach with ease.

4.6 Question classification results

Results of the analysis of the questions classes show which question class the participants found the most difficult to answer. Figure 4.2 shows a clustered bar chart with the question classes and their score for each answer outcome.

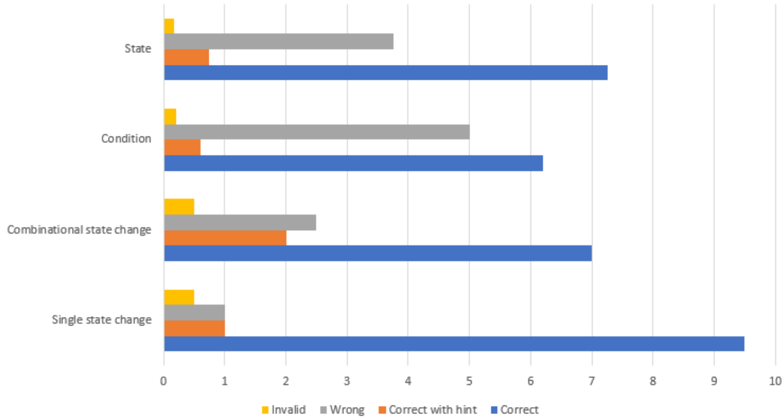

Figure 4.2: Total fixation duration for group B.

The chart shows that the Single state change class had the most correct answers and the condition class had the fewest correct answers. The Combinational state change class had the highest score in the correct with hint answer outcome. Those results show that the participants found the Condition class the most difficult, the Single state change the easiest one, and the Combinational state change one was the most confusing.
These results indicate that if a fCM model has a lot of fragments that are controlled by pre and post conditions the explanation and the model need to be very clear.

4.7 Galvanic skin response results

After analysing the GSR data the results are that group B can be considered more stressed. Group B had more than one peak event for all the questions except for question one. That means that more participants of group B generated peak events. The reason for most of the peak events for group A is that one participant in that group generated a peak events in eight questions out of eleven and was the highest in total peak events of all the participants. If that participant is excluded from the data the total peak event for group A would be eight in stead of sixteen. Figure 4.3 depicts the ER-SCRs peak distribution on each question as well as the total for both groups.

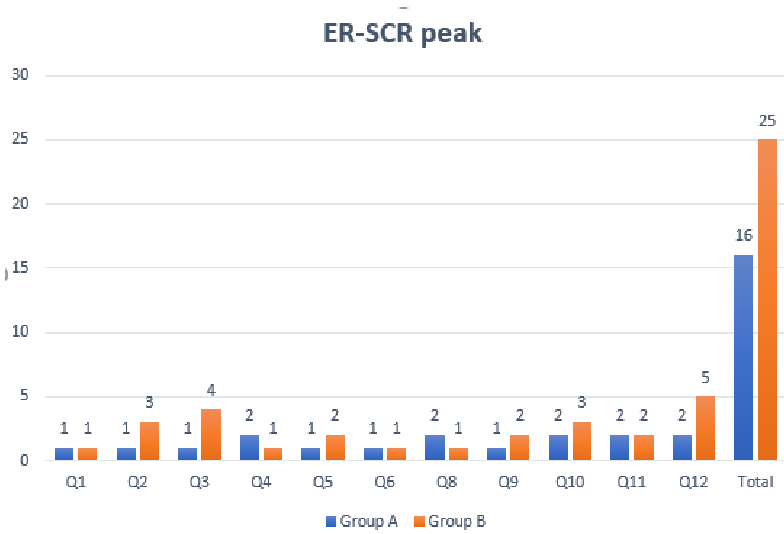

Figure 4.3: ER-SCR peak events for both groups.

The results from the signal of the GSR sensor also show that participants from group B were more stressed. Table 4.3 shows the average Micro-Siemens value for each question for both groups. Group B had a higher average value for nine questions out of eleven and 0.27 μS higher total average value.

Question	**Group A**	**Group B**
1	2.67	1.62
2	3.16	3.56
3	2.87	3.94
4	3.04	3.74
5	2.82	2.95
6	2.77	3.03
8	2.99	3.71
9	2.81	3.39
10	2.87	3.04
11	2.96	2.71
12	2.90	3.14
Total AV	2.90	3.17

Table 4.3: Average Micro-Siemens value for each question for both groups.

To show the relation between the high average value from the sensor and a high total number for ER-SCR peak events Figure 4.4 depicts a graph with two lines. The blue line is the total number of peak events for all the participants and the orange line is the average value from the GSR sensor.

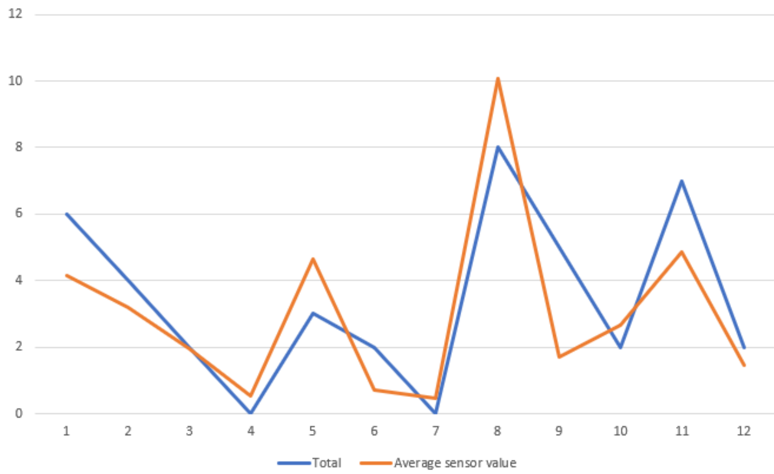

Figure 4.4: Total ER-SCR peak events with the average GSR sensor value.

The result for each question show that most of the ER-SCR peak events happened when question twelve appeared to the participants for a total of seven events, then question ten and question three followed with five each. Figure 4.5 depicts the total peak events for the questions with the groups combined.

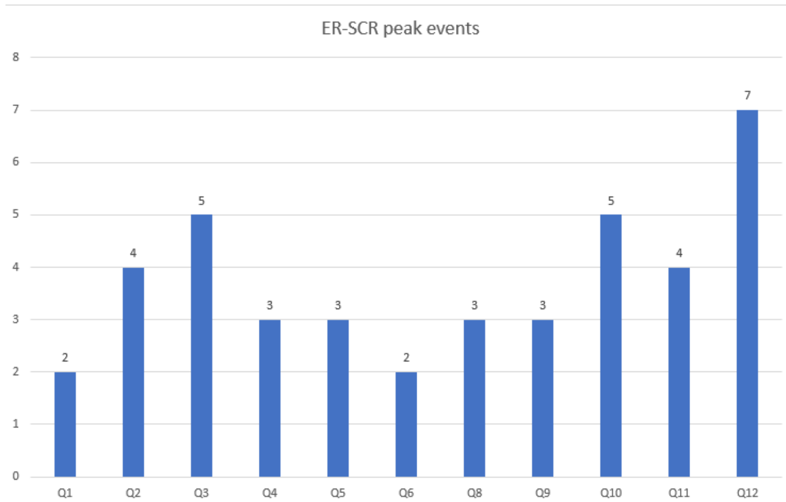

Figure 4.5: ER-SCR peak events for the questions with combined groups.

If we look at the results from the performance of the participants and take the wrong answers and compare them with the number of ER-SCR peak events for each question one can see that there is not a strong connection of giving a wrong answer and having many ER-SCR peak events. Figure 4.6 depicts the comparison of ER-SCR peak events against wrong answers.

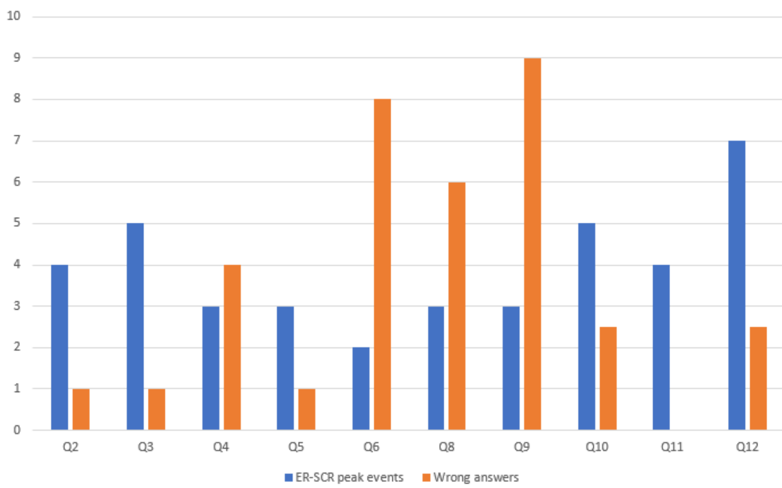

Figure 4.6: ER-SCR peak events compared with wrong answers given to a question.

4.8 Expected vs actual reading pattern results

In this section the results of the analysis of expected vs actual reading patterns is outlined.

Table 4.4 shows the results for question two.

Question	**Expected**	**Actual**
Under which circumstance(s) can a Robot change from working state to broken state?	Here I expect the participant to skim through the whole model, looking at the data objects, read the robot lifecycle and stop at the breakdown fragment where they will answer, after “Call technician” activity.	The fixation duration was highest for the Breakdown fragment, second highest for the Main process, and third highest for the question. The Robot lifecycles had the most extended duration of all the lifecycles. The most top repetitions also were between the Main process and the Breakdown fragment.

Table 4.4: Summary table for question two.

The data here is indicating that the expected reading pattern was accurate because the Robot lifecycle has the most duration of the lifecycles and the Breakdown fragment has the highest duration overall just like the expected reading pattern predicted.

Table 4.5 shows the results for question three.

Question	Expected	Actual
Under which circumstance(s) can the Label change from initial state to requested state?	Here I expect the participant to skim through the Main process, looking at the data objects, read the Label lifecycle and stop at the Shake fragment where they will answer, after "Assign dock-worker activity is executed" activity.	The fixation duration was highest for the Main process, second highest for the Shake fragment, and the Label lifecycle had the most duration of all the lifecycles. The most repetitions were between the Question and the Main process, the second most between the Main process and the Shake fragment, and the third most between the Shake fragment and the Breakdown fragment.

Table 4.5: Summary table for question three.

The data here is indicating that the expected reading pattern was to some extent accurate. The mentioned components in the expectations had the highest duration. The heat map E.4 of the reading pattern for question three shows an unexpected dwell time on the XOR in the Main process; that is something that was not considered in the expected reading pattern prediction. But this is understandable in a way because the Label is a pre-condition for the activities after the XOR.

Table 4.6 shows the results for question five.

Question	Expected	Actual
Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?	Here I expect to see the participants trying to find the Container data object and where it changes it state to scanned, then they will look for the accelerometer and try to figure out where it changes it state to sleep. After they find it in the main process, I expect them to look at the other fragments to make sure they are not there as well and then they will give an answer.	Participants were stopping at the location where the container changes to scanned state and most of the fixation duration was at the end of the Main process where the accelerometer changes it state to sleep state. The Main process had the highest duration and the second highest was the Question.

Table 4.6: Summary table for question five.

From the data you can see that the expected reading pattern was close to the actual reading pattern. The heat map E.6 shows that participants had a longer duration on the activity where the container changes to scanned state, the Accelerometer lifecycles has the highest duration of the lifecycles, and there is extensible duration on both of the fragments. The prediction did not mention that in the main process the participants looked more at the place where the accelerometer changes it stated than where the container changed it state.

Table 4.7 shows the results for question six.

Question	Expected	Actual
In all fragments, what is the minimum set of activities that should be executed prior to "Assign dock-worker to label the container" activity?	Here I expect participants to find the activity mentioned, then to look at the pre-condition for the fragment that has the activity then read the main process until they find the precondition and then say the answer.	The fixation duration was pretty evenly distributed between the Main process, the Shake fragment, and the Question. The Main process still had the highest duration. The lifecycles had a very low duration

Table 4.7: Summary table for question six.

The expected reading pattern prediction was not thorough enough so it can not be said that it was accurate. The difficulty of the question was highly underestimated in the prediction. The question was difficult for people to answer based on the results, only four out of twelve had this question correct. Participants were looking more at latter part of the Main process but it was predicted that they would stop at the pre-condition which is in the beginning of the Main process. These results are based on all participants, the prediction could be more accurate if one would look at the heat maps for the groups separately.

Table 4.8 shows the results for question eight.

Question	**Expected**	**Actual**
No shake event has occurred, a breakdown event occurs, and the “Call technician” activity is executed, what activities can then be executed after the “Drive container to dispatch terminal” activity?	Here I expect the participant to skim the model for the mentioned activity. Then to look at the breakdown fragment to see what happens in that fragment and after the “Call technician” activity. Then I expect participants to find the state of the label and then look at the main process after the mentioned activity to see what activities can be executed.	Most of the fixation duration was in the Main process, then in the Question, and the third most in the Breakdown fragment. The Shake fragment and the lifecycles had a low fixation duration

Table 4.8: Summary table for question eight.

From the data you can see that the expected reading pattern was accurate. Most of the fixation duration was in the Main process and the third most in the Breakdown fragment. The long dwell time for the question can be explained by the outcome, participants found the question difficult, only four out of twelve could answer this question correctly. The heat map E.10 further shows how the expected outcome was accurate. The focus is on the last part of the Main process and the Breakdown fragment.

Question nine first gave a trace to the participants. The trace was: *A container is in a queue to be scanned, a shake event occurs, the “Record the shake into the it-system” activity is executed as well as the “Assign dock-worker to label the container” activity. When the queue is over, and the container is in a “Scanned” state.* Then it asked two questions. Table 4.9 shows the results for question eight.

Question	**Expected**	**Actual**
Q9a) What activities are executed until the Container is in the state "Delivered"? Q9b) What are the state(s) of the Label during the main process after the scan?	Here participants should be looking at the main process after the scan, stopping at the XOR and read the Label data object state, then continue until the end where they see the Delivered state for the container.	The most fixation duration was spent in the Main process and almost all of it after the scan activity. The Question had a high duration and the Shake fragment as well, both counted in minutes. The breakdown fragment and the lifecycles had less, counted in seconds. The Label lifecycles was the highest and the Container second highest, both of them were mentioned in the question.

Table 4.9: Summary table for question nine.

From the data you can see that the expected reading pattern was accurate to some extent. If the prediction had mentioned the Shake fragment it would have been very accurate. The main fixation duration was spent in the Main process and almost all of it after the scan activity. The place where the Container is changed to delivered state (end of the main process) also got a high fixation duration. The heat map E.12 of question nine further confirms that the predicted reading pattern was accurate. You can clearly see that the Main process after the scan has a lot of weight as well as the activities after the XOR.

Question ten also gave a trace before asking two questions. The trace was: *A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed.*. Table 4.8 shows the results for question ten.

Question	Expected	Actual
Q10a) What are the state(s) of the Robot, Label, Container, and the Accelerometer? Q10b) In order for the main process to continue, what activity has to be executed next?	Here participants should be looking at the first two activities and then at the Breakdown fragment, then back up to the third activity.	The main process had the most duration closely followed by the question. The Breakdown fragment had an extensible fixation duration as well. The fixation duration for the lifecycles was evenly distributed. Participants were looking mostly from the question to the Main process and from the Question to the Breakdown fragment.

Table 4.10: Summary table for question ten.

From the data you can see that the expected reading pattern was accurate to some extent. What was missing was the part for question a, there participants are looking at the lifecycles which is understandable because the question is about the states of the data objects. The Main process has the most fixation duration and second is the Question. Third most is the Breakdown fragment and that was expected. The heat map E.14 further confirms that the expected reading pattern was accurate. The process model E.13 from Disco then shows the highest repetitions between the Question and the Main process and between the Question and the Breakdown fragment. That fits somewhat to the expected reading pattern.

Table 4.11 shows the results for question eleven.

Question	Expected	Actual
What are all possible states for the container?	Here participants should just look at the lifecycles and answer.	The Main process had the highest fixation duration, the Container lifecycle had the second highest, and the question third highest. Participants were quick and did not spend much time on this question but some distributed viewing pattern is noticed.

Table 4.11: Summary table for question eleven.

From the data you can see that the expected reading pattern was accurate. The fixation duration was very low for all the artefacts. The Main process was highest, and the Container was the second highest. Some fixation duration is noticeable as well in the Main process, that can be explained by the fact that some participants were searching for the states of the Container in the Main process as well as in the fragments. That can be seen in Section 3.10.4 where each question is analysed based on participants performance.

4.9 Results summary

So what do all these results from the different analysis mean and how are they answering the question of how people read and understand fragment-based case models. To answer that question I have summed up the results from the different sources. The sources that I used to answer that question are the performance, the question analysis, the fixation duration, the repetitions, and the think-aloud.

The results from think-aloud show that people read the models differently. Some had a strategy, and some created a strategy along the way, and others did not have a strategy at all. Then two participants said they read the model from left to right. The visual recordings of the participants though show that most of them were jumping around the model. The question analysis then shows a more individual difference in how people read fCM models. Some had a focused view, and others had a distributed view. The fixation duration and the repetitions then confirm that. The fixation duration for people with a targeted view was higher on the places where the answer could be found, and the people with a distributed view had higher fixation duration on areas that did not have a connection with the answer. The repetitions were much higher for people with the distributed view that shows that those people were looking around in the model. The people with the focused view performed better and had a better understanding of the model that was asked about.

Based on the results from the performance it shows that the fCM approach is well understandable and the different components it has are being used as intended. Those components are fragments, data objects, and lifecycles.

The question class and the GSR data were not directly involved in answering the research question. The results from these sources were intended to get an understanding of what aspects of modelling with the fCM approach could be improved. The results from those sources show that if the model has a lot of conditions (pre and post), it gets more complicated to read and understand. The results from the GSR data did not show that the most stressful questions were also the most difficult to answer.

The final source, the expected vs actual reading pattern was created to be sure that all the aspects of fCM would be covered with the questions. The expected reading pattern was then presented to a person with expert knowledge of fCM for validation. The result from the analysis of that show that I was pretty accurate most of the time and that is an indication of fCM being understandable and straightforward because of my limited experience.

Based on the results from the participants it shows that the advantages of the fCM approach are that it adds clarity and reduces the complexity of business process models. All of the participants found the idea of splitting extensive processes into different smaller fragments useful. The inconveniences are that it might get complicated to figure out where and when the fragments come to use if the process is extensive with a lot of fragments.

4.10 Discussion

This section discusses the results of the experiment. The overall results show that fragment-based case modelling (fCM) is an approach that is well readable and easily understood even to people with no prior experience with business process management (BPM). The majority of the participants in the experiment did not have any BPM experience, but the performance showed that it was not an issue regarding the understanding of the model. Some parts of the fCM approach were more challenging to understand. Participants found questions classified as a condition question the most difficult. Those questions required the participants to know how a data object is used as a pre-condition for fragments and activities. Participants also reported in the think-aloud that some information could be lost and that it could be challenging to see how the main process connects to the fragments and where the fragments help the main process. These arguments fit with the fact that the condition questions were the most difficult ones. When the participants were split into groups based on their performance it showed a clear difference in how they read the model. The group that performed better had a more focused view, and the group that performed worse had more distributed view. The fixation duration on the question artefact as well as more fixation duration overall for the group that performed better and the fact that the same group had more repetitions between the artefacts confirm what the heat maps show that this group had a more distributed view and it seems that this group was guessing more on the answers. The group that performed better and had a focused view was focusing on the components that were asked about in the question, they approached the model with a clear strategy, and they used the lifecycles for the data objects to validate the state transitions. The result from the GSR then showed that participants in the group that performed worse were also more stressed and more emotional aroused when answering the questions thus finding them more difficult. A participant in the group that performed better was the most stressed one but was also the participant the performed the best.
The reason for the stress of the participant could be that the calibration of the eye-tracker took a very long time or that the participant wanted to perform well and therefore read the questions and the model carefully before answering the questions. It is difficult to validate how that participant read the model because the eye-tracker collected low gaze samples for him. That brings me to the limitations of such an experiment. The reason for the low gaze samples could be that the participant had mascara on her eyes[10]. It could also be because the participant was looking away

from the eye-tracker a lot. There were participants in the experiment with much lower gaze samples overall and this could be a factor in the results as they were not left out of the analysis of the data. Table 4.12 shows the gaze samples collected in percentage for each participant.

Participant	**Gaze samples %**
P1	97
P2	96
P3	85
P4	90
P5	59
P6	94
P7	99
P8	39
P9	99
P10	34
P11	49
P12	96

Table 4.12: Gaze samples collected for each participant in the eye-tracking experiment.

Like the table shows some of the participants had a low percentage and because of that I calculated the interquartile range to see if they would be outliers from the data set. What that calculation showed was that they were well within range, so no participant was left out from the analysis of the data although 39% and 49% are generally very low gaze samples. Another limitation of this experiment is that people could have found the questions confusing. I noticed some indications of that. When I gave a hint or explained the problem better the participants almost answered correctly. What people found confusing, for example, was question six. It asked about the execution of activities in all fragments. Some participants then did not consider the main process in that question and therefore did not answer correctly, or at least what I said was correct based on how I designed the question. Another limitation to the validity of the experiment is how detailed I explained the fCM concept to the participants in the familiarisation task. It is very likely that I was more focused on teaching all the details to participants that I knew that they did not have any prior experience with BPM.

What I think could have been done better in the experiment is that I should have had more focus on the think-aloud to get more detailed results. The think-aloud showed some difference between the participants, but if I would have asked the participants for more detailed answers, I think more visible results would have shown. The answers in the think-aloud were most often concise and superficial. Another thing was that due to time restrictions I could not get any more experienced people to participate.

It would have been nice to have people with extensible BPM knowledge joining. That could have shown if there were a big difference in how experienced people read and understand fCM models compared to how inexperienced people do.

The conduction of the experiment did not go as smooth as I would have liked it to be. Some mistakes were made. The first one was that question six appeared twice in the experiment for the first two participants. The first participant did not notice it and gave the wrong answer again to the problem. I found the question familiar, and they are, question six and seven both start with the same text but I did not realise that it was question six again until participant two. Participant two did not notice that the question was the same again and gave a different answer. When participant two had finished, I changed the design of the experiment, removed the duplicate question and added correct question seven in. When the data was analysed to keep it fair and straightforward, I removed question seven from the data. The second mistake I did was that I forgot to start the voice recordings for participant four. It is unbelievable how I could forget that because I had three devices recording the answers for extra safety but forgot to turn on any of them. Luckily I noted down the questions order and answers while the experiment was ongoing so I got the participants performance but could not validate the scores with voice recordings. I realised the mistake before we did the think-aloud, so the recording of that was at least recorded.

The improvements that need to be done on Gryphon and Chimera were realised when the model was being created from the scenario and the constraints. To be able to fulfil all the constraints an XOR needed to be used. Gryphon is relying on data objects for the control flow, but it still isn't complete enough to completely remove the gateways.
As you can see in Figure 3.11 of the model, there were two XOR gateways. The XOR gateway in the Main process had to be there because the Label data object had to be created at the beginning of the Main process so the same instance would be used in the Shake fragment if a shake event occurs. So for the Main process to be able to finish the XOR gateway was added otherwise it would mean that a shake event always had to occur for the Main process to complete. The XOR gateway in the Shake fragment had to be there to handle the possibility of multiple shake events happening when moving the same Container. It is understood that the XOR gateway could have been removed and another fragment instance would always be created but that did not fit with the thought of having one label for each container like you would do in real life.

CHAPTER 5

Conclusion

The exploratory study aimed at investigating how people read, understand and approach fragment-based case models (fCM). A research question was asked that drove the development of this project. First, a scenario was developed that fitted with the possibilities of what fCM can do best, that is to handle variant rich processes. By combining fragments at runtime and using data objects for the control flow. Then the model was modelled with Gryphon and executed in Chimera for validation.
Questions were conceived from the model and participants were asked to answer the questions. An eye-tracking experiment was then conducted with the model and the questions as the stimuli. Participants also wear a GSR sensor to grasp the emotional experience from the experiment as well. After the eye-tracking experiment, a lot of data had been created. To analyse that data statistics and heat maps were used from the eye-tracking software, process mining was used with a tool called Disco, and qualitative data analysis method known as coding was used on the transcribed data from voice recordings. The voice recordings came from participants answering the questions and from a think-aloud that was done after the eye-tracking experiment.
First, to get an overview of how all the participants understood the model the performance of the answers from the questions was analysed. Then the participants were split into two user groups. By examining the behaviour of the two user groups, we can understand the reasons why those who did well, did well and based on those results suggestions of improvements can be outlined.

Based on the performance of the participants the overall understanding of fCM is good. No prior business process management experience is required to learn the basics of fCM. The participants found the fragments valuable, and they used the lifecycles for the data objects as indented. The fragments hold vital information about how the main process progresses based on changing data object states, and they should not be left out when fCM models are explained. Lifecycles are not just beneficial when one must know all possible states for a given data object. Lifecycles provide an overview and are a quick way to see if some transactions in the process are possible or not. When the groups were split, and the difference in how they read the model was analysed it showed that the group that performed better had a more focused view and the group that performed worse had a more distributed view. The data also indicated that the group that performed worse were guessing more on the answers instead of figuring out the solution by looking through the model. It also showed that having a strategy when reading the model is beneficial.

In this exploratory study, the focus was on the overall understanding and to see if people found fCM understandable and easy to grasp so from the results of the analysis it is difficult to find aspects of fCM that could be improved. A more thorough experiment would have to be conducted about specific parts of fCM. Results have shown that fCM is on the correct path but Gryphon and Chimera are only a subset of BPMN 2.0 so there is some development that needs to be done.

5.1 Future Work

There are different possibilities for future work for this project. First, one being that the data from the transcribed answers could be coded. Specifically, question one that asked the participants to describe the scenario. In that transcription, some valuable information could lie, and they could shed more light on how people read fCM models.

The second possibility would be to get more participants to take the eye-tracking experiment, especially people with more knowledge about the subject.

The third possibility is to investigate the gender aspect further. Is it just a coincidence that the group that performed better was almost all female and the group that performed worse were all males. That is a question that could be interesting to follow, but it would maybe not improve the possibilities of fCM, but instead, it could add some value to the argument that females are better at multitasking than males.

The fourth possibility would be not always to show the same model but develop different scenarios and create more questions with them. That could eliminate the learning possibility, and I think it could give better results about how people read the model.

The fifth possibility is to use the data gathered in the second section of the pre-experiment form (cf. Section 3.6). In that section, a screening of the participants to asses their physical ability to participate in the eye-tracking experiment was done. With the data from that screening, one could look into if some physical limitations or capabilities affect the reading and understanding of fCM.

The sixth possibility is to listen again to the recordings of the answers from the participants to confirm the theory of participants that were in the group that performed worse were guessing more and were more reckless or careless in their answers.

APPENDIX A
Images of experiment ready questions

Q1. Can you describe the scenario that the model is showing? (You have 5 min for that)

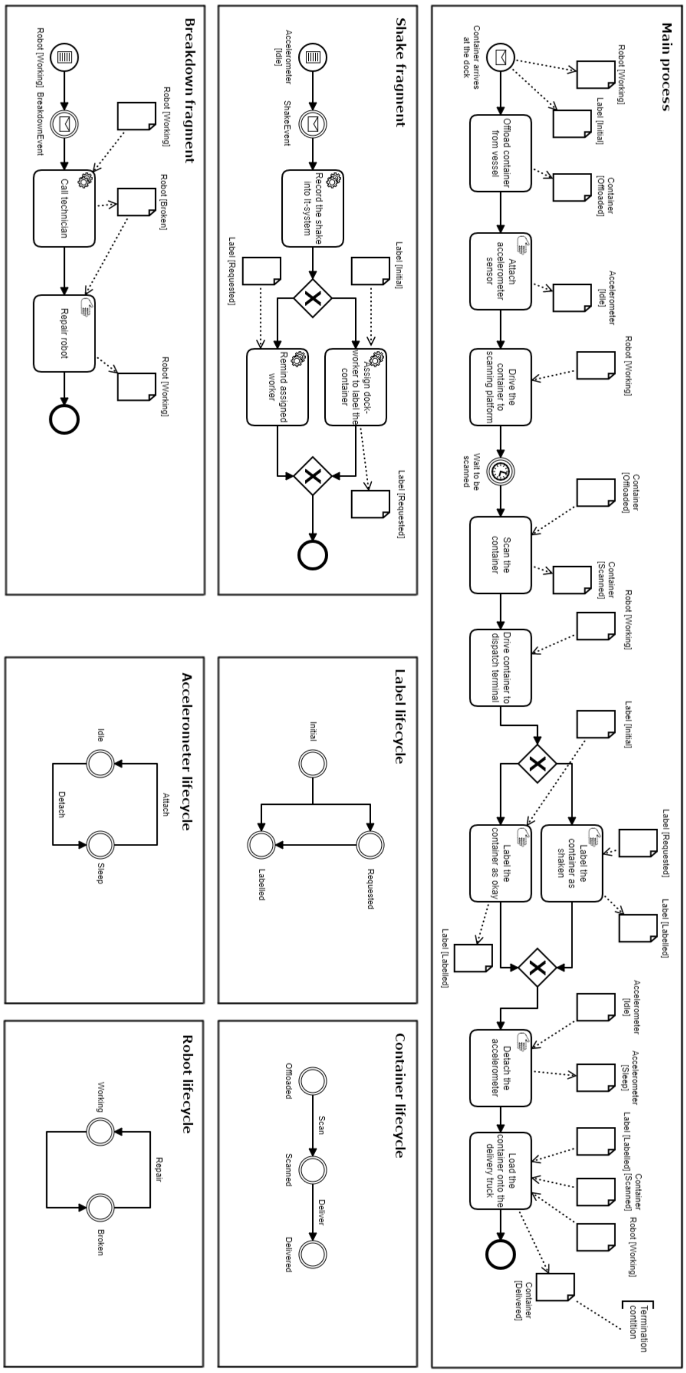

Figure A.1: Question 1 ready for experiment.

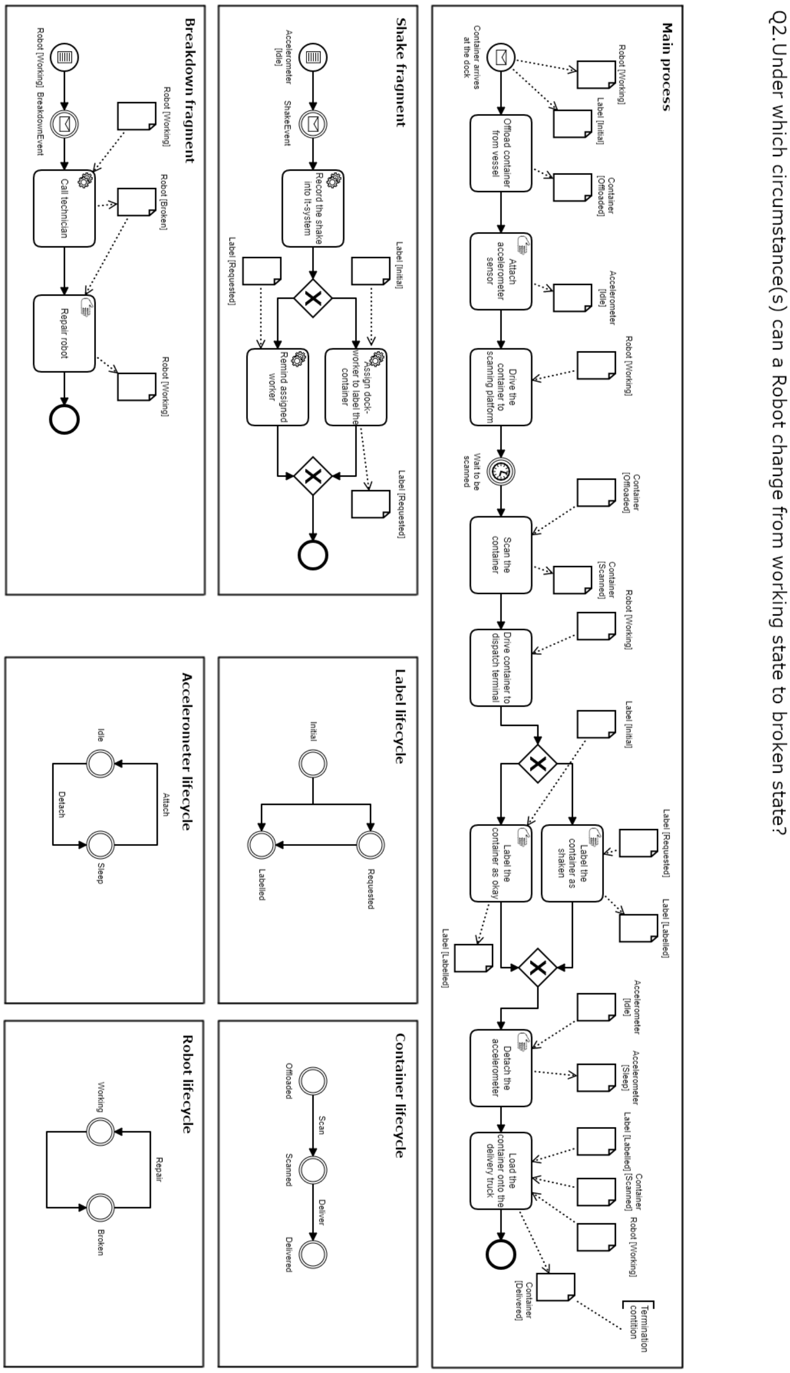

Figure A.2: Question 2 ready for experiment.

Q3.Under which circumstance(s) can the Label change from initial state to requested state?

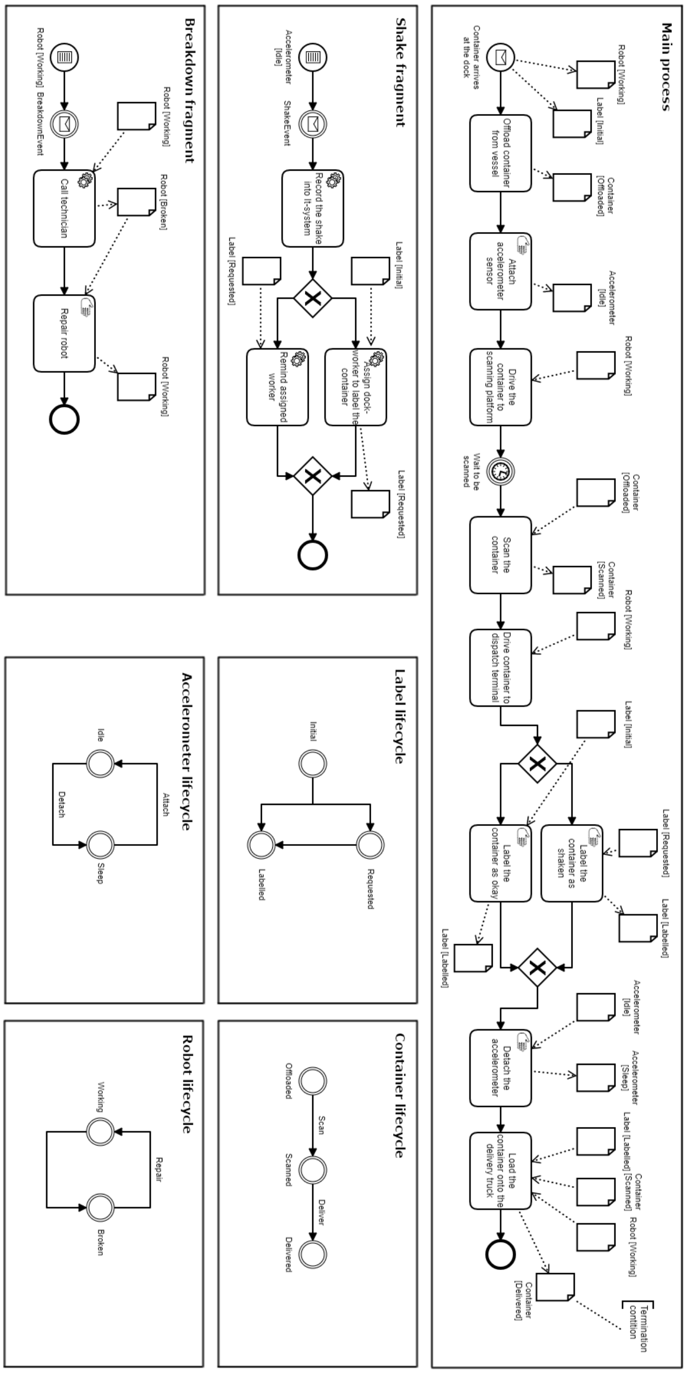

Figure A.3: Question 3 ready for experiment.

Q4. Under which circumstance(s) can the Accelerometer be in an idle state and the Label in labelled state?

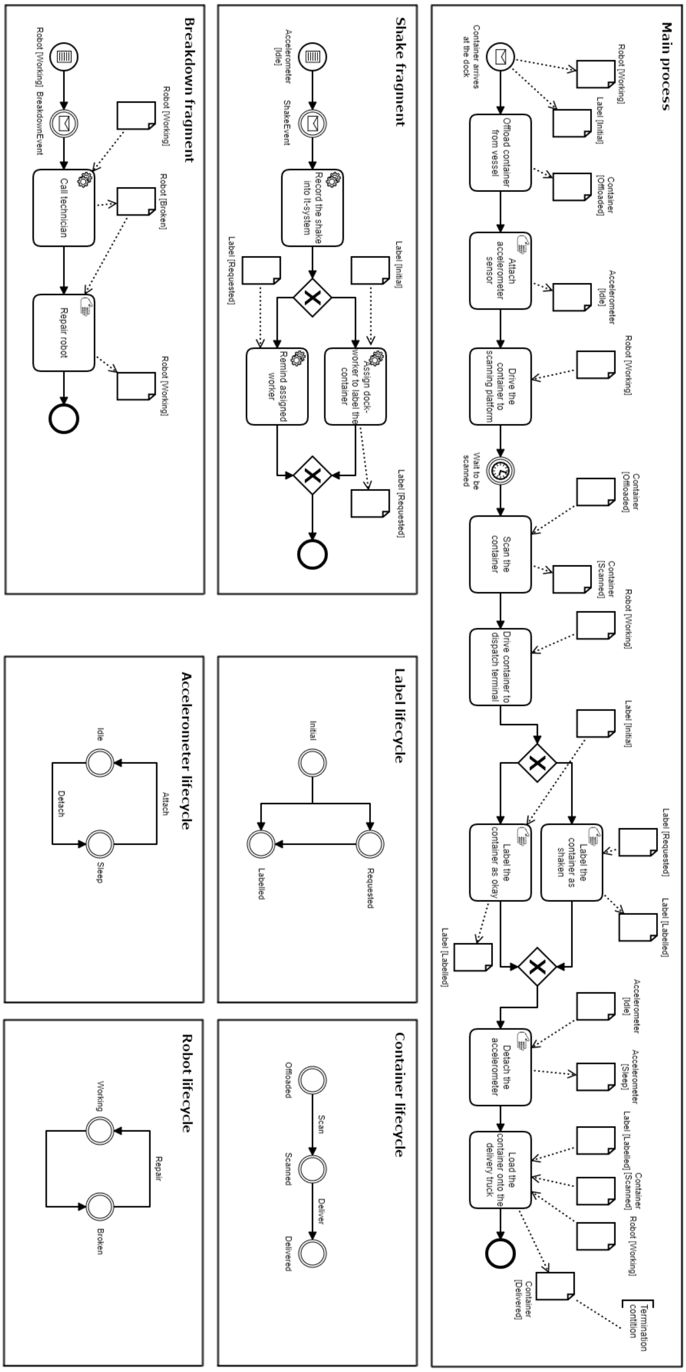

Figure A.4: Question 4 ready for experiment.

Q5. Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

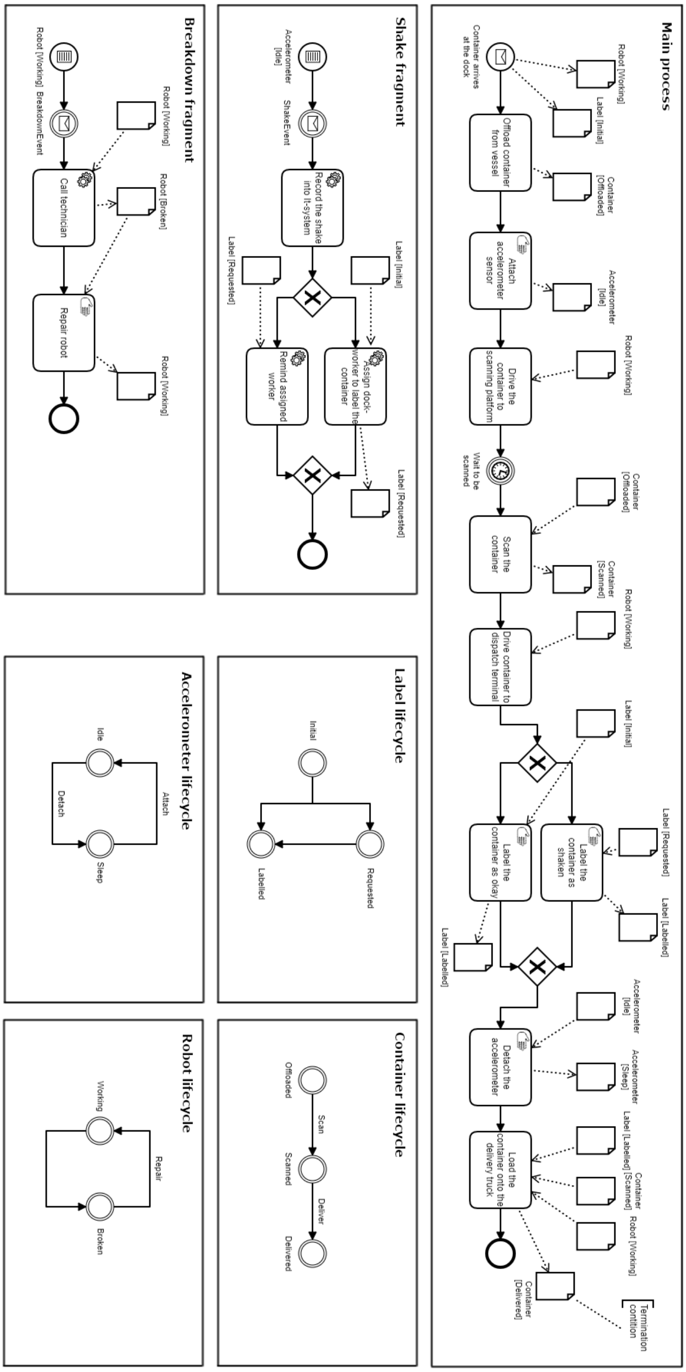

Figure A.5: Question 5 ready for experiment.

Q6. In all fragments, what is the minimum set of activities that should be executed prior to "Assign dock-worker to label the container" activity?

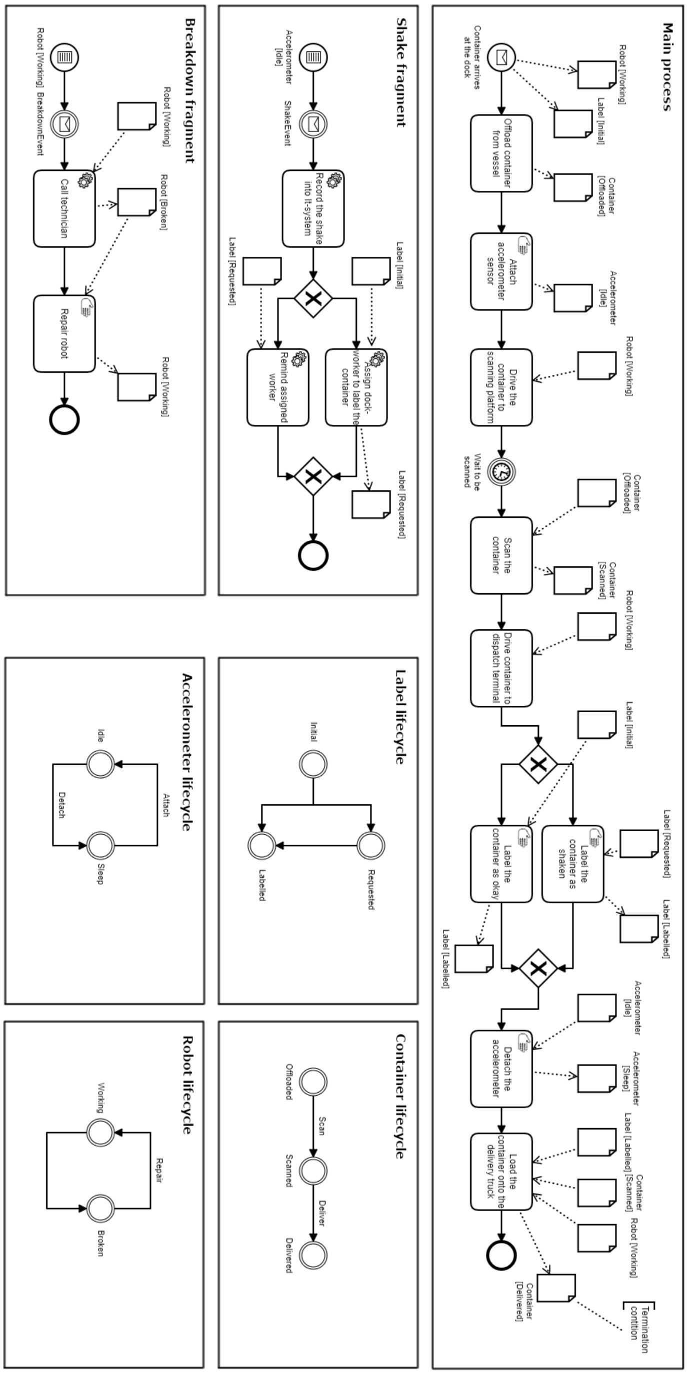

Figure A.6: Question 6 ready for experiment.

Q7. In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?

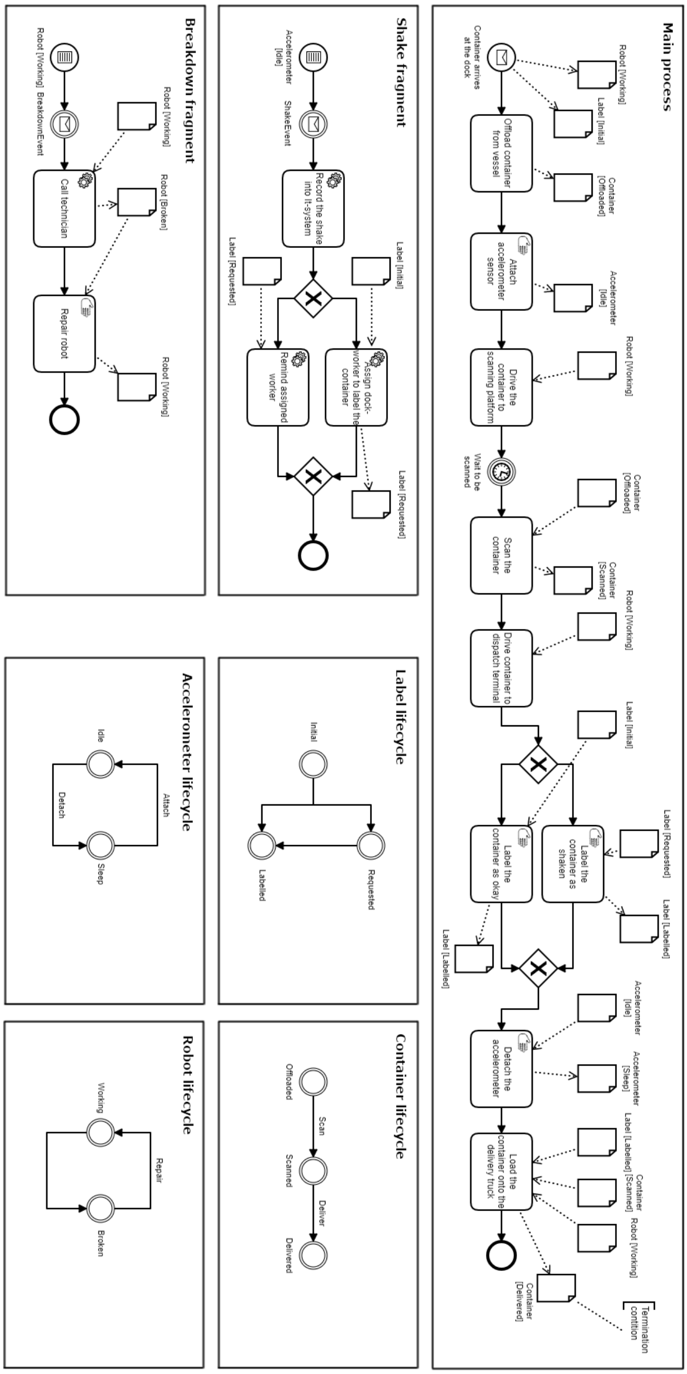

Figure A.7: Question 7 ready for experiment.

Q8. No shake event has occurred, a breakdown event occurs, and the “Call technician” activity is executed, what activities can then be executed after the “Drive container to dispatch terminal” activity in the main process?

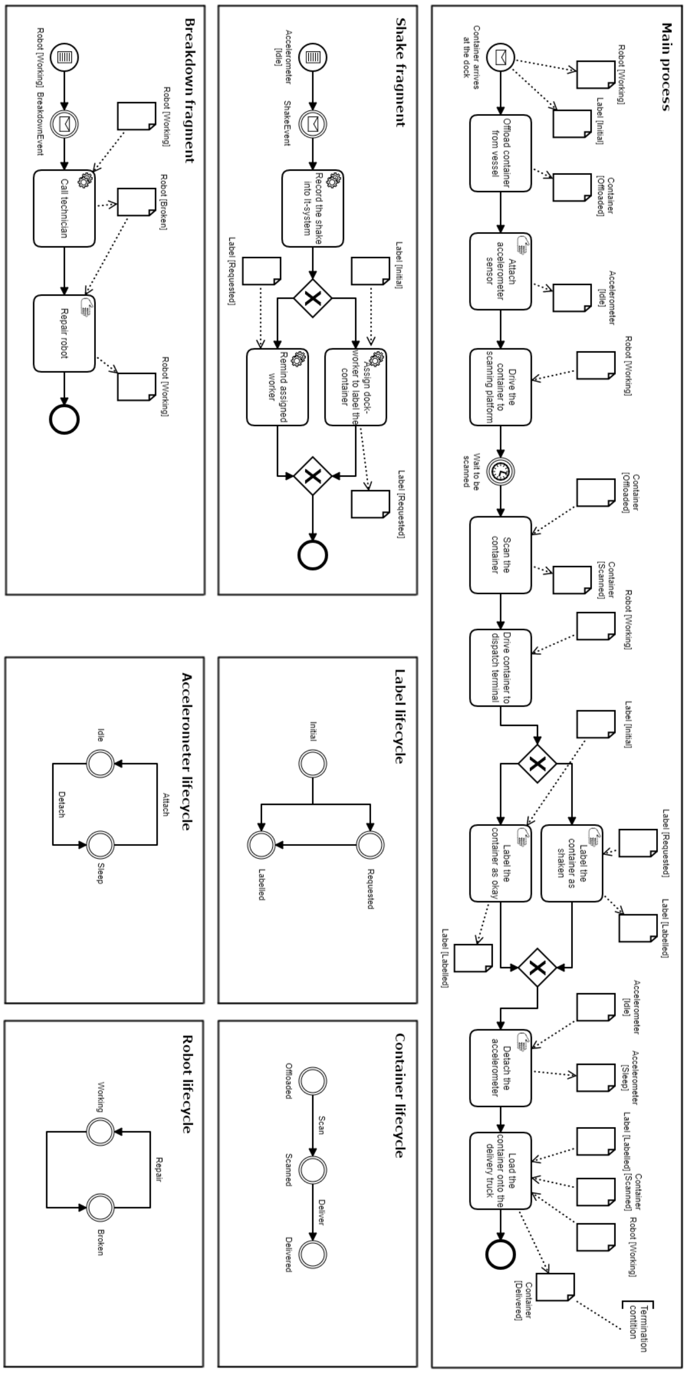

Figure A.8: Question 8 ready for experiment.

Q9. A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state.

a) What activities are executed until the Container is in the state "Delivered"?

b) What are the state(s) of the Label during the main process after the scan?

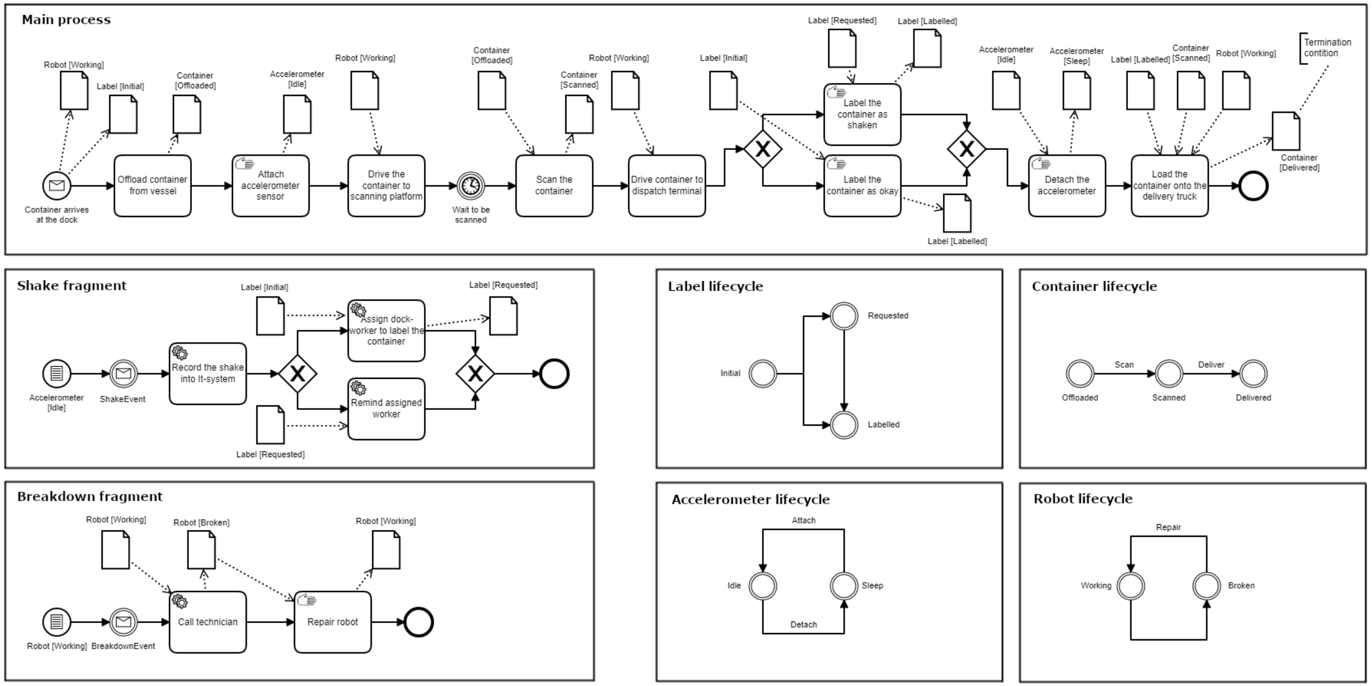

Figure A.9: Question 9 ready for experiment.

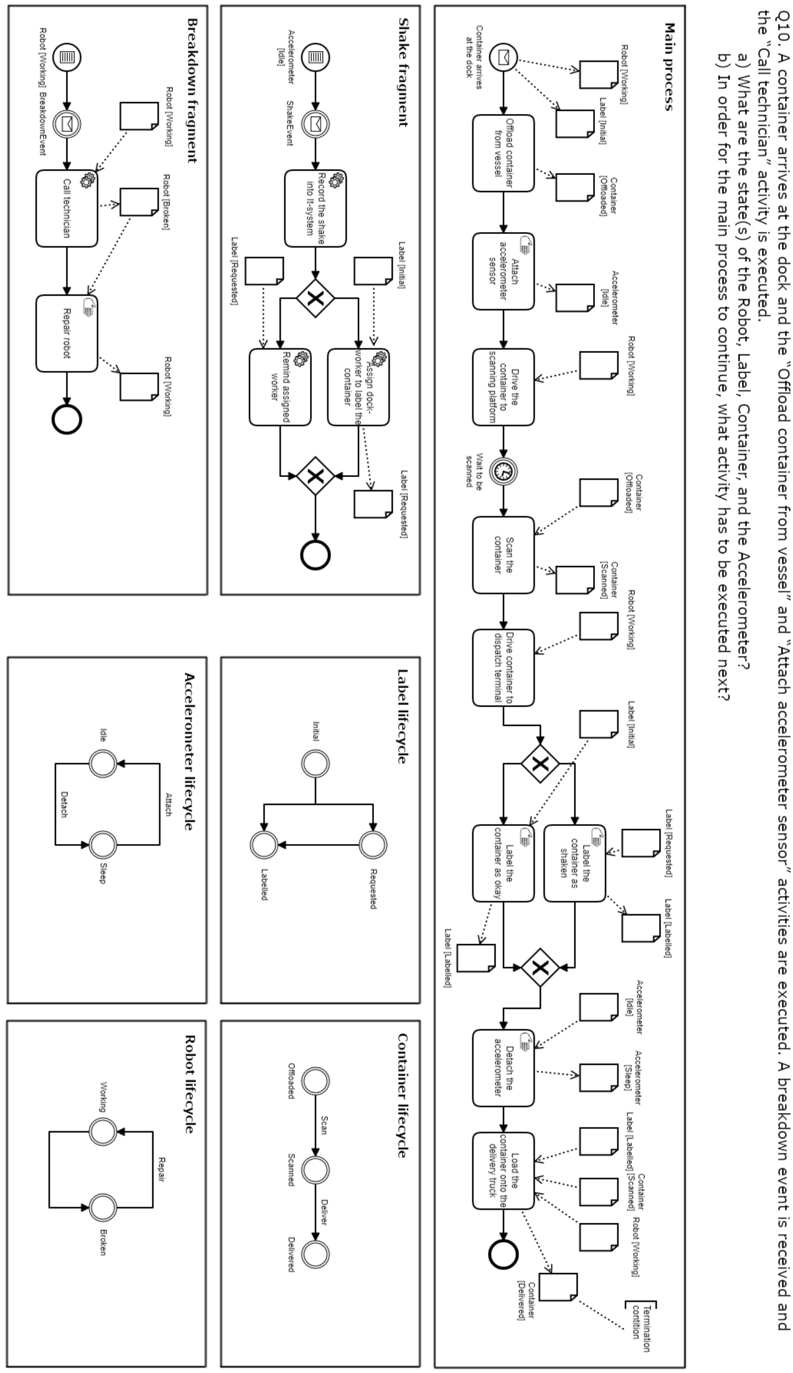

Figure A.10: Question 10 ready for experiment.

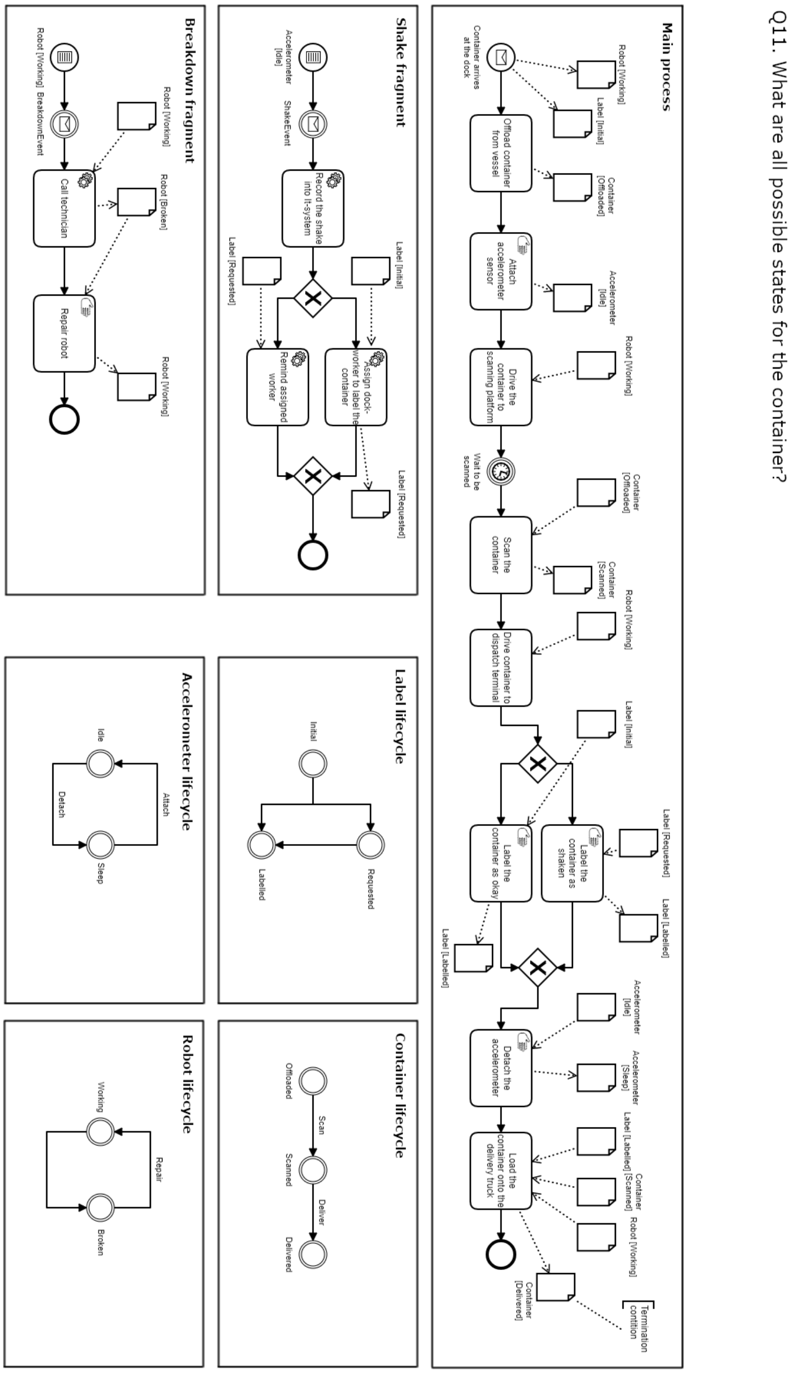

Figure A.11: Question 11 ready for experiment.

APPENDIX B
Pre-experiment form

4/3/2019 Pre-experiment form

Pre-experiment form

* Required

1. **Participant ID** *

2. **What is your gender?** *
   Mark only one oval.
   - ◯ Male
   - ◯ Female

3. **How old are you?** *

4. **What is your native language?** *

5. **What is your current profession?** *

6. **What is/was your study line?** *

7. **For how long have you been in your current profession ?** *
   Mark only one oval.
   - ◯ Less than 1 year
   - ◯ Between 1 year and 5 years
   - ◯ More than 5 years

Screening

The aim of this section is to assess your physical ability to participate in the eye tracking experiment.

8. **Are you colour blind?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

9. **Do you wear glasses?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

https://docs.google.com/forms/d/1MIJ-fluK24-QKFwTVg5Mvf2RChvSYme300A15SNj7Vs/edit 1/4

Figure B.1: Pre-experiment form.

4/3/2019 Pre-experiment form

10. **Do you wear contact lenses?** *
Mark only one oval.

- ◯ Yes
- ◯ No

11. **If you wear glasses, do they reduce the light contrast?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I don't wear glasses

12. **If you wear glasses, are they reflective?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I don't wear glasses

13. **If you wear glasses or contact lenses, what are they used for?**
Mark only one oval.

- ◯ Reading only
- ◯ Seeing distant objects only
- ◯ Both (Do you wear bifocals, trifocals, layered lenses, or regression lenses ?)
- ◯ I don't wear glasses nor contact lenses
- ◯ Other: ____________________

14. **Can you read a computer screen and the Web without difficulty with your contact lenses and/or glasses on?** *
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I don't wear glasses nor contact lenses

15. **Do you use a screen reader, screen magnifier or other assistive technology to use the computer?** *
Mark only one oval.

- ◯ Yes
- ◯ No

16. **Do you have any vision issues?** *
Mark only one oval.

- ◯ No, I don't have vision issues.
- ◯ I have cataracts (clouding of the lens in the eye).
- ◯ My pupils are permanently dilated
- ◯ Other: ____________________

https://docs.google.com/forms/d/1MIJ-fluK24-QKFwTVg5Mvf2RChvSYme300A15SNj7Vs/edit 2/4

Figure B.2: Pre-experiment form.

4/3/2019 Pre-experiment form

Familiarity

17. **Before the experiment, were you familiar with fragment based case management?** *
Mark only one oval.
- Yes
- No

18. **Before the experiment, were you familiar with BPMN 2.0?** *
Mark only one oval.
- Yes
- No

19. **Before the experiment, were you familiar with fragment based case modelling?** *
Mark only one oval.
- Yes
- No

20. **On a scale of 7, please indicate to what extent are you familiar with reading BPMN 2.0 Models.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Not familiar at all								Very familiar

21. **Approximately, how many BPMN 2.0 models have you read in the last 5 years?** *
Mark only one oval.
- 0 graph
- Less than 5 graphs
- Between 5 graphs and 20 graphs
- Between 20 and 100 graphs
- More than 100 graphs

22. **Approximately, how many hours have you spent reading BPMN 2.0 models in the last five years?** *
Mark only one oval.
- 0 hour
- Less than 2 hours
- Between 2 and 8 hours
- Between 8 hours 40 hours
- More than 40 hours

https://docs.google.com/forms/d/1MIJ-fluK24-QKFwTVg5Mvf2RChvSYme300A15SNj7Vs/edit 3/4

Figure B.3: Pre-experiment form.

4/3/2019 Pre-experiment form

23. **On a scale of 7, please indicate to what extent are you familiar with creating BPMN 2.0 models.** *

Mark only one oval.

	1	2	3	4	5	6	7	
Not familiar at all	◯	◯	◯	◯	◯	◯	◯	Very familiar

24. **Approximately, how many BMPN 2.0 models have you created in the last 5 years?** *

Mark only one oval.

- ◯ 0 graph
- ◯ Less than 5 graphs
- ◯ Between 5 and 20 graphs
- ◯ Between 20 and 100 graphs
- ◯ More than 100 graphs

25. **Approximately, how many hours have you spent creating BPMN 2.0 models in the last 5 years?** *

Mark only one oval.

- ◯ 0 hour
- ◯ Less than 2 hours
- ◯ Between 2 and 8 hours
- ◯ Between 8 hours and 40 hours
- ◯ More than 40 hours

26. **On a scale of 7, please indicate to what extent are you familiar with the simulation tool Chimera.** *

Mark only one oval.

	1	2	3	4	5	6	7	
Not familiar at all	◯	◯	◯	◯	◯	◯	◯	Very familiar

27. **On a scale of 7, please indicate to what extent are you familiar with the modelling tool Gryphon.**

Mark only one oval.

	1	2	3	4	5	6	7	
Not familiar at all	◯	◯	◯	◯	◯	◯	◯	Very familiar

Powered by Google Forms

https://docs.google.com/forms/d/1MIJ-fluK24-QKFwTVg5Mvf2RChvSYme300A15SNj7Vs/edit 4/4

Figure B.4: Pre-experiment form.

APPENDIX C

Script TSV to XES

```java
package tsv2xesSectionDemo;

import java.io.File;
import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;
import java.io.InputStreamReader;
import java.io.Reader;
import java.text.ParseException;
import java.text.SimpleDateFormat;
import org.joda.time.DateTime;
import tsv2xes.utils.XLogHelper;

import java.util.Calendar;
import java.util.Date;
import java.util.HashMap;
import java.util.Map;
import java.util.regex.Matcher;
import java.util.regex.Pattern;

import org.apache.commons.csv.CSVFormat;
import org.apache.commons.csv.CSVParser;
import org.apache.commons.csv.CSVRecord;
import org.apache.commons.io.input.BOMInputStream;
import org.deckfour.xes.model.XEvent;
import org.deckfour.xes.model.XLog;
import org.deckfour.xes.model.XTrace;
import org.deckfour.xes.out.XSerializer;
import org.deckfour.xes.out.XesXmlSerializer;

public class tsv2xes {

  private static Pattern AOIpatternsAllLC = Pattern.compile(Constants.
      AOI_PATTERN_ALL_LC);
  private static Pattern AOIpatternsLCSplit = Pattern.compile(Constants.
      AOI_PATTERN_SPLIT_LC);
  private static XSerializer serializer = new XesXmlSerializer();
  private static boolean generateEndEvent = true;

  public static void main(String[] args) throws IOException, ParseException
      {

```

```
    File path = new File("C:\\Users\\skuli\\Documents\\DTU\\Meistaraverkefni\\Experiment\\Exports\\New");
    int fileCount = 0;
    for (File inFile : path.listFiles()) {
      if (!inFile.getName().endsWith(".tsv")) {
        continue;
      }

      System.out.println(++fileCount + ". Processing `" + inFile.getName() + "'...");

      XLog combinedLifecyclesLog = XLogHelper.generateNewXLog(inFile.getName() + " - AllLC");
      XLog splitLifecyclesLog = XLogHelper.generateNewXLog(inFile.getName() + " - LCSplit");
      Map<String, XTrace> participantsToAllLCTraces = new HashMap<String, XTrace>();
      Map<String, XTrace> participantsToSplitLCTraces = new HashMap<String, XTrace>();

      Reader reader = new InputStreamReader(new BOMInputStream(new FileInputStream(inFile)), "UTF-8");
      CSVParser parser = new CSVParser(reader, CSVFormat.TDF.withHeader());
      Map<String, String> AOIfieldsAllLC = new HashMap<String, String>();
      Map<String, String> AOIfieldsSplitLC = new HashMap<String, String>();
      long sumGazeEventDurasionSplitLC = 0;
      long sumGazeEventDurasionAllLC = 0;
      System.out.println("   > parsing...");
      for (CSVRecord record : parser) {
        // identify all aoi fields from headers
        if (AOIfieldsAllLC.isEmpty()) {
          for (String header : parser.getHeaderMap().keySet()) {
            Matcher matcher = AOIpatternsAllLC.matcher(header);
            if (matcher.find()) {
              AOIfieldsAllLC.put(header, matcher.group(1));
            }
          }
        }
        if (AOIfieldsSplitLC.isEmpty()) {
          for (String header : parser.getHeaderMap().keySet()) {
            Matcher matcher = AOIpatternsLCSplit.matcher(header);
            if (matcher.find()) {
              AOIfieldsSplitLC.put(header, matcher.group(1));
            }
          }
        }

        String participantName = record.get("Participant name");
        Date startDate = findTimeStamp(record);

        // add aois using combined lifecycles
        XTrace currentSubjectTraceAllLC = participantsToAllLCTraces.get(participantName);
        if (currentSubjectTraceAllLC == null) {
```

```java
      currentSubjectTraceAllLC = XLogHelper.insertTrace(combinedLifecyclesLog, participantName);

      participantsToAllLCTraces.put(participantName, currentSubjectTraceAllLC);
    }
    for (String AOIField : AOIfieldsAllLC.keySet()) {
      if (record.get(AOIField).equals("1")) {

        XEvent eventStart = XLogHelper.insertEvent(currentSubjectTraceAllLC,
            AOIfieldsAllLC.get(AOIField), startDate);
        XLogHelper.decorateElement(eventStart, "lifecycle:transition", "start", "Lifecycle");

        String mediaName = record.get(Constants.MEDIA_NAME);
        XLogHelper.decorateElement(eventStart, "Question", mediaName);

        if (generateEndEvent) {
          int gazeEventDuration = Integer.parseInt(record.get("Gaze event duration"));
          sumGazeEventDurasionAllLC += gazeEventDuration;
          Date endDate = new Date(startDate.getTime() + sumGazeEventDurasionAllLC);
          XEvent eventComplete = XLogHelper.insertEvent(currentSubjectTraceAllLC,
              AOIfieldsAllLC.get(AOIField), endDate);
          XLogHelper.decorateElement(eventComplete, "lifecycle:transition", "complete", "Lifecycle");
          XLogHelper.decorateElement(eventComplete, "Question", mediaName);
        }

      }
    }

    // add aois splitting the lifecycles
    XTrace currentSubjectTraceSplitLC = participantsToSplitLCTraces.get(participantName);
    if (currentSubjectTraceSplitLC == null) {
      currentSubjectTraceSplitLC = XLogHelper.insertTrace(splitLifecyclesLog, participantName);
      participantsToSplitLCTraces.put(participantName, currentSubjectTraceSplitLC);
    }
    for (String AOIField : AOIfieldsSplitLC.keySet()) {
      if (record.get(AOIField).equals("1")) {
        XEvent eventStart = XLogHelper.insertEvent(currentSubjectTraceSplitLC,
            AOIfieldsSplitLC.get(AOIField), startDate);
        XLogHelper.decorateElement(eventStart, "lifecycle:transition", "start", "Lifecycle");

        String mediaName = record.get(Constants.MEDIA_NAME);
        XLogHelper.decorateElement(eventStart, "Question", mediaName);
```

```
            if (generateEndEvent) {
              int gazeEventDuration = Integer.parseInt(record.get("Gaze
                  event duration"));
              sumGazeEventDurasionSplitLC += gazeEventDuration;
              // System.out.println("Gaze event duration = " +
                  gazeEventDuration + ". Eye
              // movement type index = " + eyeMovementTypeIndex);
              DateTime jodaDate = new DateTime(startDate);
              DateTime newTime = jodaDate.plus(sumGazeEventDurasionSplitLC);
              XEvent eventComplete = XLogHelper.insertEvent(
                  currentSubjectTraceSplitLC,
                  AOIfieldsSplitLC.get(AOIField), newTime.toDate());
              XLogHelper.decorateElement(eventComplete, "lifecycle:
                  transition", "complete", "Lifecycle");
              XLogHelper.decorateElement(eventComplete, "Question",
                  mediaName);
            }

          }
        }

      }
      parser.close();

      XLogHelper.sortXLog(splitLifecyclesLog);
      System.out.println("   > dumping xes file");
      // export quadrant log
      serializer.serialize(XLogHelper.mergeEventsWithSameName(
          combinedLifecyclesLog, generateEndEvent),
          new FileOutputStream(inFile + "-AllLC.xes"));
      // export graph log
      serializer.serialize(XLogHelper.mergeEventsWithSameName(
          splitLifecyclesLog, generateEndEvent),
          new FileOutputStream(inFile + " -LCSplit.xes"));
      System.out.println("File processing complete!\n\n");
      System.out.println("Total gaze event duration Split lifecycles = " +
          sumGazeEventDurasionSplitLC);
      System.out.println("Total gaze event duration All lifecycles= " +
          sumGazeEventDurasionAllLC);
    }
    System.out.println("Done! " + fileCount + " file(s) were processed");
  }

  public static Date findTimeStamp(CSVRecord record) throws ParseException {
    SimpleDateFormat dateParser = new SimpleDateFormat("yyyy-MM-dd HH:mm:ss"
        );
    String expstart = record.get("Recording start time");
    Date expstartDate = dateParser.parse("2019-03-12 " + expstart);
    return expstartDate;

  }

}
```

APPENDIX D

Question analysis

This Appendix shows the images used to compare how the participants read the model. It shows the process map from Disco and the heat map from Tobii for each question that was used in the analysis. Because the images are relatively small in the document they the image files are also included in the online Appendix H.

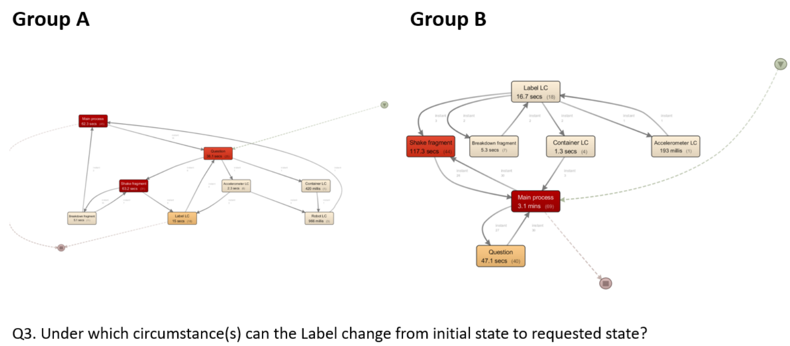

Figure D.1: Comparison of process model images from Disco for question three.

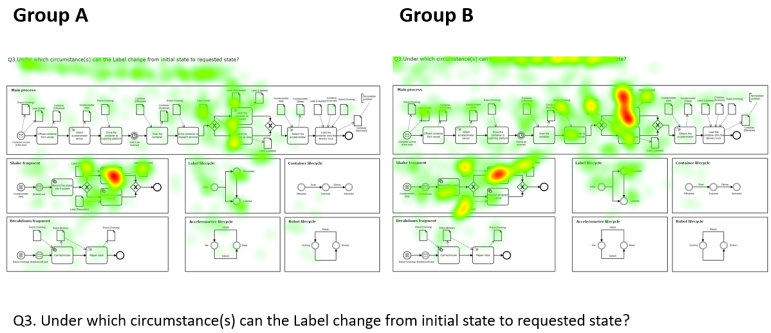

Figure D.2: Comparison of heat maps from Tobii for question three.

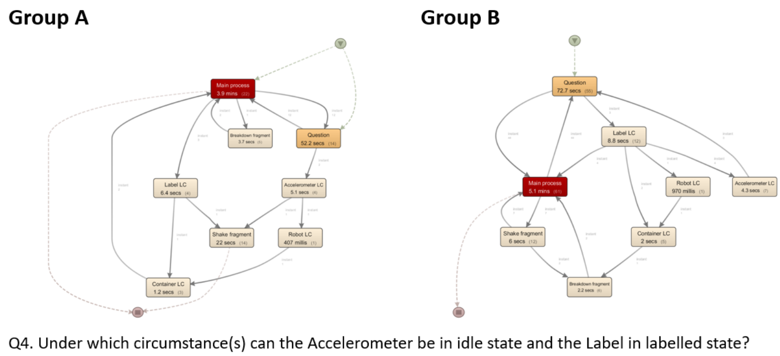

Figure D.3: Comparison of process model images from Disco for question four.

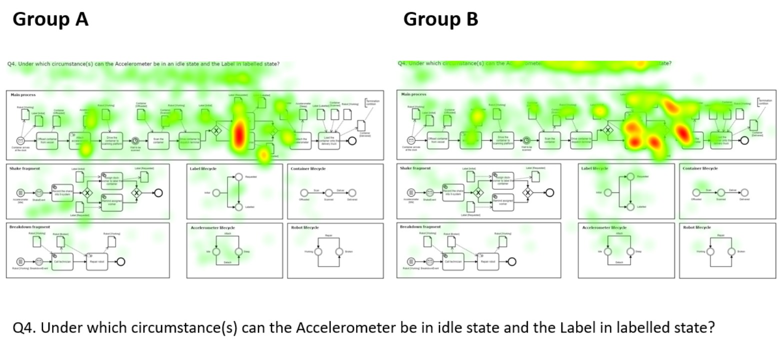

Figure D.4: Comparison of heat maps from Tobii for question four.

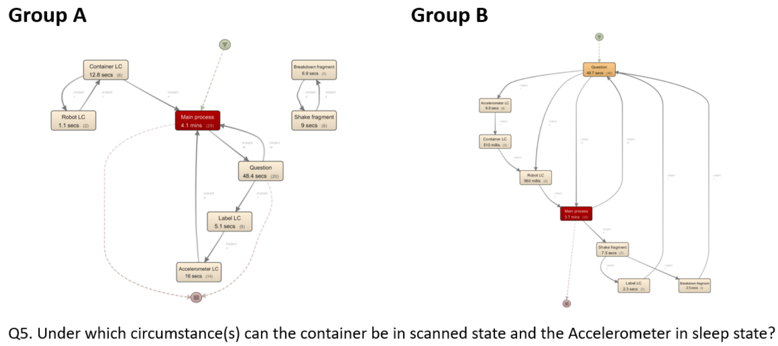

Figure D.5: Comparison of process model images from Disco for question five.

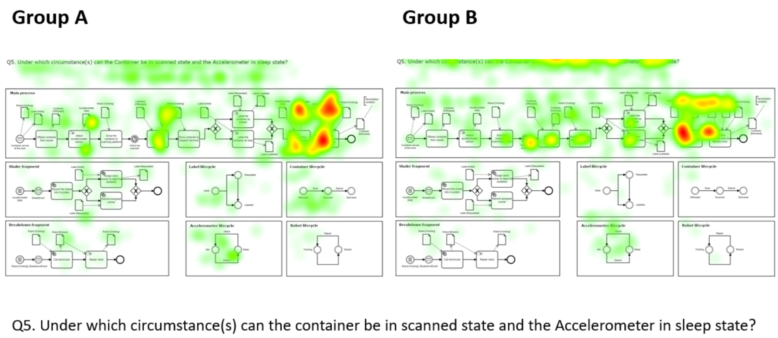

Figure D.6: Comparison of heat maps from Tobii for question five.

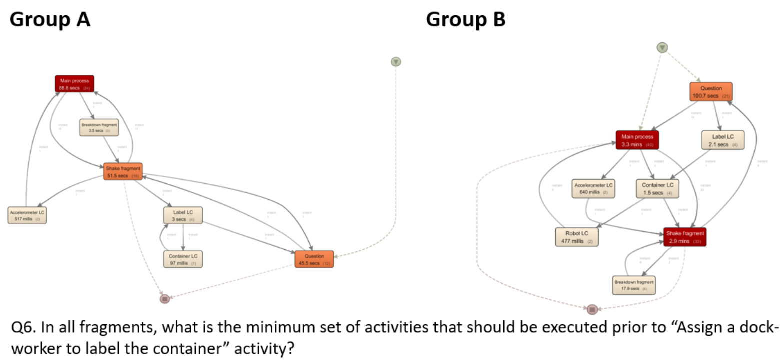

Figure D.7: Comparison of process model images from Disco for question six.

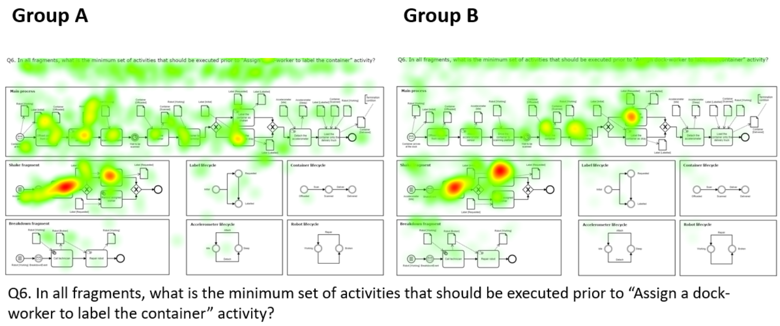

Figure D.8: Comparison of heat maps from Tobii for question six.

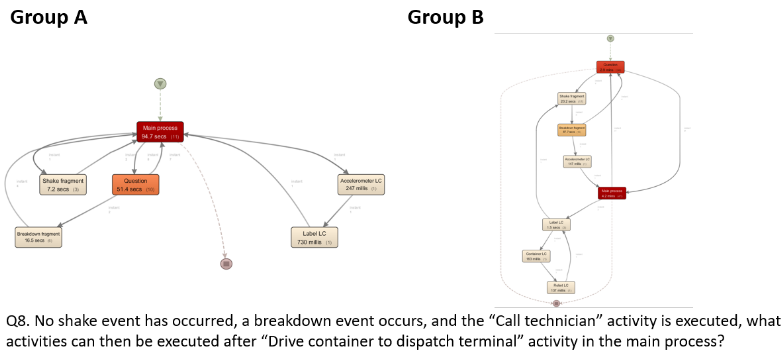

Figure D.9: Comparison of process model images from Disco for question eight.

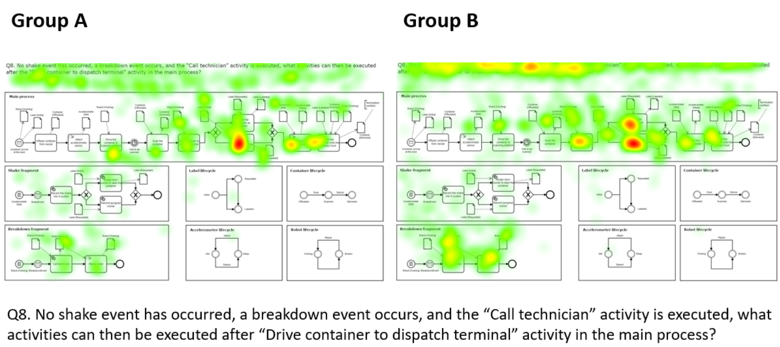

Figure D.10: Comparison of heat maps from Tobii for question eight.

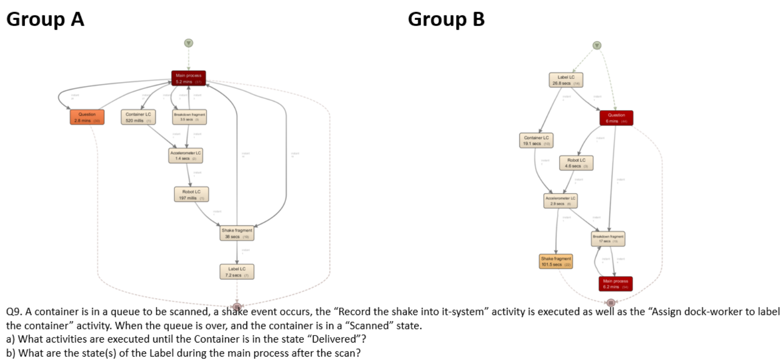

Figure D.11: Comparison of process model images from Disco for question nine.

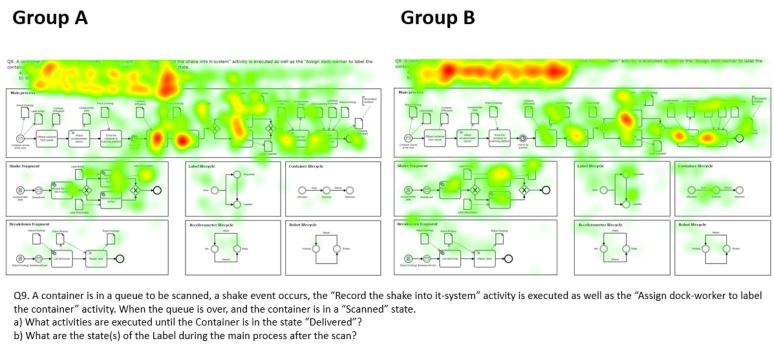

Figure D.12: Comparison of heat maps from Tobii for question nine.

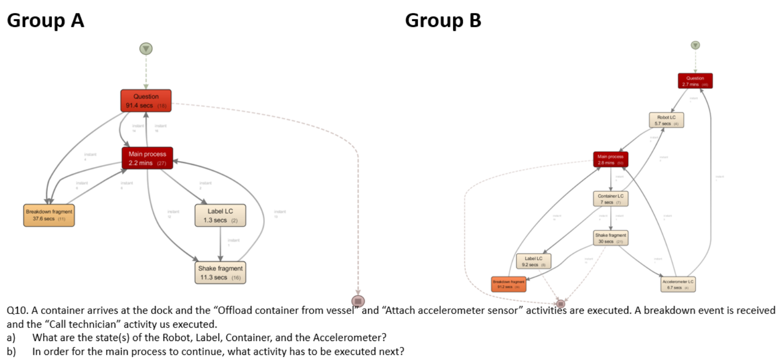

Figure D.13: Comparison of process model images from Disco for question ten.

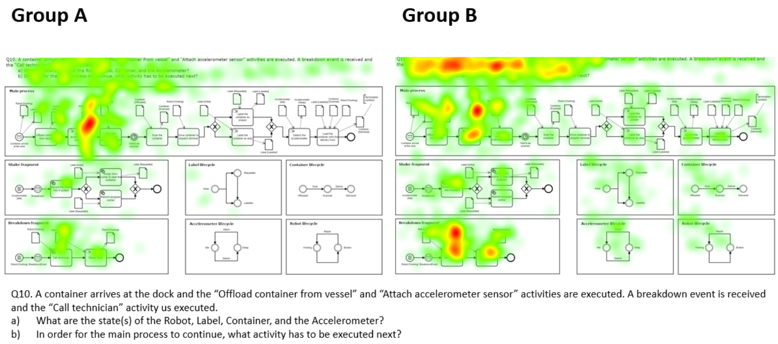

Figure D.14: Comparison of heat maps from Tobii for question ten.

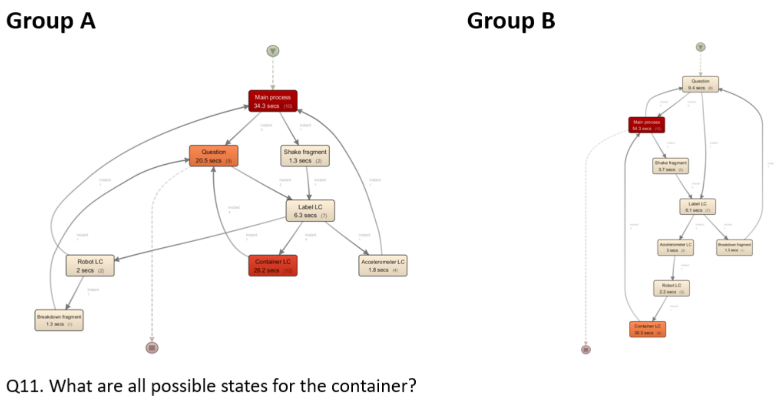

Figure D.15: Comparison of process model images from Disco for question eleven.

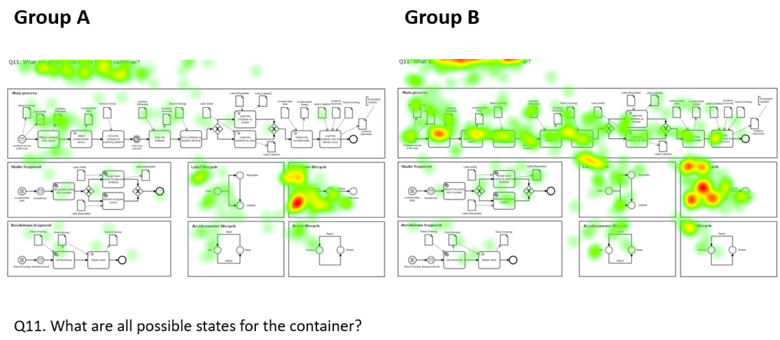

Figure D.16: Comparison of heat maps from Tobii for question eleven.

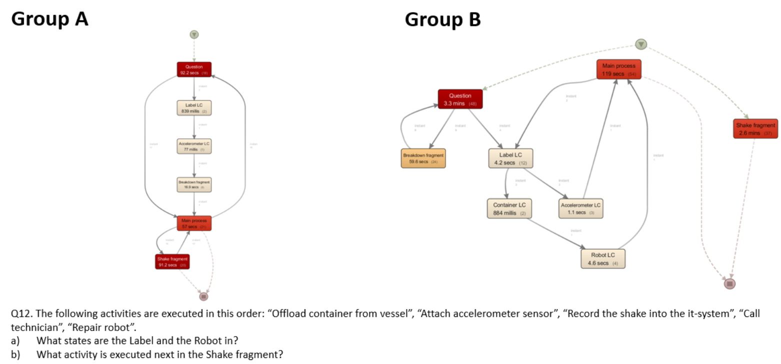

Figure D.17: Comparison of process model images from Disco for question twelve.

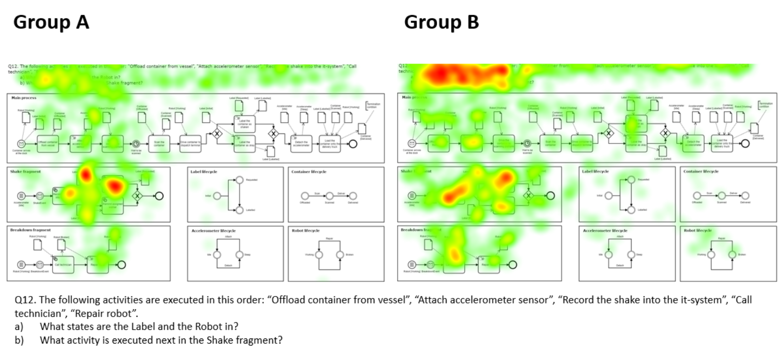

Figure D.18: Comparison of heat maps from Tobii for question twelve.

APPENDIX E
Expected vs actual reading pattern

This Appendix shows the images from the analysis of the expected vs the actual reading patterns. Those are images of process models from Disco and heat maps from Tobii.

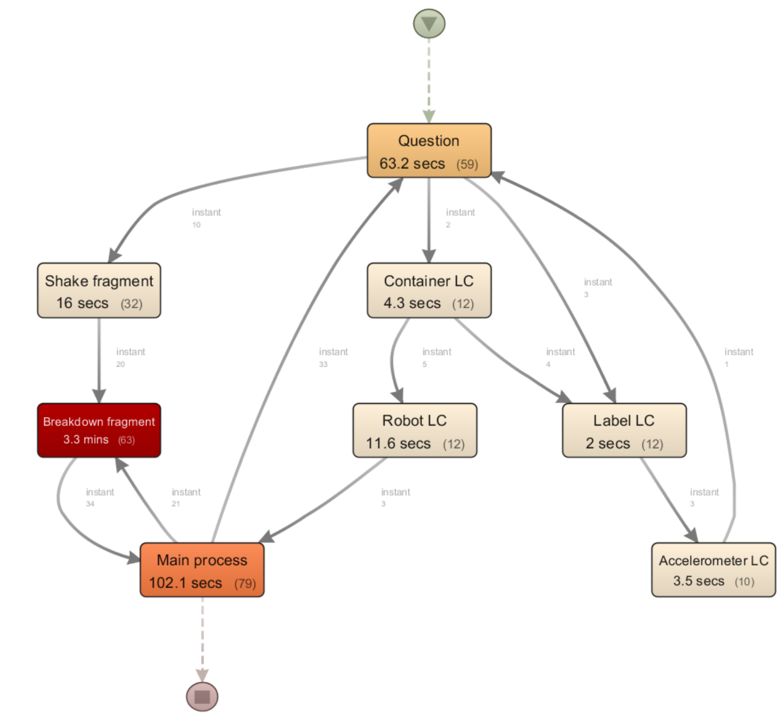

Figure E.1: Process model from Disco of the fixation duration for question two.

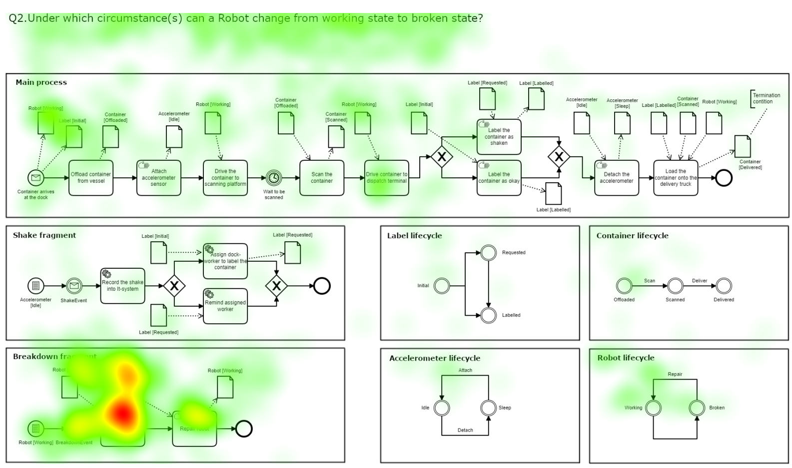

Figure E.2: Heat map from Tobii of the fixation duration for question two.

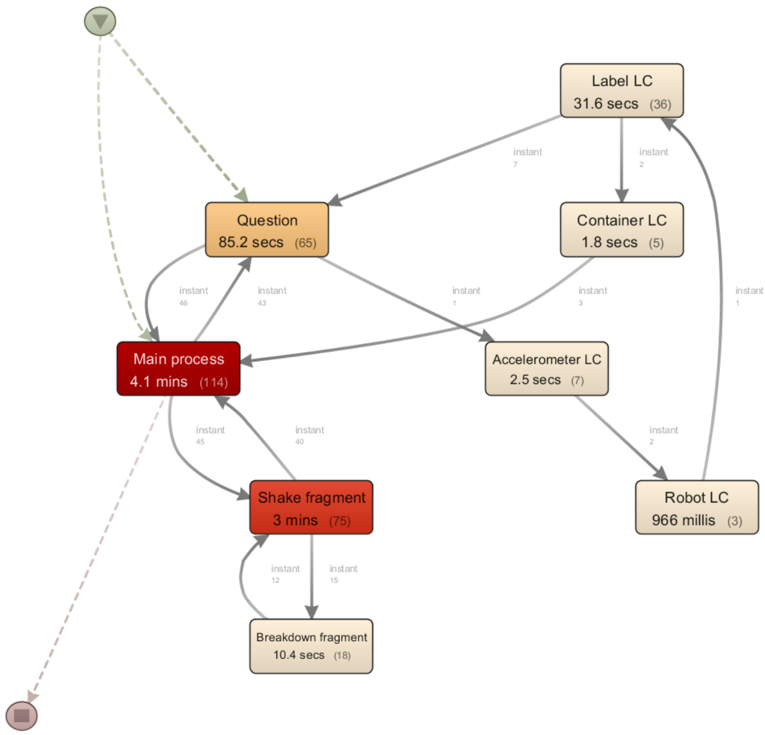

Figure E.3: Process model from Disco of the fixation duration for question three.

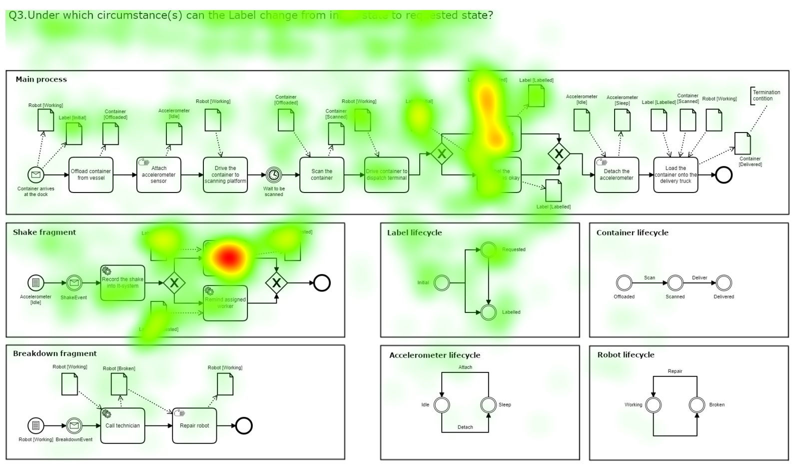

Figure E.4: Heat map from Tobii of the fixation duration for question three.

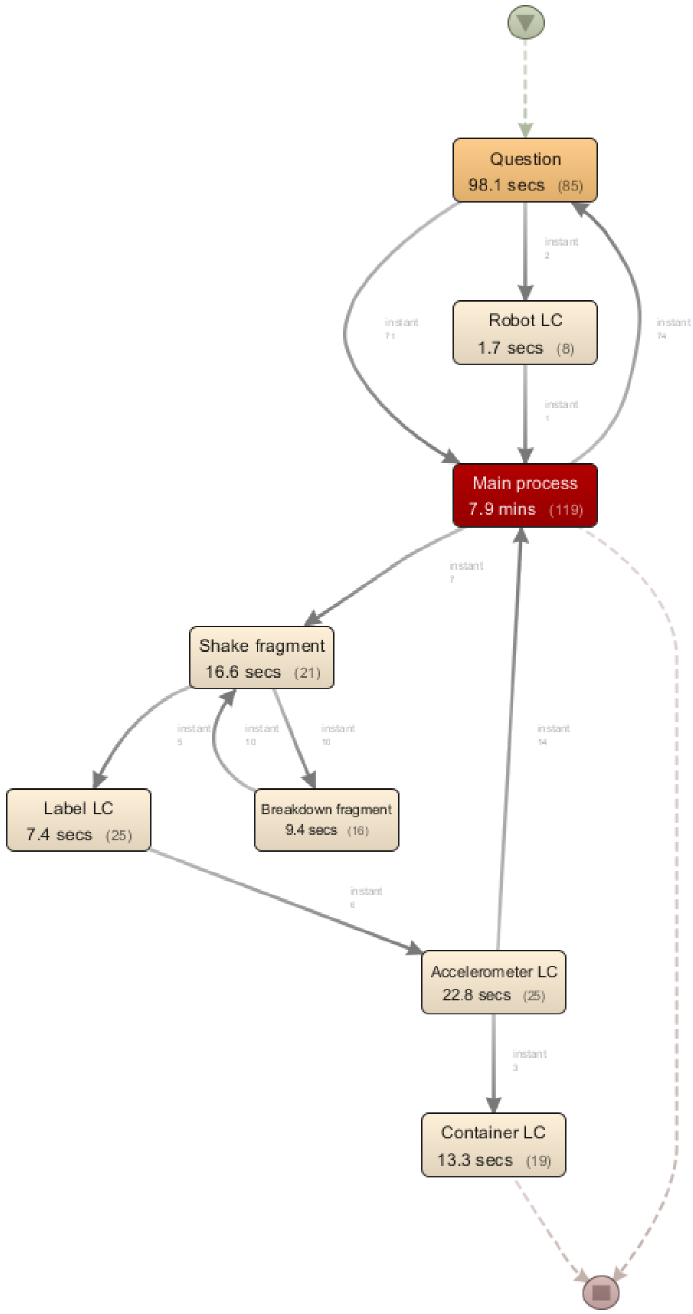

Figure E.5: Process model from Disco of the fixation duration for question five.

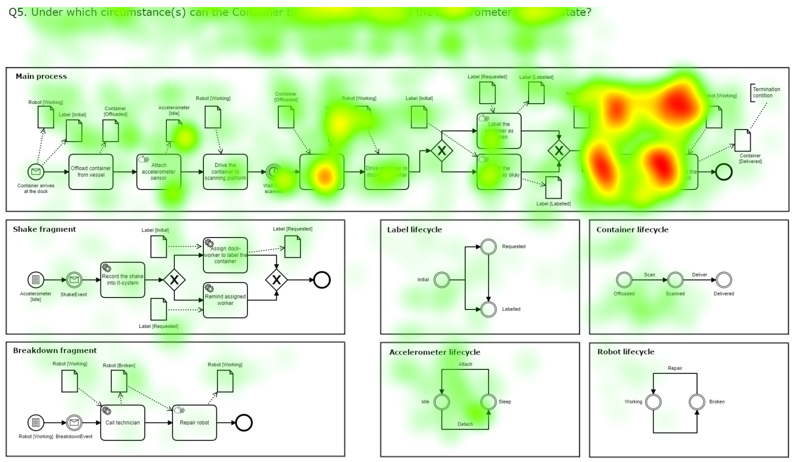

Figure E.6: Heat map from Tobii of the fixation duration for question five.

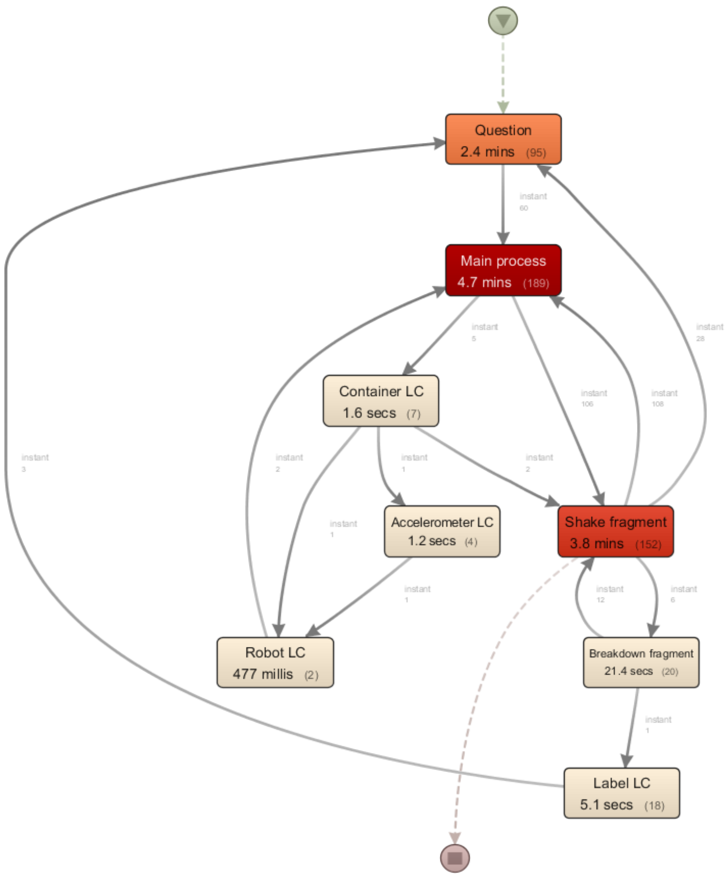

Figure E.7: Process model from Disco of the fixation duration for question six.

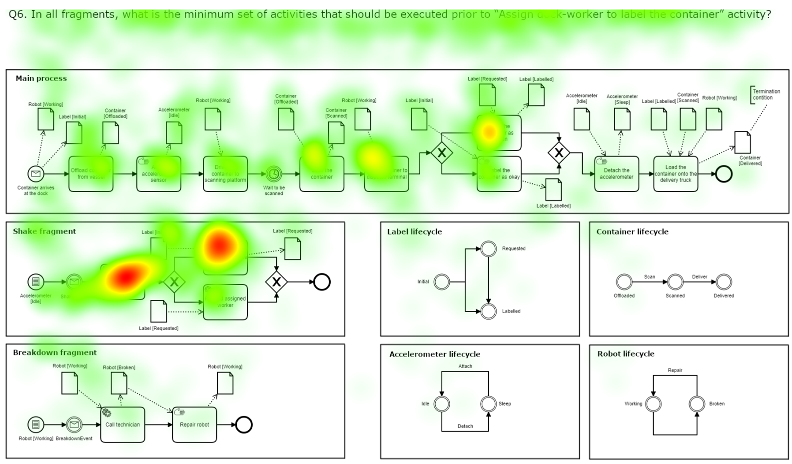

Figure E.8: Heat map from Tobii of the fixation duration for question six.

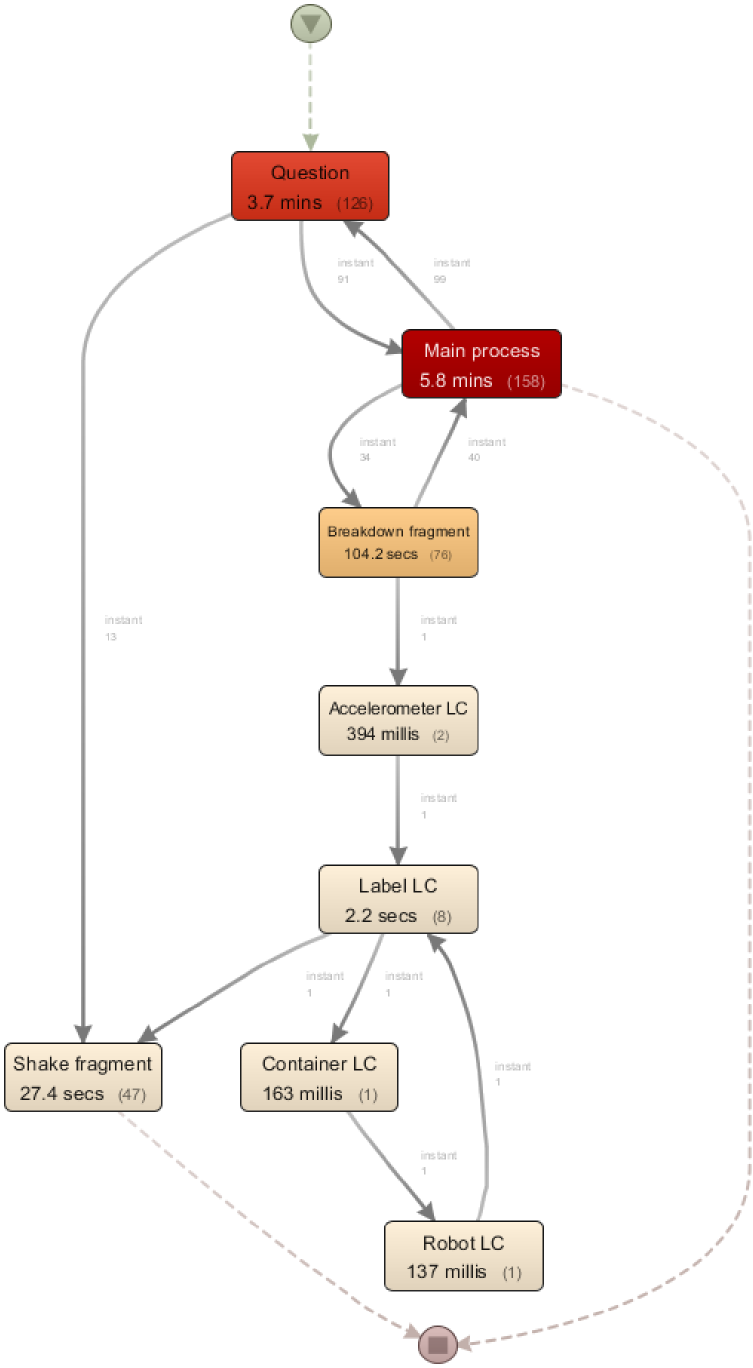

Figure E.9: Process model from Disco of the fixation duration for question eight.

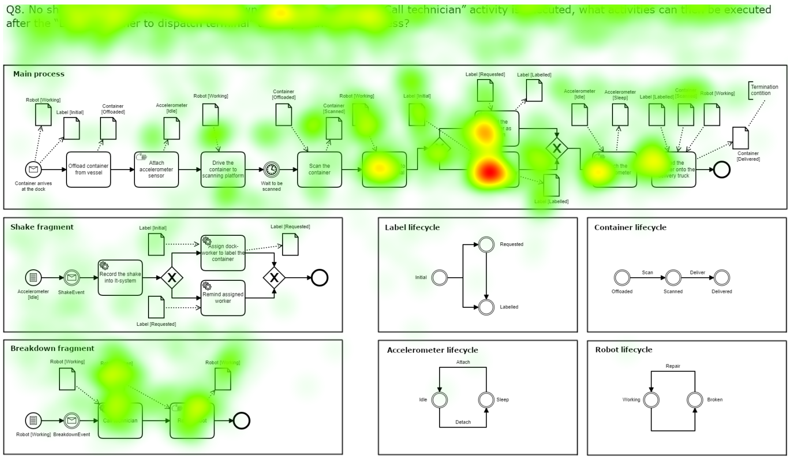

Figure E.10: Heat map from Tobii of the fixation duration for question eight.

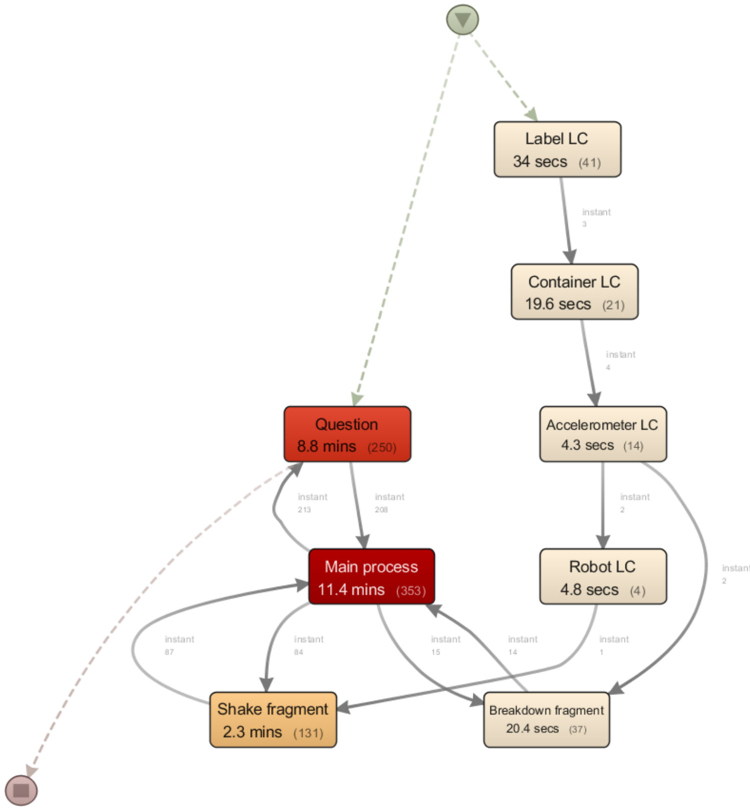

Figure E.11: Process model from Disco of the fixation duration for question nine.

Figure E.12: Heat map from Tobii of the fixation duration for question nine.

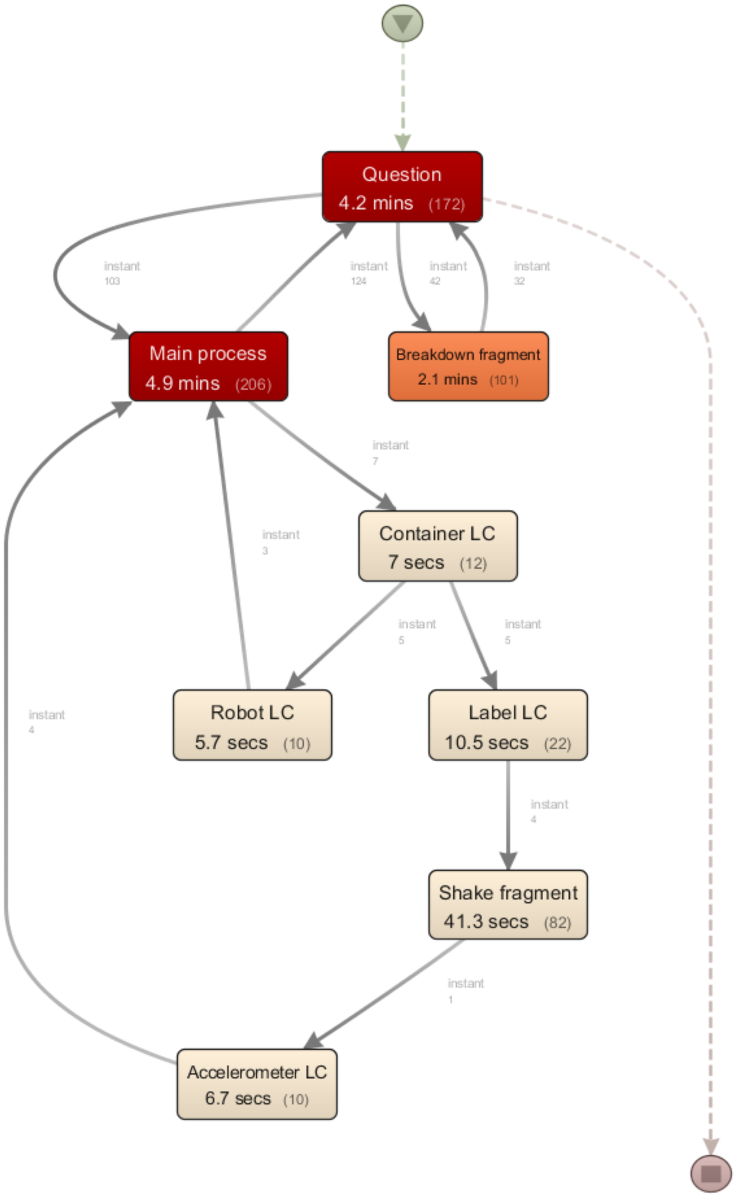

Figure E.13: Process model from Disco of the fixation duration for question ten.

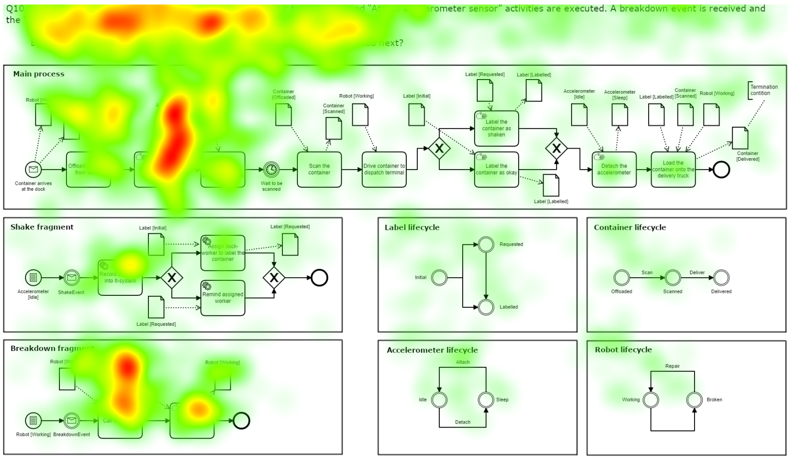

Figure E.14: Heat map from Tobii of the fixation duration for question ten.

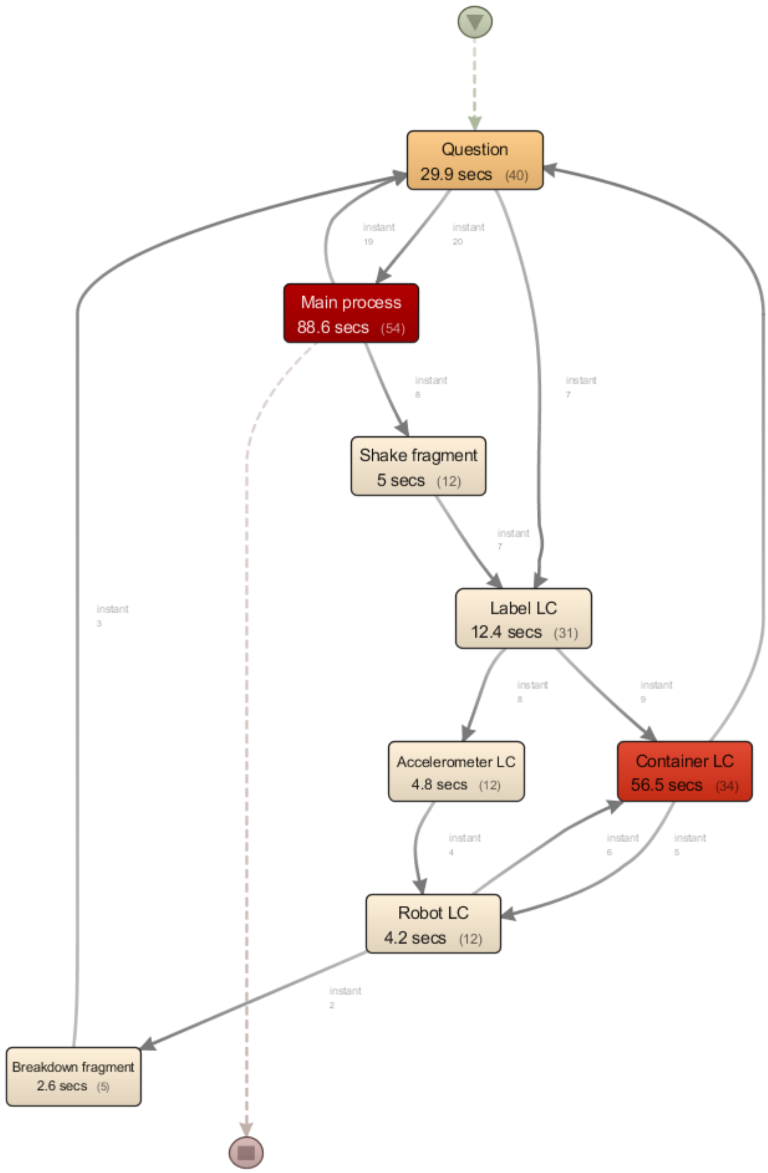

Figure E.15: Process model from Disco of the fixation duration for question eleven.

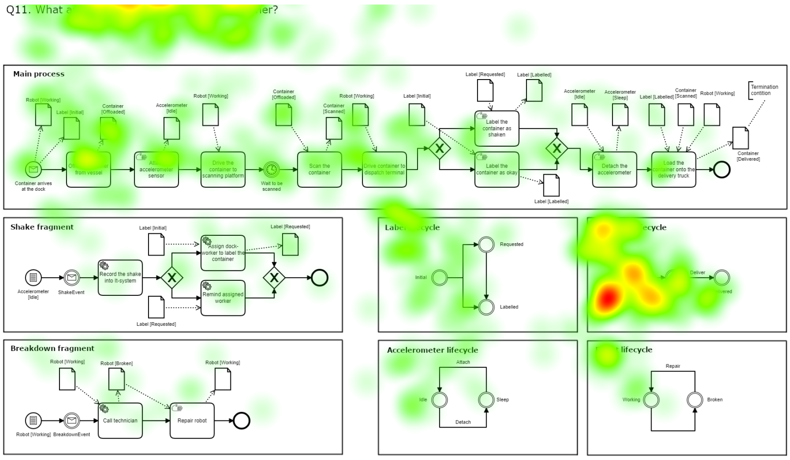

Figure E.16: Heat map from Tobii of the fixation duration for question eleven.

APPENDIX F

Online Appendix

Below is a link to a Google drive folder where the online Appendix can be found. The Appendix includes material referenced in the thesis as well as all figures in a folder called Figures.

https://drive.google.com/open?id=1B5r6uNwRGiSQ0p5lvSHq3F0O60yirl8t

APPENDIX G
Modelling with Gryphon

Figure G.1 depicts the front page of Gryphon after all the components have been created

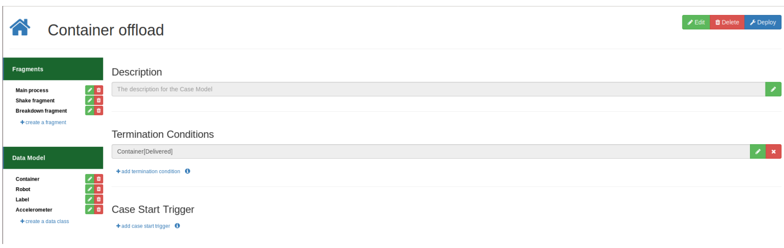

Figure G.1: The front page of Gryphon when the model is ready.

Figure G.2 depicts the model of the Main process in Gryphon.

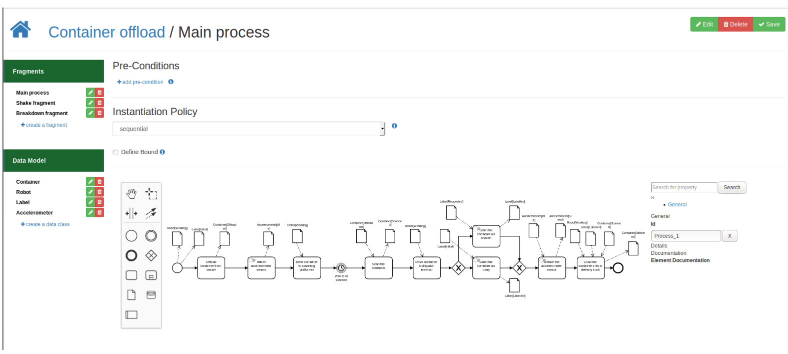

Figure G.2: The Main process in Gryphon.

Figure G.3 depicts the model of the Shake fragment in Gryphon.

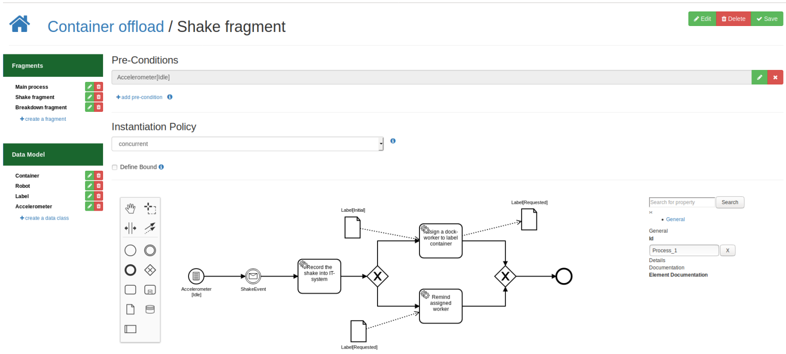

Figure G.3: The Shake fragment in Gryphon.

Figure G.4 depicts the model of the Breakdown fragment in Gryphon.

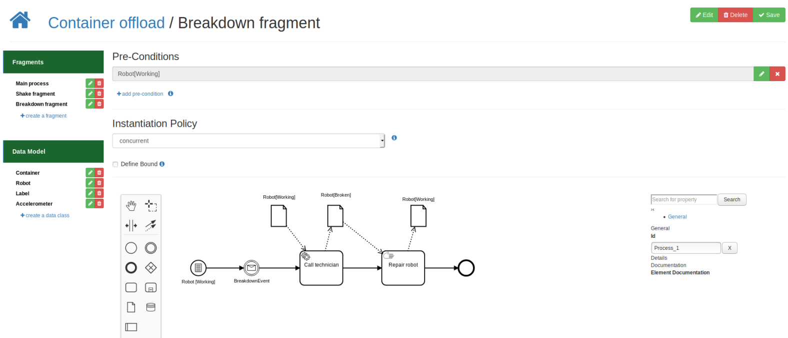

Figure G.4: The Breakdown fragment in Gryphon.

Figure G.5 depicts the data object Container in Gryphon.

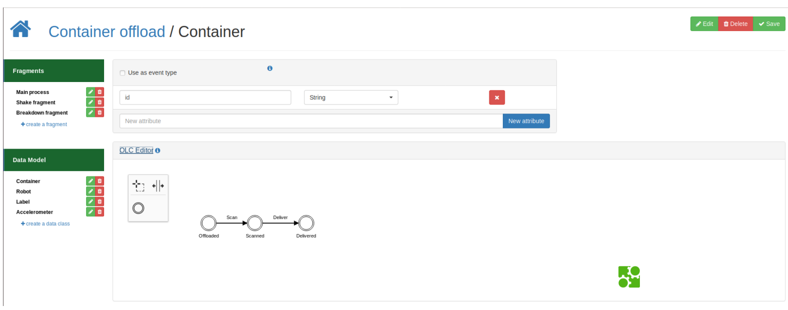

Figure G.5: The Container data object with attributes and lifecycles.

Figure G.6 depicts the data object Robot in Gryphon.

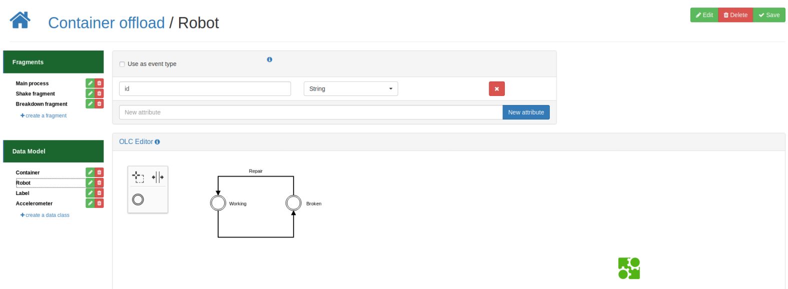

Figure G.6: The Robot data object with attributes and lifecycles.

Figure G.7 depicts the data object Label in Gryphon.

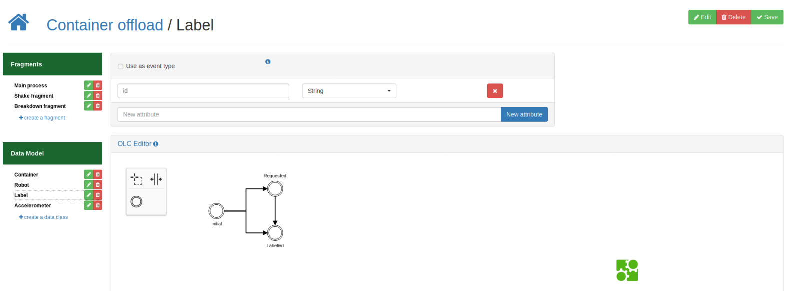

Figure G.7: The Label data object with attributes and lifecycles.

Figure G.8 depicts the data object Accelerometer in Gryphon.

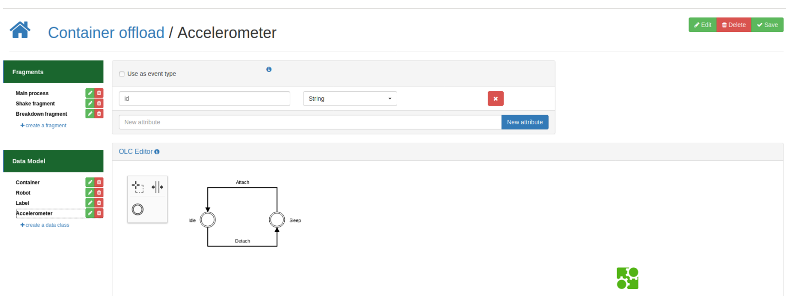

Figure G.8: The Accelerometer data object with attributes and lifecycles.

APPENDIX H

Transcription of participants answers

Participant one (P1).

Q1: Can you describe the scenario that the model is showing?

“It is most likely that they are offloading some container of a ship. Then they physically attach a sensor. Then there is a robot working on this, it drives the container. The container then waits to be scanned. The container is in offloaded state which is a pre-condition and then he is scanned and changes to scanned state which is a post-condition. Next step is to drive the container to the dispatch terminal and the robot is working on that and when that is done, we arrive at the XOR that is checking if the label on the container is okay or not... In the shake fragment we check if the product... no, the container is damaged or not. Then they main process continues, and we need to manually detach the accelerometer. Then it loads the container on to a truck that drives it to its destination”.

Q6: In all fragments, what is the minimum set of activities that can be executed prior to “Assign dock-worker to label the container” activity?

“I would say it is six activities, “Offload container from vessel”, “Attach accelerometer”, “Drive the container to the scanning platform”, ”Scan the container”, “Drive the container to the dispatch terminal”, and then in the Shake fragment it is “Record the shake into the it-system””.

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

"After the "Label the container as okay" activity".

Q11: what are all possible states for the Container?

"Offloaded, scanned, and delivered".

Q9: A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state.

a) What activities are executed until the container is in the state "Delivered"?

"It starts with "Drive the container to the dispatch terminal" activity, then it goes to "Label the container as okay", then it goes to the shake fragment to the "Assign dock-worker to label the container", then it goes back to the loop and executes "Label the container as shaken", then it executes "detach the accelerometer", and then finishes with the "Load the container on to the delivery truck", so I would say seven activities are executed".

b) What are the state(s) of the "Label" during the process after the scan? "Requested".

Q8: No shake event has occurred, a breakdown event occurs, and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity?

"There is no activity executed because the robot is broken".

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot".

a) What states are the Label and the Robot in?

"The robot is in a broken state and the label is in a requested state"

b) What activity is executed nest in the Shake fragment?

"Assign dock worker to label the container activity is executed next".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"It is when the container is okay and he can go through to the delivery truck".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

"After the Call technician activity".

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed.

a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"The robot is broken, the label is in labelled, the container is in scanned, and the accelerometer is in idle".

b) In order for the main process to continue, what activity has to be executed next?

"Repair robot has to be executed next".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"The container has to be shaken, something has to wrong with the container".

Q6: In all fragments, what is the minimum set of activities that can

be executed prior to “Assign dock-worker to label the container” activity?

“Seven activities, the first five in the main process and two in the Shake fragment”.

Participant two (P2).

Q1: Can you describe the scenario that the model is showing?

“The process is about taking containers of a ship. And there is some robot that is driving the container to its place but before it does that there is an accelerometer attached to the container that is checking for how much the container shakes while the robot is driving. When the container arrives at the terminal where it leaves the container there is a check for how much it has been shook, if it has been shook then it is registered into the system. It seems that it doesn’t matter how bad the shake was it is always labelled”.

Q11: what are all possible states for the Container?

“Offloaded, scanned, or delivered”.

Q9: A container is in a queue to be scanned, a shake event occurs, the “Record the shake into it-system” activity is executed as well as the “Assign dock-worker to label the container” activity. When the queue is over, and the container is in a “Scanned” state.

a) What activities are executed until the container is in the state “Delivered”?

“Those activities are executed: Drive the container to dispatch terminal, Label the container as shake, Detach the accelerometer, Load the container on to delivery truck and in the Shake fragment, Record the shake into the it-system and Remind assigned dock worker”.

b) What are the state(s) of the “Label” during the process after the scan?

"Initial, requested, and labelled".

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"Offload container, Attach accelerometer sensor, Drive the container to scanning platform, Scan the container and Record the shake into the it-system, so 5 activities".

Q2: Under which circumstance(s) can a Robot change from working state to broken state? "After Call technician activity".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"Only after Detach the accelerometer activity".

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed.

a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"Robot is broken, accelerometer is idle, label is initial, and container is offloaded".

b) In order for the main process to continue, what activity has to be executed next?

"Repair robot".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

"Detach the accelerometer".

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"Robot is broken, and label is initial".

b) What activity is executed next in the Shake fragment?

"Assign dock-worker to label the container".

Q8: No shake event has occurred, a breakdown event occurs, and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity?

"Label the container as okay and Detach the accelerometer".

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"Record the shake into the it-system, Drive the container to the scanning platform, Attach the accelerometer sensor, and Offload the container from vessel, so five activities".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"After Assign dock-worker to label the container".

Participant three (P3).

Q1: Can you describe the scenario that the model is showing?

"The process is about taking container of a ship. Then we attach an accelerometer to check if it shakes while it is handled by us. Then there are robots that are doing the work and we regularly check if the robots are okay or not. Then we have the shake fragment to check if the containers have had any shakes, if they have then we label them as shaken, then we put the containers on to a delivery truck".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

"That is when there is a breakdown event. Then we can call a technician and he can change the state to broken".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"That is after the "Assign dock-worker to label the container", after a shake has happened".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"After we label the container the label can be in labelled state and before the detach the accelerometer both states mentioned occurs".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

Participant skipped over this question by pressing the space bar.

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"I would say three, "Offload container from vessel", "Attach the accelerometer sensor", and "Record the shake into the it-system"".

Q7: In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?

“They are eight, “Offload container from vessel”, “Attach accelerometer”, “Drive the container to scanning platform”, “Scan the container”, “Drive the container to dispatch terminal”, “Label the container as shaken”, so six in the main, then because a shake occurs we need to execute “Record the shake into the it-system”, and “Assign a dock-worker to label the container””.

Q8: No shake event has occurred, a breakdown event occurs, and the “Call technician” activity is executed, what activities can then be executed after the “Drive container to dispatch terminal” activity?

“We can label the container as okay and detach the accelerometer nothing else”.

Q9: A container is in a queue to be scanned, a shake event occurs, the “Record the shake into it-system” activity is executed as well as the “Assign dock-worker to label the container” activity. When the queue is over, and the container is in a “Scanned” state.

a) What activities are executed until the container is in the state “Delivered”?

“Then we need “Scan the container”, “Drive container to dispatch terminal”, and because we have the label in requested state we go to “Label the container as shaken”, then we got to “Detach the accelerometer”, and finally “Load the container on to the delivery truck” and the state will be delivered”.

b) What are the state(s) of the “Label” during the process after the scan?

“It is requested until we execute “Label the container as shaken” then it will be labelled”.

Q10: A container arrives at the dock and the “Offload container from vessel” and “Attach accelerometer sensor” activities are executed. A breakdown event is received and the “Call technician” activity is executed.

a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"The container is offloaded, accelerometer is idle, then we receive a breakdown event, the robot is broken, and the label is initial".

b) In order for the main process to continue, what activity has to be executed next? Participant forgot to answer this question.

Q11: what are all possible states for the Container?

"He can be offloaded, scanned, and delivered".

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"The label is in initial, because we haven't executed the next activity and the robot is in working because we have fixed it".

b) What activity is executed nest in the Shake fragment?

"Assign dock-worker to label the container".

Participant five (P5).

Q1: Can you describe the scenario that the model is showing?

"There is some robot that is fetching a container but first there is some sensor that needs to be attached to the container. Then it needs to be driven by some robot, it needs to be scanned... there is some condition there. The condition off the robot needs to be working. The container is then scanned, then it is driven to a terminal, then it needs to be labelled, either as shaken or as okay. Then when that is finished the sensor is removed and the container is taken and put on to the truck".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

“I don’t know, at least there is a breakdown fragment, I don´t know under which circumstances it goes there”. Then I give him a hint that it is after a specific activity. “Okay then it is after “Call technician” activity”.

Q3: Under which circumstance(s) can the Label change from initial state to requested?

“Isn´t it when the container is shaken, after “Assign dock-worker to label the container” activity”.

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

“Is it after “Label the container as okay”, then the accelerometer is idle, and the label is labelled”.

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

“Isn’t it after the “Load the container on to the delivery truck”, then the accelerometer is in sleep and the container is in scanned state. No, it is before that activity, so after “Detach the accelerometer” activity”.

Q6: In all fragments, what is the minimum set of activities that can be executed prior to “Assign dock-worker to label the container” activity?

“I´m going to say seven”.

Q7: In all fragments, what is the minimum set of activities that can be executed prior to “Detach the accelerometer” if one shake occurs and there is no breakdown event?

“is it nine... no, eight”.

Q8: No shake event has occurred, a breakdown event occurs, and the “Call technician” activity is executed, what activities can then be executed after the “Drive container to dispatch terminal” activity?

“Isn’t it just “Label the container as shaken”, no “Label the container as okay” because there was no shake”.

Q9: A container is in a queue to be scanned, a shake event occurs, the “Record the shake into it-system” activity is executed as well as the “Assign dock-worker to label the container” activity. When the queue is over, and the container is in a “Scanned” state. a) What activities are executed until the container is in the state “Delivered”?

“Detach the accelerometer and load the container on to the delivery truck”.

b) What are the state(s) of the “Label” during the process after the scan? “Labelled”.

Q10: A container arrives at the dock and the “Offload container from vessel” and “Attach accelerometer sensor” activities are executed. A breakdown event is received and the “Call technician” activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

“Container is offloaded, Robot is working, label is initial, accelerometer idle”.

b) In order for the main process to continue, what activity has to be executed next?

“Drive container to dispatch terminal is executed next but the Robot has to be working”.

Q11: what are all possible states for the Container?

“That is offloaded, scanned and delivered”.

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"I´m a bit confused, the activities are not in order... is this a trick?". "The label is in requested and the robot is in working".

b) What activity is executed nest in the Shake fragment?

"Isn´t it "Assign dock-worker to label the container"".

Participant six (P6).

Q1: Can you describe the scenario that the model is showing?

"The main process is about a container that has something in it, it is offloaded. Then we have a shake fragment to asses if something has happened and then there is another fragment that is for the robot, to check if the robot breaks down or not. So, in the beginning a container arrives and that puts the robot in a working state. Then I think if the robot does not work the breakdown fragment starts but if it the robot works then the main process continues. Also when the container arrives the label goes to initial, the label can also be in requested or labelled state. The container is offloaded and the container data object gets created. Then we go and attach the accelerometer sensor and the accelerometer becomes idle state which leads to the shake fragment being started, but we wait for a shake event. We either assign a dock-worker or if the label is in requested then we can remind the worker. Then to continue with the main process we drive the container to the scanning platform, then the robot has to be working. We then wait for the container to be scanned. The container then is offloaded and scanned. The container can be offloaded, scanned, and delivered. After the scan it becomes scanned. Then we drive the container to the dispatch terminal and again we use a robot to do that. Then we either label the container as shaken or as okay, so either it has been damaged or it hasn´t. If he has not been damaged, then we use the initial label, if it has been damaged then we use the requested label. The outcome of both of them is that the label becomes labelled. Then we detach the accelerometer that was attached previously to the container, the container was idle after we attached it and when we take it off it goes to sleep state. Then we go to "Load the container on to the delivery truck", then the label needs to be in labelled, the container needs to be scanned and the robot needs to be working, so, if one of those states are not fulfilled we need to execute the breakdown fragment or the shake fragment. Then the container becomes delivered and the scenario ends".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

"I don´t understand, he can do that whenever...". I then told P6 that it is after a specific activity. "The robot is working and then we execute "Call technician" and it will be broken".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"That happens after "Assign dock-worker to label the container"".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"Okay that is "Label the container as okay", and "Label the container as shaken"".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

"That is only in "Load the container on to the delivery truck", no, it is before that, after "Detach the accelerometer" activity".

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"They are three, "Offload container from vessel", "Attach accelerometer sensor", and "Record the shake into it-system"".

Q7: In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?

"I´m going to say eight".

Q8: No shake event has occurred, a breakdown event occurs, and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity?

"it goes to "Label the container as okay", from there it goes to "Detach the accelerometer", then we need to wait until the robot is working again, so it is those two".

Q9: A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state. a) What activities are executed until the container is in the state "Delivered"?

"it goes to "Drive container to dispatch terminal", then it goes to "Label the container as shaken", then it goes to the "Detach the accelerometer", and finally it executes "Load the container on to the delivery truck" and the container will be left in delivered state".

b) What are the state(s) of the "Label" during the process after the scan?

"It is going to be requested and labelled".

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

“The robot is in broken state, the label is still in initial, the accelerometer is idle, and the container is offloaded”.

b) In order for the main process to continue, what activity has to be executed next?

“That is repair robot”.

Q11: what are all possible states for the Container?

“He can be offloaded, scanned, and delivered. This one was easy”.

Q12: The following activities are executed in this order: “Offload container from vessel”, “Attach accelerometer sensor”, “Record the shake into the it-system”, “Call technician”, “Repair robot”. a) What states are the Label and the Robot in?

“The robot is working, and the label is in initial”.

b) What activity is executed nest in the Shake fragment?

“That is “Assign dock-worker to label the container””.

Participant seven (P7).

Q1: Can you describe the scenario that the model is showing?

“So the main process of this one is scan the container, if the container is shaken or not the business process can make sure of that. The main process is actually scanning the container and we are checking if the container is shaken or okay”.

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

“It is after “Call technician””.

Q3: Under which circumstance(s) can the Label change from ini-

tial state to requested?

“There are two circumstances, one is after “Assign dock-worker to label the container”, and the other is “Record the shake into the it-system””.

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

“I think after “Label the container as shaken”, and after “Label the container as okay” activities”.

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

“After the “Detach the accelerometer””.

Q6: In all fragments, what is the minimum set of activities that can be executed prior to “Assign dock-worker to label the container” activity?

“It should be “Record the shake into it-system”, “Drive container to dispatch terminal”, and “Label the container as shaken”, those three”.

Q7: In all fragments, what is the minimum set of activities that can be executed prior to “Detach the accelerometer” if one shake occurs and there is no breakdown event?

“They are nine, “Offload container from vessel”, “Attach the accelerometer sensor”, “Drive the container to scanning platform”, “Scan the container”, “Drive the container to dispatch terminal”, “Label the container as shaken”, “Record the shake into it-system”, “Assign dock-worker to label the container”, ahh okay no they are eight because it is an XOR condition”.

Q8: No shake event has occurred, a breakdown event occurs, and the “Call technician” activity is executed, what activities can then be executed after the “Drive container to dispatch terminal” activity?

"We can do the "Label the container as okay", then "Detach the accelerometer", and then "Load the container on to the delivery truck"".

Q9: A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state. a) What activities are executed until the container is in the state "Delivered"?

"We have only one, "Load the container on to the delivery truck"".

b) What are the state(s) of the "Label" during the main process after the scan?

"Initial, we have three of them, initial, requested and labelled I can see that from the lifecycle".

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"The state of the robot becomes working to broken, the label becomes initial, and the container is still offloaded, and the accelerometer idle".

b) In order for the main process to continue, what activity has to be executed next?

"The activity should be "Call technician"".

Q11: what are all possible states for the Container?

"All the possibilities for the container are three, offloaded, scanned, and delivered".

Q12: The following activities are executed in this order: "Offload

container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"The label is initial, and the robot is working".

b) What activity is executed next in the Shake fragment?

"I think "Assign a dock-worker to label the container"".

Participant eight (P8).

Q1: Can you describe the scenario that the model is showing?

"It is about taking containers from a ship and they are loaded on to a truck. First we have to attach an accelerometer that is a sensor. Then we need to drive it to some platform, then we need to scan it, then we need to drive it to some dispatch terminal, then we need to label it somehow, either we label it as shaken or not shaken, then we detach the accelerometer and finally we load it on to the truck. While this is happening we can go through a breakdown fragment and a shake fragment".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

"After "Call technician", there it changes from working to broken".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"It is either after "Assign dock-worker to label the container", is there something else, no, it is only after that one".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"That is after we have labelled the container, both activities included".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

"After "detach the accelerometer", then they are both in the states stated".

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"I say that they are three".

Q7: In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?

"They are eight, six in the Main process and two in the Shake fragment".

Q8: No shake event has occurred, a breakdown event occurs, and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity?

"We can label the container as okay, then we need to detach the accelerometer, and then we can´t do anything else because the robot is broken".

Q9: A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state. a) What activities are executed until the container is in the state "Delivered"?

"Then we have to execute "Drive container to dispatch terminal", then we need to execute "Label the container as shaken", then we go to "Detach the accelerometer", and then we execute "Load the container on to the delivery truck", then the container will be delivered".

b) What are the state(s) of the "Label" during the main process

after the scan?

The participant skipped over this question

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"The robot is in broken state, the label is in initial because we haven´t labelled yet, and the containers have been offloaded so they are in offloaded state, and the accelerometer is in idle".

b) In order for the main process to continue, what activity has to be executed next?

"Repair robot needs to happen next".

Q11: what are all possible states for the Container?

"The container can be offloaded, scanned, and delivered".

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"The robot is in working state, and the label is in initial state".

b) What activity is executed next in the Shake fragment?

"I would say "Assign a dock-worker to label the container"".

Participant nine (P9).

Q1: Can you describe the scenario that the model is showing?

"Some container arrives at the dock and then a process starts. First, if a robot is working the breakdown fragment can start, then it goes to offload the container, then we attach the accelerometer and the shake fragment can start, then it is driven, then it is scanned, and then it is moved to a terminal, then we check if it is the correct container, it is either correct or... no, no, it is either shaken or not then we take it off and it is loaded on to a delivery truck and the process ends ".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

"When it is repaired, so after the "Repair robot" activity".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"That is after "Assign a dock-worker to label the container"".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"it is after "Label the container as okay" or "Detach the accelerometer", no, only after "Label the container as okay"".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

"That is after "Detach the accelerometer" activity".

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"I think it is only one, "Record the shake into the it-system"".

Q7: In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?

"You can execute two activities, either "Label the container as shaken" or "Label the container as okay"".

Q8: No shake event has occurred, a breakdown event occurs, and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity?

"It goes straight to the "Label the container as okay", then it goes to "Detach the accelerometer", and then it goes to "Load the container on to the delivery truck" and the process ends".

Q9: A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state. a) What activities are executed until the container is in the state "Delivered"?

"what is executed is "Drive container to dispatch terminal", "Label the container as shaken", "Detach the accelerometer", and "Load the container onto the delivery truck"".

b) What are the state(s) of the "Label" during the main process after the scan?

"The label is in requested".

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"The robot is working, accelerometer is idle, initial for label, and the container is offloaded".

b) In order for the main process to continue, what activity has to be executed next?

"We need to repair the robot".

Q11: what are all possible states for the Container?

"There are three states, offloaded, scanned, and delivered".

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"I think the robot is in working and the label in initial".

b) What activity is executed next in the Shake fragment?

"The next activity is "Assign a dock-worker to label the container"".

Participant ten (P10).

Q1: Can you describe the scenario that the model is showing?

"It is about checking containers, if they are okay or not. In the beginning a robot check if it is okay or not. If it is not okay it goes through another process".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

"After "Call technician" activity".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"That is just when you have to "Assign a dock-worker to label the container"".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"It has to be before the "Detach the accelerometer", so it is after either "Label the container as shaken" or "Label the container as okay"".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

"At least the container has to be scanned and we need to detach the accelerometer so, it is before the final step(activity)".

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"That is three, two in the Main process and one in the Shake fragment".

Q7: In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?

"If it is prior to, then they are eight".

Q8: No shake event has occurred, a breakdown event occurs, and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity?

"It is just "Label the container as okay" activity".

Q9: A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state. a) What activities are executed until the container is in the state "Delivered"?

"it needs to go through "Scan the container", "Drive the container to dispatch terminal", "Label the container as shaken", "Detach the accelerometer", and "Load the container on to the delivery truck"".

b) What are the state(s) of the "Label" during the main process after the scan?

"The label is in requested".

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"The robot is broken, the label is initial, the container is offloaded, and the accelerometer hasn´t got any state yet... oh no, attach is executed so the accelerometer is idle".

b) In order for the main process to continue, what activity has to be executed next?

"Repair robot".

Q11: what are all possible states for the Container?

"The container Is first offloaded, and then scanned, and delivered".

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"The label is in initial state and the robot is back into working state".

b) What activity is executed next in the Shake fragment?

"If the state is initial for the label then the next activity is "Assign a dock-worker to label the container"".

Participant eleven(P11).

Q1: Can you describe the scenario that the model is showing?

"So what I think the scenario is, is that a container arrives at a dock and it is offloaded and there is a process for the robot to attach an accelerometer to it and then it drives the container to a scanning platform there the container is scanned, then it is driven to a dispatch terminal, that is some cargo shipping area. Then there is a process for the labelling. There is some labelling that determines if it is shaken or okay and if it gets shaken it means it got corrupted somehow according to the accelerometer and then the accelerometer is detached and the container is loaded and sent off. Then there is different fragments for different parts, like the shake fragment showcases what events should occur for the label to be considered as shaken or shook. And then there is a breakdown fragment which refers to I guess a breakdown of technology. Then we can see different lifecycles. Basically it shows us if things are broken or not in short".

Q2: Under which circumstance(s) can a Robot change from working state to broken state?

"it is "Call technician"".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

The participant skipped over this question

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"Both label activities".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

“If the container has been scanned and the accelerometer has been detached then we would have both of these states together”.

Q6: In all fragments, what is the minimum set of activities that can be executed prior to “Assign dock-worker to label the container” activity?

“Five activities in the Main process and in the Shake fragment it must be one activity”.

Q7: In all fragments, what is the minimum set of activities that can be executed prior to “Detach the accelerometer” if one shake occurs and there is no breakdown event?

“Repair robot”.

Q8: No shake event has occurred, a breakdown event occurs, and the “Call technician” activity is executed, what activities can then be executed after the “Drive container to dispatch terminal” activity?

“First we do “Label the container as okay”, then we can only do “Detach the accelerometer”, only those two”.

Q9: A container is in a queue to be scanned, a shake event occurs, the “Record the shake into it-system” activity is executed as well as the “Assign dock-worker to label the container” activity. When the queue is over, and the container is in a “Scanned” state. a) What activities are executed until the container is in the state “Delivered”?

“So, it has been labelled, scanned and robot working”.

b) What are the state(s) of the “Label” during the main process after the scan? “Idle and labelled”.

Q10: A container arrives at the dock and the “Offload container from vessel” and “Attach accelerometer sensor” activities are ex-

ecuted. A breakdown event is received and the "Call technician" activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer? "The robot has to be broken, the label is in initial, the container has to be scanned, and the accelerometer idle".

b) In order for the main process to continue, what activity has to be executed next? "Repair robot".

Q11: what are all possible states for the Container?

"Offloaded, scanned, delivered, yeah, offloaded, scanned, and delivered".

Q12: The following activities are executed in this order: "Offload container from vessel", "Attach accelerometer sensor", "Record the shake into the it-system", "Call technician", "Repair robot". a) What states are the Label and the Robot in?

"Labelled and the robot is working".

b) What activity is executed next in the Shake fragment? "It is "Remind assigned worker"".

Participant twelve (P12).

Q1: Can you describe the scenario that the model is showing?

"Okay so there is a robot and its main job is to receive containers. It will take the containers from a vessel and then it waits until it has an accelerometer attached then after that it will start to scan it and after it finishes scanning it will take all these items it collected from the container to somewhere else... to a terminal okay. It checks if the container is shaken or not. Then someone will detach the accelerometer and the container will be loaded to a truck and then the container will be delivered". **Q2: Under which circumstance(s) can a Robot change from working state to broken state?**

"Well at any time... after every activity... In the breakdown fragment, after "Call technician" activity".

Q3: Under which circumstance(s) can the Label change from initial state to requested?

"The circumstance is that it has been assigned a doc-worker to label the container".

Q4: Under which circumstance(s) can the Accelerometer be in idle state and the Label in labelled state?

"So after we attach the accelerometer it becomes idle, so after that we are waiting for the time when the label becomes labelled, there are two options there, either we label the container as shake or we label it as okay, during this procedure the accelerometer is already idle and the label becomes labelled, so only after those two activities".

Q5: Under which circumstance(s) can the Container be in scanned state and the Accelerometer in sleep state?

"Okay so I think after we detach the accelerometer the accelerometer goes to sleep, and the container is scanned so it is just after the "Detach accelerometer"".

Q6: In all fragments, what is the minimum set of activities that can be executed prior to "Assign dock-worker to label the container" activity?

"The system should start, that is the minimum thing, so a container arrives".

Q7: In all fragments, what is the minimum set of activities that can be executed prior to "Detach the accelerometer" if one shake occurs and there is no breakdown event?

"Ten activities... that´s a maybe. I would say nine, offload container, attach the accelerometer, drive the container, scan the container, drive container to dispatch terminal, and we are at label the container as shaken so those six and then I have three extras in the shake fragment, record the shake, assign a dock-worker or remind dock-worker. So, I guess what is happening here is that we execute this twice... Ahh so they are ten... at least ten".

Q8: No shake event has occurred, a breakdown event occurs, and the "Call technician" activity is executed, what activities can then be executed after the "Drive container to dispatch terminal" activity?

"Nothing can be executed because the robot is broken, we have to wait until the robot is repaired".

Q9: A container is in a queue to be scanned, a shake event occurs, the "Record the shake into it-system" activity is executed as well as the "Assign dock-worker to label the container" activity. When the queue is over, and the container is in a "Scanned" state. a) What activities are executed until the container is in the state "Delivered"?

"So, there is two activities that should be executed until we deliver the container, those are "Detach the accelerometer" and "Load the container on to the delivery truck"".

b) What are the state(s) of the "Label" during the main process after the scan?

"It is just labelled".

Q10: A container arrives at the dock and the "Offload container from vessel" and "Attach accelerometer sensor" activities are executed. A breakdown event is received and the "Call technician" activity is executed. a) What are the state(s) of the Robot, Label, Container, and the Accelerometer?

"So, the robot is in broken state and the label is in initial state, the container is offloaded, and the accelerometer... oh it has been executed so it is idle".

b) In order for the main process to continue, what activity has to be executed next?

“Yeah it should be repair the robot so it becomes working and it can continue”.

Q11: what are all possible states for the Container?

“There is three states and they are offloaded, scanned, and delivered”.

Q12: The following activities are executed in this order: “Offload container from vessel”, “Attach accelerometer sensor”, “Record the shake into the it-system”, “Call technician”, “Repair robot”. a) What states are the Label and the Robot in?

“After they have been executed the robot is in working condition and the label... it is in initial state”.

b) What activity is executed next in the Shake fragment?

“So we execute the “Assign a dock-worker to label the container””.

APPENDIX

Transcription of the think-aloud recordings

Question 1. Can you describe the strategy you have followed to answer the questions?

P1. “I started by reading the questions. Then I tried to locate the things mentioned in the questions to try to figure out where everything was. Then if I didn’t find anything I would read the question again and try searching again”.
P2. “It was dependent on if the question was about the boxes (data objects) or the other thing (activity). I looked at the name of the states in the square brackets to figure out the state”.
P3. “Hmm I don´t know, I tried to follow what was happening and tried to imagine what would happen and when some state changed what affects would that have. After some time, I knew where the process was so I was quicker to find the answer, I also tried to think what would happen in real life”.
P4. “First, I looked at the lifecycles to figure out where it was in relation to the questions then if it was anything breakdown or shake related, I cross-referenced them with the current state, then I would go to the main process to try to figure out where I´m currently at. Sometimes I first looked up the activity that was performed or needed to be performed but looking at the life-cycles or the labels (data objects) gave a quick overview of where the lifecycle of the data was”.
P5. “Started by reading the question, then I looked at the activities mentioned in the question, or the label and that, and tried to find some connection between the question and the model... yeah I don´t know, something like that”.
P6. “I usually went to the event that was asked about or I searched for that by looking from left to right and went outside of the main process if it stated something about the robot for example I would go to that fragment and ex-

plore it, I would say that I used a linear approach when I searched the model".
P7. "I used what you told me about how activities and data objects work and how they connect".
P8. "I just did something random... I think... I tried to follow and jump around, if it said container something, I tried to find it but that´s maybe not a strategy".
P9. "I didn't really have a strategy, I tried to follow the words in the questions and to follow the process".
P10. "At the end I had come up with a strategy but first I thought I would get a new model each time, so I was just scanning the whole model. I looked mainly at the Main process".
P11. "I'm not that familiar with this so my strategy was to look for keywords and passwords and then look through the main process, if I recognised a keyword, I would look at the different fragments. I usually looked at the Main process from left to right".
P12. "It was basically the different things names that were mentioned in the questions, I was looking for them, what their names was, what activities then I looked directly at the activities and what their names were mentioned then I looked directly at the files and I was just looking directly at the files (probably means fragments here)".

Question 2. Was the main process enough to get an understanding of the process?

P1. "Yes, I would say it was enough and it was really nice to have the model broken down in fragments".
P2. "I think so".
P3. "Yes, it was, at least that is what I think".
P4. "The main process is a good way to get a rough understanding of the process. It is not immediately clear weather or not... Like the naming of the labels (data objects) specifically they are points for Label initial, requested, and labelled is a bit unclear sometimes, specifically in the XOR when you are choosing to label the container as okay or as shaken, but that is mostly from... Ahh yeah, I think there is a bit of a... some information is lost specifically between the shake events, the connection between the shake events and the label lifecycle if you are just looking at the main process it is a bit unclear. But with the Robot it makes a perfect sense, either it is working, or it is not working... yeah that makes sense for the context".

P5. “I would say mostly, the fragments then helped to get a better understanding”.
P6. “No, I think it was not enough. A crucial part missing from there is the breakdown fragment, because in there you can see how it changes to broken state, if it wasn’t there you could think that the robot could never break down. It is good to have all the details, at least that is what I think is nice to have”.
P7. “I can understand the whole thing, but the fragments are inner processes of the main, so they are good to have for more details”.
P8. “Hmmm yes that was nice I was just a little reluctant in the beginning... Yes I think it was enough, I didn’t need the repair robot”.
P9. “Yes, I think I got the overall picture of what was going on, but some details are missing”.
P10. “It takes a longer time to understand, it is better to also show the fragments”.
P11. “No, I don’t think so”.
P12. “Yes”.

Question 3. For what purpose have you used the lifecycles?

P1. “To see what states the data objects were in, the Robot and the Label”.
P2. “I used them very little, just to validate the state transitioning’s”.
P3. “I didn’t use them much, there was one question that asked about them, I used them then but not for the other questions”.
P4. “I specifically used them to see how the transitioning works and I used them to figure out the default states for the data objects, like for the accelerometer it doesn’t specifically say whether or not it sleeps, or it is idle as the default state”.
P5. “I didn’t really use them at all... yeah I didn’t use them”.
P6. “I have never worked with this before so I... (then I tell the participant that it is just about how you used them to answer the questions) ... I used them when the questions asked about states and I used them to see how the states can go from one state to another. So, I clearly used them 100%”.
P7. “Only to see what states the data objects can have. Some questions were targeted at them. I used them, they are easy to understand”.
P8. “Yes, I used them when I was searching for something, but I don´t know why... one of the questions asked about possible states... I was trying to use them because I found one state but not the next one so I looked at the lifecycle

so I didn't need to go through the whole model to find it... so at least I used them a little bit".
P9. "I think I used them once, that was for one question that asked about them. But I glanced at them as well occasionally".
P10. "Never".
P11. "Honestly nothing".
P12. "I used them at some point to answer some questions about the states. In general I looked around what they have in the brackets".

Question 4. For what purpose have you used the different fragments?

P1. "To see what activities were executed in them for example when the container needed to be labelled. I used them specially when the question asked about the circumstances".
P2. "To realise what happens if the robot breaks down or if there is a shake event".
P3. "When the question was about the fragments, I used them to see what goes on in the fragments, they were both event based so if it was about that I used them".
P4. "I specifically looked at the shake fragment to figure out what happens... what a hell a shake event is... and figure out why a label would be initial or requested. I barely needed to look at the breakdown fragment because it was pretty intuitive".
P5. "When a question asked about them, I had to use them to see what goes on inside of them".
P6. "I used them when it was their turn in the main process, e.g. when the accelerometer was idle, I would look through the shake fragment and if the question was about a broken robot, I would look through the breakdown fragment".
P7. "How the data objects work inside of the fragments, how the state changes, and to see more activities than those in the main fragments. So, to see more details about the main process". P8. "Firstly, to answer the questions, and you needed to jump... working, working ... should I have used them for something else?...".
P9. "To answer questions about them".
P10. "Almost in every question, except for maybe three of them or something".

P11. “Mainly when a question asked specifically about the fragments, if it was about the robots, I would look more in the fragments then I would look in the main process”.
P12. “I used the different fragments when I was asked to answer under which circumstances and also about the minimum set of activities that have been executed so I would know how much of them are executed”.

Question 5. Do you see any benefits in combining the main process, with fragments and lifecycles?

P1. “It helps to break it down into fragments, it would be much more crowded if it would all be in the same process, it makes it clearer, it is cleaner and better organised”.
P2. “The shake can happen anywhere between here (points at the screen). I think it would be difficult to model the shake into the main process”.
P3. “Yes, I can see benefits, especially with the fragments but not so much for the lifecycles, the lifecycles are still good to have, when the model gets more complicated, they can really help. Splitting the process up to makes it easier to model and to follow. The fragments seem to be something that is not always running in a company, but the main process is, so I think it could be difficult to model them in with the main process, they would have to figure out all possible scenarios and that could be challenging. The fragments are more like a contingency plan”.
P4. “I´m specifically certain on how to phrase it but you gain... you get a more abstracted level that is more intuitive to understand but you lose some information if you don’t do the quotation marks correctly, specifically around the labels (data objects) where it is a bit unclear”.
P5. “I would say doing it this way helps. I would say it makes it clearer to read and it gives you deeper understanding by including the fragments”.
P6. “I would say it makes it simpler, the lifecycles are really good to show in a simple way the different states of the data objects and they give you an overview of what can be done so you don´t have to remember that. It would be difficult to model the shake fragment into the main process I think otherwise it would become way to complicated. It is nice that the processes are only one line, it is very good to have it broken down like this into fragments”.
P7. “Some of the benefits are that you can get a better understanding about the main process and how it works and how it connects to the data objects. You can get more details this way”.

P8. “I think it is better to do it this way, it is easier to understand... it is better to break it down like this instead of having it all twisted around”.
P9. “I think it is better to break it down like that, it is easier to understand and quicker to read”.
P10. “I can see the benefits of using the fragments but not the lifecycles, I didn’t use them at all”.
P11. “Yes and no, it can be quite disorienting to use them all but it is an advantage if I’m looking for the purpose of how they connect to one another”.
P12. “I think it helps, it gives an understanding between what I should expect this object other to do... yeah so for example I expect the label object to be in initial, requested, and labelled state at some point so I know where to look at”.

Question 6. Do you see any challenges in combining the main process, with fragments and lifecycles?

P1. “I would say it is more complicated to combine the process and fragments because of all the rules about lines cannot cross each other, I would not combine them”.
P2. “Just what we talked about, it would be difficult to integrate the shake into the main process because it can happen when ever”.
P3. “It could also get complex and the events can happen at any time so that is a challenge to make it fit with the main process. It could become complex, but it could also simplify other things. Specially if you have many lifecycles, it would be difficult to look them all up”.
P4. “You could lose some information”.
P5. “No there is nothing that comes to mind... One thing though, it could be difficult to understand where and what fragments connect to the main process is the only thing I can think of”.
P6. “I think it is difficult because it can go so often to robot working to the robot broken, then it would have to be beneath the main process and it would have so many inputs from different places so it would be more complicated than having it standalone, and the shake fragment is happening over a long period of time so it doesn’t fit with the timeline of the main process, and if it would be integrated beneath the main process you would think it would be happening at the same time”.
P7. “Yeah it is going to be complicated sometimes because when you are going to put those fragments into the main process scenario the scenario becomes more complicated and also if the user wants to read it then it is more

complicated, so it takes more time and you use more energy. When you have the fragments and processes split you can magnify them when you want”.
P8. “It could lead to that you forget to repair the robot, if you forget to look at it... like if you don´t realise that you need to go here (breakdown fragment) to repair the robot... but if you know how this works then I think there is no problem with this... if you do it yourself then you know what you are doing... if you explain this to others then there is no problem”. P9. “I´m not sure... It could become confusing... I can´t really think of any challenges”.
P10. “No, I don´t see any challenges, I think it could be used for more complex modelling as well”.
P11. “Well it can be disorienting”.
P12. “I can see a lot of stress in the diagram I would say, there are many things that need to be considered. It would be nice to have some indication where the fragments can happen in the main process... It would be nice to have more connection with the items... yeah of course the shake fragment can happen somewhere in the process but if it was a bigger process how can I just navigate to this shake fragment from what I see in those activities. Yeah that is the main challenge I think.”

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