ABSTRACT
This paper describes an experiment on the influence of domain knowledge on the creation of context diagrams. The participants, 21 second year students of Business&IT at the University of Twente, received a text which did or did not contain domain knowledge and they had to create a context diagram from it. Unfortunately, the results show no difference in the completeness or correctness of the diagrams made by the two groups. This shows that domain knowledge has no influence, or the domain knowledge has to be given in another way.

Keywords
Context diagram, domain knowledge, requirements analysis, OMT, UML

1. INTRODUCTION
In these days people put a lot of effort in creating good and extensive specifications for information systems. An easy way to concretize the scope is to make a context diagram. A diagram in which the all parts of the system and the people using it or being close to the system are shown.

As mentioned, in this diagram the parts of the system and the people using it or being close to the system, but also the data flows and so the parts where an interface needs to be created are visualized. Besides that, the scope of the project will be shown by drawing a concrete line between the objects that will be part of the system and the parts that do not need to be taken into account. A context diagram is easy to read. Even when a person does not know how to program or does not have IT knowledge. Because of that, it is easier to make a context diagram to show to the people who will be using the system.

To create the diagram, knowledge of the organization seems to be necessary. We are wondering how much influence this domain knowledge has on the correctness and completeness of the created diagram.

Despite the fact that context diagrams are very useful, there has not been many research conducted on them. This might be

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because Context diagrams are not a part of the Unified Modelling Language (UML). The diagrams are a part of the Object Modelling Technique (OMT), and are not taken along to the UML dictionary, but this might have been a wrong choice at the time, because the alternatives for a context diagram in UML do not create an overview as can be provided with a context diagram. This makes it even more grounded to do research or conduct an experiment on the improvement and knowledge of context diagrams. In the experiment described in this paper, two groups of people will create a context diagram. One of the groups will have more domain knowledge than the other group. This will give us more insight to the impact of domain knowledge on creating a context diagram.

2. BACKGROUND
2.1 Context Diagram
When creating a complex information system, it is important to know what the scope of the project is. A lot of information is placed and explained using diagrams and text. Unfortunately there is rarely an overview available for all parts of the system and the people using it. This overview of the machine/program and the world around it could easily be created by using a context diagram. See Figure 1 where the world, the machine and the interface or information that is shared between the two are made visual.

Figure 1: Machine, World, Intersection
In a context diagram you draw everything that is related to the information system and the parts it exists of. Besides the subsystems, the people using it and the people close to using it are also in the diagram. Lines between the components will be placed to show where data flows take place. By placing circles around the components that belong to the system, there is a clear line for the scope of the project. See . [3]
The diagram can be seen as a low level representation of user cases, because a line between objects shows an action going on in the system. All the use cases are generalized to one data flow line. [2] Another important value the context diagram brings us is the knowledge of where there needs to be an interface for communicating with the system. All the data flow lines to people need a visual interface, but there also needs to be an interface for parts of the system to exchange data.
The diagram could be created by programmers, since they program the system which the diagram represents. But to create the diagram, knowledge of the system and the people using it, is necessary. The users of the system will know more of the organization and having this knowledge, they might build a better diagram.

2.2 History
Nowadays most people who have to set up requirements use the methodology technique UML. Before UML existed, there were three methodologies: One that focused mostly on design (Brooch), one that was stronger on analysis (OMT) and one that was good with user experience (Jacobson). In 1997, the new methodology was submitted, including the best parts of the three separate methodologies, named UML. [5] The context diagram was part of the OMT methodology and was not taken along to UML which might have been a wrong decision since in a new methodology from 2008: UML-B, the context diagram showed up again. [6] Explained as a diagram that seems like a class diagram, but with constant data and more associations.

2.3 Domain Knowledge
Domain knowledge gives us the opportunity to bridge the gap between the requirements and specifications. [8] It is a set of knowledge that needs to be added to the knowledge of requirements that already exists, to create the correct specification. The domain knowledge shows where the system should interact and where it stops and the people take over. This knowledge is not necessary to create a correct context diagram, but it might help and make it easier.

3. EXPERIMENTAL SETUP
3.1 Experiment definition
3.1.1 Research Questions
The goal of this experiment is to find out whether domain knowledge has much influence on creating a context diagram. Therefore, a group of students will create a context diagram whilst one part of the group has more domain knowledge than the other group. The first hypothesis we try to prove true by this experiment is:

“Requirements engineers with domain knowledge create context diagrams of a better quality than requirements engineers without domain knowledge.”

This quality will be measured by comparing to a perfect answer where all aspects are included. The extra domain knowledge gives the student more information about the organization where a system will be implemented. This information is not necessary to create the diagram, but it helps understanding the organization and the question is whether this makes it easier to create a context diagram. Hence the second hypothesis.

“Persons with domain knowledge experience that creating a context diagram is more easy than persons without domain knowledge.”

To test this hypothesis, we will measure how long the students take to create a diagram and they will fill in a survey after they made the context diagram in which they can fill in how they think they scored on the assignment of creating the diagram.

3.2 Planning
3.2.1 The assignment
The assignment [4] the participators will receive is a text about Netflix their record system and how they want to change this. Along with the text they will receive the instruction to create a context diagram. The basic text (without domain knowledge) has been written years before and it has been used in a few exams. This makes sure that the text is understandable and suitable for students on this level. It contains enough information to create a good context diagram as it has been used for that purpose before. The teacher of the course added domain knowledge to the text to make it suitable for the experiment.

3.2.2 The survey
After the participators are done with the assignment, they will receive a survey [4] to answer some questions about the experiment and about themselves. The supervisor on the experiment will first write the time the participant receives the survey, so the time he/she will take to create the diagram will be derivable. One question will ask whether the participant made context diagrams before and the others are about the feeling the participant has about the text, such as there was enough or too much information in it. The questions of the survey are shown in Appendix A.

3.2.3 Participators
The participators of the experiment will all be students of Business & IT at the University of Twente. The 21 students who participate are following a course on Requirements Engineering
in which they learn how to create a context diagram. They learn this together with other styles in formulating requirements. The participators are not aware of the specific nature of the experiment. They only know that the experiment is related to a topic they have learned about in the course. The students are not participating voluntarily, but as a part of the course they are taking. To make sure the participators will put enough effort in the experiment, they will receive a grade on the delivered diagram.

3.2.4 Variables
To determine the variables and threats we have used the methodology of Wohlin. [7] Wohlin describes various threats on an experiment and some ways to avoid these. The biggest threats will be explained in this section and a solution for the threat in this experiment is given.

3.2.4.1 Domain knowledge
The first variable is the domain knowledge the participators might already have on the subject. The subject of the text on which they have to make a context diagram is Netflix and the record system they use. Students who use Netflix, have used the system and therefore have some domain knowledge.

To make sure that this domain knowledge is taken into account on the experiment, we made the decision to include this variable in the creation of groups. To find out how much domain knowledge the participators have, they have to fill in a small starting survey[4] in which we ask whether they used Netflix and how much. The students with more Netflix experience are placed in the group with domain knowledge. When there are participators with equally much knowledge, they will be allocated to groups using a random number generator.

3.2.4.2 Knowledge on context diagrams
The current knowledge of a person about context diagrams can result in students creating a better diagram than others. To make sure this will not influence the results of the experiment, we will use their current knowledge and compare this to the results of the experiment. We will use the information on how they perform on the experiment compared to how they have previously performed on the course to make conclusions on the experiment.

The result of the score of a participator can be noted as:

\[
\text{Result} = A - (B + C)
\]

Where: A = score on experiment. B = average score on assignments in the Requirements Engineering class. C = Experience in context diagrams specifically.

The scores on A and B are grades received on a scale of 1 to 10. Variable C is a bit more difficult to set. The students worked on the assignments in teams, so we wouldn’t be sure how many context diagrams they have made themselves. We decided to subtract 2 points from the score on B if the participator has never made a context diagram before. When a participator has made only one diagram, we will subtract 1 point from the score and when a participator has created all diagrams alone or with his/her partner, nothing will be subtracted. Including the amount of created context diagrams with the grades on earlier assignments, gives a more realistic view on the pre knowledge of context diagrams.

3.2.4.3 Participators’ behavior
According to Wohlin, the emotional state of participators could have influence on the results. By this, we mean that some might be stressed or feel pressured to deliver a good result, while others are fairly relaxed. This is mainly solved by making the result count for every participator. On the assignment, they would receive a grade that was part of their final grade on the course they were following. Every participator should want to receive a good grade and try their best to create a good diagram. Another way the behavior of the students could be influenced is when they would have the feeling that they have to hurry. To reassure the participators, they will be told that they have two hours to complete the assignment. They are also told that they probably would not need this much time, so they should not have to hurry to finish the assignment and every person could create it at their own time.

3.2.4.4 Equal group treatment
Another variable that Wohlin claims to be important is the equal treatment of groups. Because both groups were in the same room during the experiment, most threats, like noise or different explanations of the exercises, were avoided. Before the experiment, the groups cannot be treated differently because the groups were made five minutes before the experiment took place. The participators might have thought that one group has more information and with that, a greater chance on a good grade. To avoid this thinking, we will mention to the participators that if there will be a difference between the grades of both groups, these will be balanced so nobody has a greater change on a high grade than others.

3.3 Conducting the experiment
Every student was supposed to be in the class on time to receive the small survey which divided them into two groups. When all 21 students arrived, and had filled in the survey, the group was easy to divide. 10 out of 21 filled in that they used Netflix sometimes (option B and C) or that they were regular users (option A). The other 11 filled in that they knew Netflix, but did not use it often (option D). See Error! Reference source not found.

Table 1: Knowledge of Netflix

<table>
<thead>
<tr>
<th>Answer</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: More than 5 hours a week</td>
<td>3</td>
</tr>
<tr>
<td>B: Weekly, but no more than 4 hours a week</td>
<td>6</td>
</tr>
<tr>
<td>C: A few hours a month</td>
<td>1</td>
</tr>
<tr>
<td>D: Never used it</td>
<td>11</td>
</tr>
<tr>
<td>E: Never heard of it</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
</tr>
</tbody>
</table>

The eleven participators who claimed never to have used Netflix, were placed in group A, who received the assignment without knowledge. The other ten participators were placed in group B. Because they already had domain knowledge which could add on the domain knowledge in the assignment.

After the experiment started, it appeared that some of the participators didn’t know what the term “context diagram” meant exactly. To ensure that that they wouldn’t make a different diagram, an example was written on the board. This example gave enough information to let the participators realize what diagram they had to create, but had nothing to do with the exact case. The students all realized what a context diagram was at that moment because they have made a diagram or seen a diagram like that before. The shown diagram on the board was more of a refreshment to the participators.

4. RESULTS
4.1 Processing the data
4.1.1 Pre-knowledge
After the experiment, a lot of raw data was available. [4] First thing to do was to adjust the data to something we could use. The score on the context diagram would be adjusted to the previous
knowledge of the participators. To do so, the score on homework-assignments of the participators was used. This gives an indication of the previous knowledge. The scores on the homework assignments are being adjusted to the specific experience in context diagrams because it is possible that students let their partners create the diagrams and they wouldn’t have any experience themselves. The distribution of this experience, as the participators have stated in the exit survey, is shown in Figure 3: experience in creating context diagrams.

![Figure 3: experience in creating context diagrams](image)

As explained in the planning section, 1 point would be added to participators who had created context diagrams before. The people who made just one diagram or who made it together, got no extra points and the participators who let their partners create the diagrams, would get one point less on their previous score. This creates the following averages and standard deviations on the groups. See Error! Reference source not found.

<table>
<thead>
<tr>
<th>without domain knowledge (Group A)</th>
<th>with domain knowledge (Group B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>previous</td>
<td>previous</td>
</tr>
<tr>
<td>mean</td>
<td>9,0</td>
</tr>
<tr>
<td>std.dev.</td>
<td>0,5</td>
</tr>
</tbody>
</table>

Looking at Figure 3 and Table 2, we see that the groups are almost of the same height in the last two options and the first two options both mean that the student worked on all diagrams. Based on the results from Table 2 we conclude that the previous experience in creating context diagrams has no influence on the results.

### 4.1.2 Score on experiment

The answers of the participators were compared to an answer model and graded. The participators were graded on the information they took from the text and whether they included the elements of a context diagram correctly. The more and better the elements are placed, the higher the grade received was. The scores on the pre-knowledge were subtracted from the score on the experiment. This gave an idea of the performance of the participators on the assignment. In table 3 the average scores of the students are shown in a table. A score of -1.4 means that the student scored 1.4 points lower on the experiment than on the average assignments before.

### Table 3: Score on assignment

<table>
<thead>
<tr>
<th></th>
<th>without domain knowledge (Group A)</th>
<th>with domain knowledge (Group B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>-1,4</td>
<td>-1,4</td>
</tr>
<tr>
<td>std.dev.</td>
<td>0,6</td>
<td>1,0</td>
</tr>
</tbody>
</table>

### 4.1.3 Time taken on experiment

When the participators were finished with the assignment and they received the survey, the instructor wrote down at which time the participant got the survey. The starting time was known too, so the time students took to create the diagram is known and shown in Table 4.

### Table 4: Time taken for exercise (minutes)

<table>
<thead>
<tr>
<th></th>
<th>without domain knowledge (Group A)</th>
<th>with domain knowledge (Group B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>46,3</td>
<td>45,5</td>
</tr>
<tr>
<td>std.dev.</td>
<td>9,1</td>
<td>4,8</td>
</tr>
</tbody>
</table>

Too see whether this time has any influence on the score; we placed these two factors in a scatter plot which is shown in Figure 4: Influence of time taken on grade. Unfortunately, there is no direct correlation visible and all points are in the same area.

![Figure 4: Influence of time taken on grade](image)

### 4.1.4 Participators’ experience on the experiment

In the survey the participators filled in after the experiment, they were asked about how they think the experiment went and whether they missed information. The exact questions are outlined in appendix A.

Only two participators stated that there was not enough information in the text of the experiment and both participators were from different groups. There were more participators in group A who were doubtful about whether they received enough information. However, the information they were missing was mostly about the difference between two systems described in the text. The versions with and without domain knowledge had both just as much information about this in the text and it was not taken into account when grading the diagrams, so this has not influenced the results.

A lot of participators stated that there was text which they did not use at all. This was mostly about the introduction for both groups. The group with domain knowledge noted that they did not use a paragraph which was added as extra information as domain knowledge. Not all students realized that this was not necessary to create the diagram, but eight out of ten did.

Then there is the grade the students expected to get for the experiment. From the 21 participators, two named that they would expect a 10 on the assignment. From the text they placed by the question, we can expect that they were not serious when filling in the answer, so we excluded these answers from our
results. We do not know whether the two participators who did not fill in the survey in a serious manner did this because they expected a low grade or that they really expected to receive a 10 (perfect score). The average on their real grades was lower than the average of all participators from group B. This gives us the following average expected grades. See Error! Reference source not found.. The grade had to be a number between 1 and 10 with 10 the highest possible and 5.5 a sufficient grade.

Table 5: Expected grade by participators

<table>
<thead>
<tr>
<th></th>
<th>without domain knowledge (Group A)</th>
<th>with domain knowledge (Group B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>6.4</td>
<td>6.7</td>
</tr>
<tr>
<td>std.dev.</td>
<td>0.67</td>
<td>0.63</td>
</tr>
</tbody>
</table>

5. DISCUSSION AND CONCLUSION

In this experiment we tried to find out how much influence domain knowledge has on creating a context diagram by letting participators create a context diagram whilst having or not having extra domain knowledge. Their answer would be compared to a answer model to compare the results correctly and afterwards they filled in a survey on their experience on the text and creating the model. With the previous described results, we come to the following conclusions.

5.1 Research questions.

The first hypothesis we tested is:

“Requirements engineers with domain knowledge create context diagrams of a better quality than requirements engineers without domain knowledge.”

With the knowledge we have from Table 3, we have to reject this hypothesis. The quality of the created context diagrams are equal for both the groups, so the level of domain knowledge of a Requirements Engineer does not seem to influence the quality of the created context diagrams.

There could be two reasons that the hypothesis has to be rejected. The first possible explanation is that the hypothesis was wrong and that there is simply no difference in results when a diagram is created with or without domain knowledge. The second possible reason is that the experiment is not valid. A likely reason for this is the wrong use of domain knowledge. The domain knowledge used in this research was a bit of previous experience with the system as a user and some extra knowledge in the text. The question is whether this extra knowledge in the text really counts as domain knowledge.

The second hypothesis is:

“Persons with domain knowledge experience that creating a context diagram is more easy than persons without domain knowledge.”

This hypothesis will be tested on two subjects, namely the time taken for participators and the grade the participators thought they would receive on the assignment.

Based on Table 4 we can see that the participators with domain knowledge were ready with the diagram almost just as fast as the participators who made the diagram without domain knowledge. There was a small difference, but this were clearly not significant.

The second way to answer the hypothesis is by looking at the grade the participators expected to receive on the experiment. As can be seen in Error! Reference source not found.. group B expected a higher grade on their assignment than group A. However, the mean is based on eleven responses from group A and only eight responses from group B. This, together with the small difference of 0.3 on a scale of 10 makes the result not significant.

These two aspects taken into account gives us no reason to confirm the hypothesis and therefore we have to reject it.

6. FUTURE WORK

The experiment could be performed another time whilst some changes in the setup are made. The most important change has to do with the domain knowledge of which we doubt whether it was sufficient in this experiment. You might perform the experiment once again whilst have given another form of domain knowledge to the participators. For example, let them work with the system as a user. Or by giving information beforehand and let the participators think about that for a week. More research on real domain knowledge is needed in any case of repeating this experiment with more participators.

7. ACKNOWLEDGEMENTS

I would like to thank Klaas Sikkel for his help in conducting the experiment and his feedback and support during the process. Also, I would like to thank Maya Daneva for giving the opportunity to conduct the experiment during her course.

8. REFERENCES


APPENDIX

A. Exit-Survey

In the exit survey, the following questions were asked:

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time finished with assignment:</td>
</tr>
<tr>
<td>Name (is used for grade, not for research):</td>
</tr>
<tr>
<td>Age:</td>
</tr>
<tr>
<td>Year that you started the studies BIT:</td>
</tr>
<tr>
<td>1. Did you have version A of B?</td>
</tr>
<tr>
<td>2. During the homework assignments, have you made Context Diagrams, or</td>
</tr>
<tr>
<td>did you leave this mostly to your partner?</td>
</tr>
<tr>
<td>3. Did the text provide you enough information for you to create the</td>
</tr>
<tr>
<td>diagram?</td>
</tr>
<tr>
<td>4. If not so: which information was missing</td>
</tr>
<tr>
<td>5. Were there large pieces of text within the text which you haven’t</td>
</tr>
<tr>
<td>used at all?</td>
</tr>
<tr>
<td>6. If so: which pieces?</td>
</tr>
<tr>
<td>7. What grade do you expect to receive for this assignment? (on a scale</td>
</tr>
<tr>
<td>of 1 to 10)</td>
</tr>
</tbody>
</table>

The first question was filled in by the instructor before the participants received the survey. The first questions are used for grading the assignment and are not used for the experiment. The numbered questions are used in the research.