The handle [http://hdl.handle.net/1887/66798](http://hdl.handle.net/1887/66798) holds various files of this Leiden University dissertation.

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APPENDIX A. LIST OF PRIMARY STUDIES (related to Chapter 2)

The papers considered as primary studies in the systematic mapping study presented in this paper and that have been treated as primary studies are presented below.


Appendix A


of Software Engineering Languages and Technologies (WEASEL'07), pp. 25-30.


APPENDIX B. DEFINITIONS OF MEASURES (related to Chapter 2)

The definition of the measures for the dependent variables used in the empirical studies covered in this systematic mapping study is presented below. In the definition of the measures we use the word *question* to simplify the definition, but we can also refer to a *task*. Note that in Table 7, all the studies that use measures which measure the same concept are grouped together (even though they were originally presented with different names), using the names according to the classification set out below.

**Correctness**
Definition: The percentage of questions that are answered correctly.
Formula: Number of correct answers/Number of questions.
Papers which use this measure: [P9], [P7], [P8], [P9], [P18], [P20], [P10]

**Accuracy**
Definition: the number of correct answers.
Papers which use this measure with this name: [P23], [P34], [P36], [P37]
Papers which use this measure with different names:
- Total score: [P4], [P21], [P24], [P29]
- Correct interpretation: [P6]
- Number of responses: [P22]
- Comprehension: [P2]
- Without a specific name: [P14], [P17], [P31]

**Effectiveness**
Definition: The percentage of questions answered which are correct.
Formula: Number of correct answers/Number of answers
Papers which use this measure with this name: [P32]
Papers which use this measure with a different name:
- Correctness: [P7], [P13], [P19]

**F-Measure**
Definition: It is an aggregate measure which is a standard combination of the *recall* and *precision*, defined as their harmonic mean.
Formula: 
\[
F - Measure = \frac{2 \cdot precision_{s,l} \cdot recall_{s,l}}{precision_{s,l} + recall_{s,l}}
\]

Recall
Definition: It measures the fraction of expected items that are in the answer.

Formula: \[
\frac{|A_{s,i} \cap C_i|}{|C_i|}
\]

\(A_{s,i}\): Set of elements mentioned in the answer to question \(i\) by subject \(s\).
\(C_i\): The correct set of elements expected for question \(i\).

**Precision**
Definition: It measures the fraction of items in the answer that are correct.

Formula: \[
\frac{|A_{s,i} \cap C_i|}{|A_{s,i}|}
\]

\(A_{s,i}\): Set of elements mentioned in the answer to question \(i\) by subject \(s\).
\(C_i\): The correct set of elements expected for question \(i\).

Papers which use this measure: [P1], [P25], [P26]

**Efficiency**
Definition: The number of correct answers per time units.

Formula: Number of correct answers/Time

Papers which use this measure with this name: [P7], [P32], [P10]

Papers which use this measure with a different name:
- Efficacy: [P17]

**Relative time (for a correct answer)**
Definition: It measures the time that a subject took to obtain a correct answer.

Formula: Time/Number of correct answers

Papers which use this measure: [P29], [P7]

**Perceived comprehensibility**
This is a subjective measure obtained as a ranking of the subject’s perceived understandability of a certain diagram. Measured using a 1-5 Likert ordinal scale, where the score of 1 indicated that the diagram was absolutely incomprehensible.

Papers which use this measure: [P3], [P12]

**Perceived ease of construction**
This is a subjective measure obtained as a ranking of the subject’s perceived ease of construction of a certain diagram. It is measured using a 1-5 Likert ordinal scale, where the score of 1 indicates that the diagram is very difficult.

Papers which use this measure: [P14]
Time
This is a measure which is used to calculate the number of units of time used to perform a task.

Papers which use this measure: [P3], [P4], [P5], [P7], [P8], [P9], [P11], [P12], [P13], [P14], [P17], [P18], [P19], [P21], [P22], [P23], [P28], [P29], [P32], [P32], [P36], [P37], [P38]

Errors
This is a measure which counts the number of mistakes made in solving a specific task.

Papers which use this measure: [P9], [P8], [P9], [P15], [P16], [P27], [P28], [P33]
APPENDIX C. THE SEARCH STRINGS (related to Chapter 2)

The definition of the search strings used in each search engine is presented as follows. As commented on in Table 2.1 we had three major terms, and we also considered alternative spellings and synonyms of, or terms related to, the major terms. The original search string was:

\[(UML \text{ OR (Unified Modelling Language))})\]

\[\text{AND} \]

\[(\text{Maintenance OR Maintainability OR Modularity OR Reusability OR Analyzability OR Changeability OR Evolution OR Evolvability OR Modification OR Stability OR Testability OR Comprehensibility OR Comprehension OR Understandability OR Understanding OR Misinterpretation})\]

\[\text{AND} \]

\[(\text{Empirical OR Experiment OR Survey OR Case study OR Action research})\]

Owing to the limitation of the search engines, we observed that such a long string could not be used directly in all the search engines. It was therefore necessary to tailor the search string to each digital library by splitting the original search string and then combining the results manually. The search strings used for each digital source are presented below.

**ACM and IEEE search string**


**Science Direct and SCOPUS search string**

\[(\text{TITLE-ABSTR-KEY((UML OR (Unified AND Modeling AND Language))})\] AND \[(\text{Maintenance OR maintainability OR modularity OR reusability OR analyzability OR changeability OR evolution OR evolvability OR (modification AND stability) OR testability OR comprehensibility OR comprehension OR understandability OR understanding})\] AND \[(\text{empirical OR experiment OR survey OR (case AND study) OR (action AND research))}])\]
Springerlink search string

The search string was divided into 28 search strings because this string only allows 10 terms to be placed in the search string textbox. After the searches have been carried out, we combined their results using the SLR-Tool, which automatically detects duplicate papers.

**String 1:** ab:(UML and maintenance and(empirical or experiment or survey or(case and study)or(action and research)))

**String 2:** ab:(UML and maintainability and(empirical or experiment or survey or(case and study)or(action and research)))

**String 3:** ab:(UML and modularity and(empirical or experiment or survey or(case and study)or(action and research)))

**String 4:** ab:(UML and reusability and(empirical or experiment or survey or(case and study)or(action and research)))

**String 5:** ab:(UML and analyzability and(empirical or experiment or survey or(case and study)or(action and research)))

**String 6:** ab:(UML and changeability and(empirical or experiment or survey or(case and study)or(action and research)))

**String 7:** ab:(UML and evolution and(empirical or experiment or survey or(case and study)or(action and research)))

**String 8:** ab:(UML and evolvability and(empirical or experiment or survey or(case and study)or(action and research)))

**String 9:** ab:(UML and(modification and stability)and(empirical or experiment or survey or(case and study)or(action and research)))

**String 10:** ab:(UML and testability and(empirical or experiment or survey or(case and study)or(action and research)))

**String 11:** ab:(UML and comprehensibility and(empirical or experiment or survey or(case and study)or(action and research)))

**String 12:** ab:(UML and comprehension and(empirical or experiment or survey or(case and study)or(action and research)))

**String 13:** ab:(UML and understandability and(empirical or experiment or survey or(case and study)or(action and research)))

**String 14:** ab:(UML and understanding and(empirical or experiment or survey or(case and study)or(action and research)))

**String 15:** ab:("Unified Modeling Language" and Maintenance and(empirical or experiment or survey or(case and study)or(action and research)))

**String 16:** ab:("Unified Modeling Language" and maintainability and(empirical or experiment or survey or(case and study)or(action and research)))
String 17: ab: ("Unified Modeling Language" and modularity and (empirical or experiment or survey or (case and study) or (action and research)))

String 18: ab: ("Unified Modeling Language" and reusability and (empirical or experiment or survey or (case and study) or (action and research)))

String 19: ab: ("Unified Modeling Language" and analyzability and (empirical or experiment or survey or (case and study) or (action and research)))

String 20: ab: ("Unified Modeling Language" and changeability and (empirical or experiment or survey or (case and study) or (action and research)))

String 21: ab: ("Unified Modeling Language" and evolution and (empirical or experiment or survey or (case and study) or (action and research)))

String 22: ab: ("Unified Modeling Language" and evolvability and (empirical or experiment or survey or (case and study) or (action and research)))

String 23: ab: ("Unified Modeling Language" and (modification and stability) and (empirical or experiment or survey or (case and study) or (action and research)))

String 24: ab: ("Unified Modeling Language" and testability and (empirical or experiment or survey or (case and study) or (action and research)))

String 25: ab: ("Unified Modeling Language" and comprehensibility and (empirical or experiment or survey or (case and study) or (action and research)))

String 26: ab: ("Unified Modeling Language" and comprehension and (empirical or experiment or survey or (case and study) or (action and research)))

String 27: ab: ("Unified Modeling Language" and understandability and (empirical or experiment or survey or (case and study) or (action and research)))

String 28: ab: ("Unified Modeling Language" and understanding and (empirical or experiment or survey or (case and study) or (action and research)))

Wiley Inter Science search string

We used the advanced search in which it is possible to use three (or more) textboxes to enter complex strings (see Figure 1). We used a search string divided into three parts, which were linked by AND connectors. Different textboxes were used to introduce each part of the search string:
Figure 1. Wiley advanced search.

UML or (Unified and Modeling and Language)

AND

Maintenance OR maintainability OR modularity OR reusability OR analyzability OR changeability OR evolution OR evolvability OR (modification AND stability) OR testability OR comprehensibility OR comprehension OR understandability OR understanding

AND

empirical OR experiment OR survey OR (case AND study) OR (action AND research)
APPENDIX D. EXAMPLES OF LOW AND HIGH LOD DIAGRAMS (related to Chapter 3)

This appendix shows examples of a low LoD class diagram (Figure D.1) and a high LoD class diagram (Figure D.2).

Figure D.1. Example of a low LoD class diagram.

Figure D.2. Example of a high LoD class diagram.
APPENDIX E. INTERVIEW QUESTIONNAIRE (related to Chapter 6)

The following lines present the questionnaire used to carry out the interviews. The questionnaire is divided into 3 blocks:

Common questions for all the interviewees

1. What is your background and your experience?
2. What is your role, and what are your responsibilities within the project?
3. Which kind of documentation do you use to perform maintenance tasks: diagrams, code, textual information, etc.?
4. How do you use documentation/diagrams?
5. How often do you use the documentation?

Block of questions for those interviewees who use UML diagrams

6. Why do you use UML diagrams? (Give reasons) / For what purpose is UML modelling used?
7. For maintenance, do you manage (look up/ create/ modify) diagrams in a modelling tool (i.e. Enterprise Architect, Visio, etc.)? Or do you look them up in the documentation (i.e. word documents, pictures, etc.)? Did you receive any training about the tool?
8. Which diagrams do you consider to be most frequently used to perform the maintenance tasks? Which diagrams do you consider to be the most useful for performing the maintenance tasks?
9. Do diagrams help in solving defects?
   IF the answer is YES
   9.1. How do they do so?
10. When you maintain the code, do you also maintain the diagrams?
    IF the answer is YES
    10.1. How much time does it take?
    10.2. Who maintains the diagrams? (The same person who maintains the code or a different one?)
    IF the answer is NO
    10.3. Why do you not maintain the diagrams? Are the diagrams correct but not the code? Or is there another reason?
11. Do you like UML?
12. Do you think using UML has an impact on the time of the project? Do you think using UML has an impact on the quality of the final product? How?
13. What cost factors are related to using UML modelling in your work (training, tooling, etc.)?
14. Do you think there is another way in which to improve your work other than UML (i.e. another kind of diagram, etc.)?
15. Did you receive any training about UML at the Company? And before coming to the Company?
16. Do you think that the use of modelling allows errors to become incorporated?
17. Where does the diagram originate from and go to? (chain of use)
18. Do you reuse documentation from previous projects?

**Block of questions for those interviewees who do not use UML diagrams**

19. Do you use any kind of diagram to maintain the system and to communicate between team members?
20. Would you like UML diagrams to be available?
   
   If the answer is YES
   20.1. How do you think UML would help you to maintain the system?
   20.2. What benefits do you think UML diagrams could contribute to your work?
   20.3. Do you think UML helps to improve the quality of the final product? How?
   20.4. What cost factors are related to using UML modelling in a project?
   20.5. Do you think the size of the system influences the way in which UML is used (or not used) on a project?
   20.6. Do you think the size of the team influences the way in which UML is used (or not used) on a project?
APPENDIX F. BACKGROUND INFORMATION RELATED TO EACH INTERVIEWEE (related to Chapter 6)

Table F.1 summarizes the main background information related to each interviewee of the case study.
<table>
<thead>
<tr>
<th>Interviewee</th>
<th>ICT experience</th>
<th>Context</th>
<th>Educational field</th>
<th>Educational level</th>
<th>Gender</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Int1]</td>
<td>very high</td>
<td>common project</td>
<td>n.a.</td>
<td>school</td>
<td>male</td>
<td>project architect</td>
</tr>
<tr>
<td>[Int2]</td>
<td>medium</td>
<td>n.a.</td>
<td>computer sciences</td>
<td>master's degree</td>
<td>male</td>
<td>project manager</td>
</tr>
<tr>
<td>[Int3]</td>
<td>very high</td>
<td>n.a.</td>
<td>electronics and mathematics</td>
<td>bachelor's degree</td>
<td>male</td>
<td>project architect</td>
</tr>
<tr>
<td>[Int4]</td>
<td>n.a.</td>
<td>n.a.</td>
<td>computer sciences</td>
<td>bachelor's degree</td>
<td>male</td>
<td>project architect</td>
</tr>
<tr>
<td>[Int5]</td>
<td>medium</td>
<td>n.a.</td>
<td>computer sciences</td>
<td>bachelor's degree</td>
<td>male</td>
<td>information analyst</td>
</tr>
<tr>
<td>[Int6]</td>
<td>low</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>technical lead</td>
</tr>
<tr>
<td>[Int8]</td>
<td>very high</td>
<td>n.a.</td>
<td>navy</td>
<td>n.a.</td>
<td>male</td>
<td>test engineer</td>
</tr>
<tr>
<td>[Int9]</td>
<td>high</td>
<td>outsourcing</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>delivery lead</td>
</tr>
<tr>
<td>[Int10]</td>
<td>very high</td>
<td>Embedded real-time programming</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int11]</td>
<td>very high</td>
<td>n.a.</td>
<td>computer sciences</td>
<td>bachelor's degree</td>
<td>female</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int12]</td>
<td>low</td>
<td>migration</td>
<td>art</td>
<td>high school</td>
<td>male</td>
<td>test coordinator</td>
</tr>
<tr>
<td>[Int13]</td>
<td>very high</td>
<td>n.a.</td>
<td>n.a.</td>
<td>school</td>
<td>male</td>
<td>technical lead</td>
</tr>
<tr>
<td>[Int14]</td>
<td>high</td>
<td>n.a.</td>
<td>computer sciences</td>
<td>n.a.</td>
<td>male</td>
<td>information analyst</td>
</tr>
<tr>
<td>[Int16]</td>
<td>n.a.</td>
<td>web/mobile projects (SCRUM)</td>
<td>electronics</td>
<td>n.a.</td>
<td>male</td>
<td>SCRUM master</td>
</tr>
<tr>
<td>[Int18]</td>
<td>very high</td>
<td>n.a.</td>
<td>chemistry and physics</td>
<td>bachelor's degree</td>
<td>male</td>
<td>system analyst</td>
</tr>
<tr>
<td>[Int19]</td>
<td>high</td>
<td>common project</td>
<td>computer sciences</td>
<td>master's degree</td>
<td>female</td>
<td>programmer / application developer</td>
</tr>
</tbody>
</table>

Table F.1. Background information of interviewees of the case study.
<table>
<thead>
<tr>
<th>Interviewee</th>
<th>ICT experience</th>
<th>Context</th>
<th>Educational field</th>
<th>Educational level</th>
<th>Gender</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Int20]</td>
<td>very high</td>
<td>n.a.</td>
<td>Business and Finances</td>
<td>bachelor's degree</td>
<td>male</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int21]</td>
<td>n.a.</td>
<td>n.a.</td>
<td>computer sciences</td>
<td>master's degree</td>
<td>male</td>
<td>analyst developer</td>
</tr>
<tr>
<td>[Int23]</td>
<td>very high</td>
<td>n.a.</td>
<td>n.a.</td>
<td>high school</td>
<td>female</td>
<td>analyst developer</td>
</tr>
<tr>
<td>[Int24]</td>
<td>very high</td>
<td>web/mobile projects (SCRUM)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>project architect</td>
</tr>
<tr>
<td>[Int25]</td>
<td>very high</td>
<td>n.a.</td>
<td>n.a.</td>
<td>bachelor's degree</td>
<td>male</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int26]</td>
<td>very high</td>
<td>common project</td>
<td>computer sciences</td>
<td>master's degree</td>
<td>male</td>
<td>project architect</td>
</tr>
<tr>
<td>[Int27]</td>
<td>very high</td>
<td>mainframe</td>
<td>n.a.</td>
<td>HBO</td>
<td>male</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int28]</td>
<td>very high</td>
<td>old legacy system</td>
<td>psychology</td>
<td>HBO</td>
<td>male</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int29]</td>
<td>very high</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>team leader</td>
</tr>
<tr>
<td>[Int31]</td>
<td>high</td>
<td>common project</td>
<td>computer sciences</td>
<td>bachelor's degree</td>
<td>male</td>
<td>deployer</td>
</tr>
<tr>
<td>[Int32]</td>
<td>very high</td>
<td>common project</td>
<td>computer sciences</td>
<td>HBO</td>
<td>male</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int33]</td>
<td>very high</td>
<td>web and mobile projects (SCRUM)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>programmer / application developer</td>
</tr>
<tr>
<td>[Int35]</td>
<td>very high</td>
<td>change from mainframe to agile</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>information analyst</td>
</tr>
<tr>
<td>[Int36]</td>
<td>very high</td>
<td>old legacy system</td>
<td>computer sciences</td>
<td>n.a.</td>
<td>male</td>
<td>program analyst</td>
</tr>
<tr>
<td>[Int37]</td>
<td>high</td>
<td>outsourcing</td>
<td>n.a.</td>
<td>n.a.</td>
<td>male</td>
<td>project manager</td>
</tr>
</tbody>
</table>

Table F.1. Background information of interviewees of the case study.