Business Processes Dataflow Low-Code Solution: From Modeling to Execution
Evaluation

No Author Given

No Institute Given

1 Objectif

In this document, we will discuss the assessment results of our experiments. Section 2 presents the xDF-BPMN understandability experiment. Moreover, in section 3, we assess the usability of our solution. Lastly, in section 4, we will provide the LLM assessment of the Gherkin language.

2 xDF-BPMN Understandability Experimentation

In this section, we provide a more detailed explanation of the experimental planning and design underlying the empirical evaluation of the undestandability xDF-BPMN. In particular, we provide a summary of the main concepts explained during subject training, show the complete text of conducted exercises and related questionnaires, and describe the obtained raw results, their interpretation and the chosen correction methods.

The proposed two-phased experimental evaluation follows a survey approach, that is, it makes use of questionnaires to gather human attitudes, opinions, and impressions on the proposed modeling method. The phases of the experiment are detailed in Fig. 1.

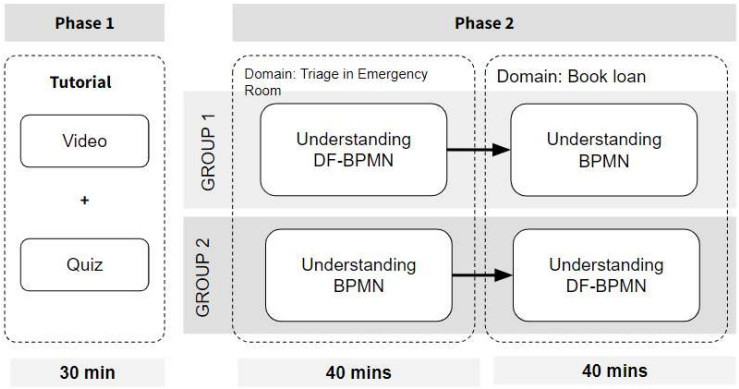

Fig. 1. Evaluation phases of the understandability of DF-BPMN

2.1 Phase1 - Tutorial

Phase 1 consisted of a 30-minute tutorial on xDF-BPMN, which included a 12-question quiz. Since all the participants had already taken a course on BPMN, we began by explaining the limitations of BPMN. We then illustrated how xDF-BPMN resolves these limitations, followed by an explanation on how to use the symbols of xDF-BPMN, supported by examples. Next, we conducted a quiz to ensure that the participants fully understood the symbols before moving on to Phase 2. All the quiz questions are illustrated below.

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Quiz

This quiz allows the evaluation of your understanding of DA-BPMN based on the video you just watched (before the exercices of the next steps).

* Indicates required question

1. Is BPMN restricted in its capacity to represent data? *

Mark only one oval.

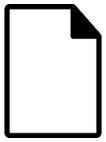
- ◯ Yes
- ◯ No

2. What kind of element can BPMN represent? *

Check all that apply.

- ☐ Data object
- ☐ Data store (database)
- ☐ Data from User
- ☐ Data from system

3. What data is represented by this icon? *



Mark only one oval.

- ◯ Data Object
- ◯ Data store (database)
- ◯ User Data
- ◯ System Data
- ◯ Other: _____

4. What data is represented by this icon? *

Mark only one oval.

- ◯ Data Object
- ◯ Data store (database)
- ◯ User Data
- ◯ System Data
- ◯ Other: _____

5. Is BPMN allowing the interaction of different data types? *

Mark only one oval.

- ◯ Yes
- ◯ No

DA-BPMN quiz

6. What is DA-BPMN? *

Check all that apply.

- ☐ Extention of BPMN
- ☐ graphical representation
- ☐ tabular representation

7. What kind of element can DA-BPMN represent? *

Check all that apply.

- ☐ Data object
- ☐ Data store (database)
- ☐ Data from User
- ☐ Data from system

8. What does this shape represent? *

Mark only one oval.

- ◯ Input
- ◯ Output

9. What is the type of this shape? *

Mark only one oval.

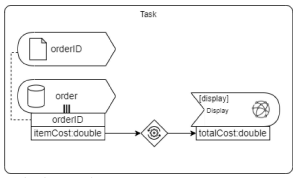
- ◯ Data object
- ◯ Data store (database)
- ◯ User data
- ◯ System data

10. What does this shape represent? *

Mark only one oval.

- ◯ Input data store (database)
- ◯ Input user data
- ◯ Output data store (database)
- ◯ Output system data

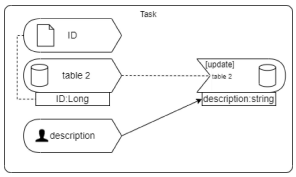
11. What is the name of the data class that was read from the database? *



Mark only one oval.

- orderID
- order
- display

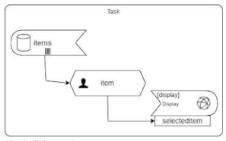
12. What's the type (equivalence or assignment) interaction between: *



Mark only one oval per row.

	equivalance	assigne the value of the first [What, input?] into the second [WHAT, attribute]
[The "description" user's input] and [The "description" attribute of table 2 in the DA-BPMN data store output element]		
[The "ID" data object input] and [The "ID" attribute of the input table 2 in the DA-BPMN data store output element]		
[The "table2" DA-BPMN data store input] and [The "table2" DA-BPMN data store output]		

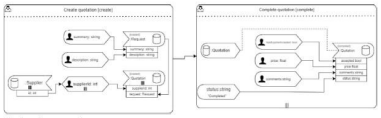
13. What is "items" in the following DA-BPMN input? *



Check all that apply.

- [ ] One instance object
- [ ] Multi-inctance object
- [ ] Data object input
- [ ] Data store input

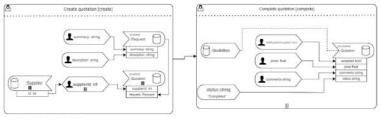
14. Which data class is used as **read-only** in this model? *



Mark only one oval.

- Supplier
- Request
- Quotation

15. Which activity updates the data class "Quotation"? *



Mark only one oval.

- Create quotation
- Complete quotation

2.2 Phase2 - Understanding of xDF-BPMN

Phase 2 was designed to evaluate xDF-BPMN and consisted of two subjects (see Fig. 1), with an overall duration of around 80 minutes. Each subject was provided with two exercises, both involving a textual description of a business process, its data access to

a database, the BPMN process model, and the UML Class Diagram of the accessed domain database.

However, for each subject, one group was also provided with the xDF-BPMN replacing BPMN, while the other group was asked to solve the same exercise without xDF-BPMN. The experimental design ensured that the same subjects solved the exercises both with and without xDF-BPMN. This setup required a paired t-test accounting for both the systematic variability between groups and variability between subjects [1].

Furthermore, the group provided with xDF-BPMN had two runs: the first involved only the process model (xDF-BPMN), and the second included all the other information. This affected the execution time of the second run.

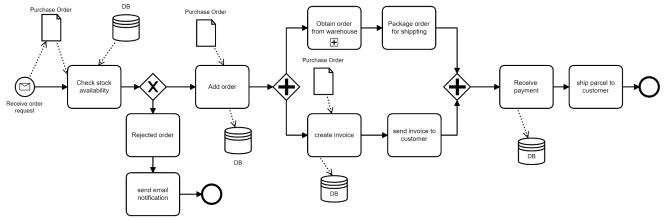
Our primary goal was to evaluate whether and to what extent (i) subjects provided with the xDF-BPMN could answer the questions more quickly, (ii) the accuracy of the answers improved with the help of xDF-BPMN, and (iii) textual descriptions were necessary when using xDF-BPMN. The second aspect strongly correlates with the understandability of the proposed model, as the subjects must thoroughly comprehend xDF-BPMN to use it correctly.

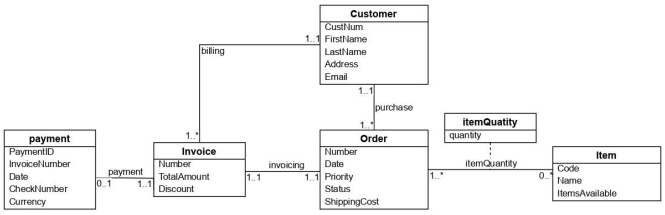
The texts and questionnaires of the two subjects from Phase 2 are reported below. We have replaced the open-ended questions with multiple-choice questions to facilitate our survey.

Exercise 1 - Shipping order from website

The process describes a purchase order on a web-site.
A new process instance is created when an order request is received from a customer. The order request contains information about the customer, the order and the ordered items. We assume that all the customers are already registered and their information saved in the database. Then, an employee checks the availability of the order items from the warehouse database. If these items are not available, the customer receives an email that her or his order is rejected. Otherwise, the order is automatically added to the database. An order contains a preamble of general information, such as its number, priority, and shipping costs, but it also contains the list of items and the related quantity. Afterwards the ordered items are obtained from the warehouse and are boxed for shipment. While obtaining the items and boxing them, an invoice is created and, then, it is sent to the customer. When invoice creation begins, the order number and the number of the purchasing customer must be checked and, then, the new invoice is created and added to the database. Then, the process waits for the payment to be received. The operator that receives the proof of payment must record it in the database, prior to updating the status of the order to "Ready". Then, the parcel is shipped to the customer.

The process ends when the order is fulfilled. The BPMN diagram and the UML class diagram corresponding to the description above are provided below.





Questions:

Correct answers have been reported in between parentheses in blue, for completeness purposes

Start time:_____ (hh:mm)

1. Is there a data class that has access to the activity "Check stock availability"? Which ones, if any?
_____(Item)

2. Is there a data class that has access to the activity "Add order"? Which ones, if any?
_____ (Order, ItemQuantity)

4. Are there activities that have updated the data class “ItemQuantity”? If so, which ones?
_____(Add order)

5. Which data classes are most frequently utilized by activities?
_____(Order)

6. Which are the activities that take input from the user?
_____(Receive payment, Create invoice, Add order)

7. Are there activities that are connected to external resources? if so, which ones?
_____(Send email)

8. Are there any user operations on the activity “Create invoice”? if so, what are?
_____(discount)

9. Does the user make a decision based on data selected from the database? if so, in which activity it does?
_____(None)

10. After the “receive payment” has been done, could you specify the status of the order? if so, what is it?
_____(Ready)

11. Is there any relation between the data object “Purchase Order” and data store “DB” in the activity “Check stock availability”? If so, detail it?
_____(items = code)

12. Are there activities that access the same data classes multiple times? If so, which data classes?
_____(ItemQuantity, Item)

13. Are there classes that are used only for read operations? If so, which ones?
_____(YES. Item)

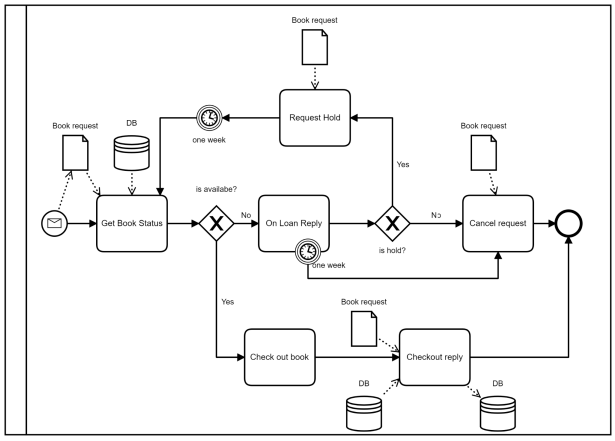
End time:_____ (hh:mm)

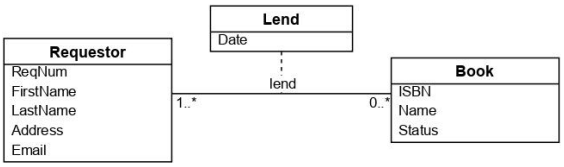
Total time:_____ (in minutes)

Exercise 2 - Book Lending

The process describes book lending.
A new process instance is created when a book request is received from a requestor. The book request contains all the information of the book and the requestor. We assume that all the customers and the book information are already registered and their information saved in the database. Then, a service checks the availability of the book. If the book is available the requestor checks the book and then receives an email and updates the status of the book to "Loan" in the database. Otherwise, the requestor decides if he or she needs to hold or cancel her or his request, with a maximum of one week to automatically cancel the request. In two cases, he or she receives an email notification to approve their decision. Then, if the requestor requests a hold, after one week the process to check the availability of the book is repeated.

The process ends when the order is fulfilled. The BPMN diagram and the UML class diagram corresponding to the description above are provided below.





Questions:

Correct answers have been reported in between parentheses in blue, for completeness purposes

Start time:_____ (hh:mm)

1.Is there a data class that has access to the activity "Get book status"? Which ones, if any?
_____(Book)

2. Is there a data class that has access to the activity "One load ready"? Which ones, if any?
_____ (None)

3.Are there activities that have updated the data class "Book"? If so, which ones?
_____(Checkout reply)

4. Which data classes are most frequently utilized by activities?
_____(Book)

5. Which are the activities that take input from the user?
_____(On Loan Reply)

6. Are there activities that are connected to external resources? if so, which ones?
_____(Checkout reply, Cancel request, Request hold)

7. Are there any user operations on the activity “On Loan Reply”? if so, what are?
_____(hold)

8. Does the user make a decision based on data selected from the database? if so, in which activity it does?
_____(None)

9. After the “Checkout reply” has been done, could you specify the status of the book? if so, what is it?
_____(Loan)

10. Is there any relation between the data object “Book request” and data store “DB” in the activity “Check stock availability”? If so, detail it?
_____(ISBN of book request = ISBN of book table from DB)

11. Are there activities that access the same data classes multiple times? If so, which data classes?
_____(None)

12. Are there classes that are used only for read operations? If so, which ones?
_____(No)

End time:_____ (hh:mm)

Total time:_____ (in minutes)

Raw Results. The exercises were evaluated using the most restrictive criteria for correctness, meaning they were considered correct only if the answers were both accurate and complete. Each question was worth one point. However, we deducted 0.5 point for each extra selected response or for each missing response.

The detailed results are shown in Fig. 2. The numbers within the tables represent the answers to the questions in each exercise for each subject. In both subjects, xDF-BPMN outperforms BPMN in terms of correct answers.

Subject 1

BPMN

Note	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	%
1	17	3	6	23	2	9	8	6	23	10	4	2	23
0.5	9	28	6	2	11	6	6	0	0	0	2	8	16
0	15	10	29	16	28	26	27	35	18	31	35	31	61

DF-BPMN without text

Note	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	%
1	51	44	57	58	49	36	58	51	47	50	33	39	74
0.5	10	10	1	1	3	1	0	0	0	0	5	4	5
0	0	7	3	2	9	24	5	20	14	11	56	18	22

DF-BPMN with text

Note	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	%
1	49	43	55	53	45	35	42	37	46	47	34	35	67
0.5	9	11	0	3	4	1	0	0	0	0	7	7	5
0	3	7	6	5	12	25	16	24	15	14	20	19	21

Subject 2

BPMN

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	%
25	12	22	22	1	0	6	6	18	18	5	4	41
2	0	0	1	0	5	0	0	0	0	0	0	2
1	16	6	5	27	23	22	22	10	10	23	24	56

DF-BPMN without text

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	%
50	42	44	50	44	33	50	35	47	44	35	28	79
3	0	2	3	0	6	0	0	0	0	0	0	2
0	11	7	0	9	14	3	18	6	9	18	25	19

DF-BPMN with text

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	%
48	45	45	48	44	36	51	33	48	41	39	16	78
5	0	2	0	0	4	0	0	0	0	0	0	2
0	8	6	5	9	13	2	20	5	12	14	37	21

Fig. 2. Result of our experimentation

3 xDF-BPMN Usability Experimentation

In this section, we provide a more detailed explanation of the experimental planning and design underlying the empirical evaluation of the usability of xDF-BPMN. In particular, similar to the evalutation of the undestandability we conducted human evaluation by providing a summary of the main concepts explained during subject training, show the complete text of conducted exercises and ask the participant to model and implement the exercice, and describe the obtained raw results, their interpretation and the chosen correction methods.

The phases of the experiment are detailed in Fig. 3.

3.1 Phase1 - Tutorial

Phase 1 consisted of a 60-minute tutorial on xDF-BPMN, which included a 12-question quiz (same question of the first evaluation). Since all the participants had basic knowloadge of BPMN, we began by explaining the BPMN and their limitations. We then illustrated how xDF-BPMN resolves these limitations, followed by an explanation on how to use the symbols of xDF-BPMN, supported by examples. Next, we explain how to use Bonita, and how to use xDF-BPMN tool. Then a video contain a demo of each tool to help the participant to well understand these tools. Next, we conducted a quiz to ensure

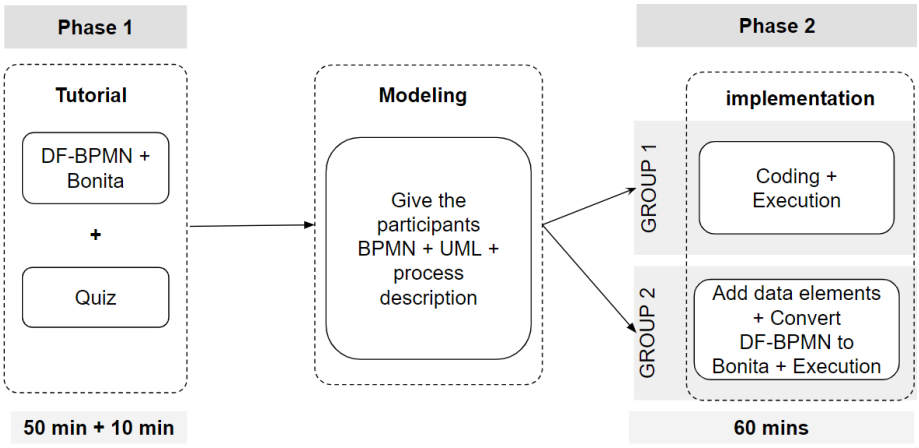


Fig. 3. Evaluation phases of the usability of DF-BPMN

that the participants fully understood the symbols before moving on to Phase 2. All the quiz questions are illustrated in section 2.

3.2 Phase2 - Usability of xDF-BPMN

Phase 2 was designed to evaluate the usability of xDF-BPMN and consisted of one subject (see Fig. 3), with an minimum duration of around 60 minutes. This subject was provided with an exercise, involving a textual description of a business process, its data access to a database, the BPMN process model, and the UML Class Diagram of the accessed domain database.

While we acknowledge that only four participants may not be sufficient for an in-depth quantitative analyze, this initial phase is critical in verifying our approach before doing additional investigations with a larger participant pool.

This phase involved two groups: one group utilized the xDF-BPMN tool for modeling, automatically converted for execution within Bonita, while the other group implemented the model directly within Bonita. The primary goal was to compare the modeling and implementation time between xDF-BPMN and the Bonita ecosystem, with time measurements taken during different phases (modeling/implementation). The exercise included textual descriptions of the model, BPMN, and UML class diagram.

Exercise - HR Salary Calculation

The process describes a HR salary calculation.
The HR salary calculation process is initiated upon receiving a request to calculate an employee's salary. The process begins when the HR member (referred to as the "user" in the remainder of this description) decides if he/she needs to add a new employee or not. If the user is tasked with adding new employees to the system, they are required to input the following personal information for each new employee (Full name, Monthly work hours, Base salary) and then store this information in the database. In cases where new employees are not being added, the user selects an existing employee stored from the HR database for salary calculation. After selecting an employee, the user collects the following information: work hours, deduction, bonus. Then, the Gross salary calculation begins, which includes the following steps:

- Calculate overtime hours as (monthly work hours) - (work hours).
- Calculate overtime pay using the formula:
  - Overtime Pay = (Overtime Hours) * (Overtime Rate)
- Overtime Rate = (Base Salary) / (Work Hours)
- If the employee works more than 10 hours overtime, calculate the overtime rate * 1.5.
- Calculate the gross salary as follows:
  - Gross Salary = Base Salary + Bonus + Overtime Pay

Then, the deductions will be automatically calculated, which is the sum of tax, and 35 euro insurance, and the deduction collected during employee information collection. Moreover, determine the tax rate based on the employee's monthly base salary. Tax rates are as follows:

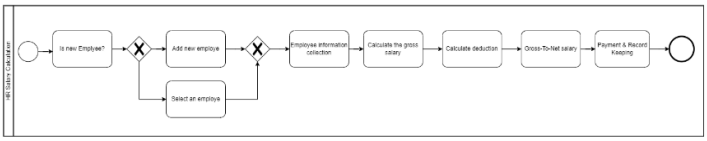
- No tax for annual incomes up to 10,722.
- 11% tax for annual incomes ranging from 10,722 to 27,478.
- 30% tax for annual incomes ranging from 27,478 to 78,570.
- 41% tax for annual incomes ranging from 78,570 to 168,994.
- 45% tax for annual incomes exceeding 168,994.

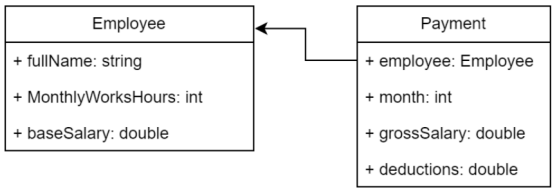
Followed, Calculate the net salary using the formula:

- Net Salary = Gross Salary - Total Deductions

Finally, HR initiates the payment to the employee based on the net salary calculated, and records the gross salary and deductions in the HR database for future reference and reporting.

The process ends when the order is fulfilled. The BPMN diagram and the UML class diagram corresponding to the description above are provided below.





Then we ask each group to start by creating the BDM within Bonita, followed by modeling, followed by implementation, and we ask the participants to add the time for each step.

4 LLM Experimentation

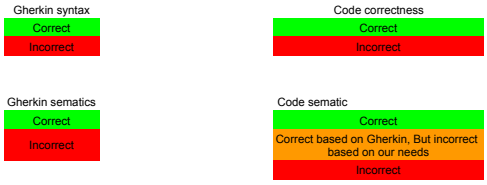
4.1 Prompt Engineering

Prompt engineering refers to the systematic practice of constructing prompts to improve the generated output of a generative model. In our github, you can find the templates for the prompts employed in our methodology. Two templates are designed to generate Gherkin language and validate the syntax in conjunction with the input and output of the data processing operator. Conversely, two other templates are employed to create Groovy script and verify the variable names within the Groovy script, aligning them with the input and output.

4.2 Evaluation LLM

This section outlines the methods employed to evaluate LLM within the described scenarios. We used few-shot learning to generate a specific format of output, enabling the execution of xDF-BPMN without any modification of the code.

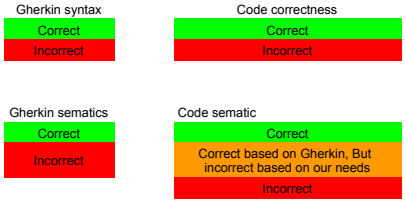
The results of GPT 3.5 turbo



25 scenarios => 5 scenarios each with 5 variations

	Text to Gherkin			Gherkin to code			
scenario	correctness	semantic	time	correctness	semantic	comments	time
1.1	1	1	15	1	1		7
1.2	1	1	16	1	1		8
1.3	1	1	17	1	1		6
1.4	1	1	14	1	1		7
1.5	1	1	15	1	1		6
2.1	1	1	6	1	1		5
2.2	1	1	7	1	0	add data example, error in the sematic	10
2.3	1	1	6	1	1		5
2.4	1	1	9	1	0	add data example, error in the sematic	13
2.5	1	1	8	1	0	add data example, error in the sematic	8
3.1	1	1	16	1	1		7
3.2	1	1	15	1	1		7
3.3	1	1	10	1	1		7
3.4	1	1	20	1	1		3
3.5	1	1	9	1	1		6
4.1	1	1	12	0	1	not call function to execut it directly	13
4.2	1	1	12	1	0		10
4.3	1	1	12	1	0		10
4.4	1	1	15	1	0		10
4.5	1	1	11	1	1		10
5.1	1	0	13	1	0		13
5.2	1	1	13	0	1	not call function to execut it directly	14
5.3	1	1	13	0	0		11
5.4	1	1	11	1	1		12
5.5	1	0	16	0	0		13

The results of GPT 4



25 scenarios => 5 scenarios each with 5 variations

	Text to Gherkin				Gherkin to code		
scenario	correctness	semantic	comments	time	correctness	semantic	time
1.1	1	1		15	1	1	10
1.2	1	1		14	1	1	10
1.3	1	1		14	1	1	8
1.4	1	1		11	1	1	8
1.5	1	1		12	1	1	8
2.1	1	1		6	1	1	6
2.2	1	1		8	1	1	6
2.3	1	1		6	1	1	7
2.4	1	1		9	1	1	6
2.5	1	1		8	1	1	4
3.1	1	1		15	1	1	7
3.2	1	1		14	1	1	7
3.3	1	1		8	1	1	7
3.4	1	1		17	1	1	6
3.5	1	1		17	1	1	7
4.1	1	1		13	1	1	10
4.2	1	1		10	1	1	9
4.3	1	1		14	1	1	13
4.4	1	1		13	1	1	10
4.5	1	1		12	1	1	9
5.1	1	0	error in understand our needs	13	1	0	15
5.2	1	0	it does not contain all the information	12	1	0	13
5.3	1	1		12	1	1	14
5.4	1	1		15	1	1	13
5.5	1	0	error in understand our needs	14	1	0	15

References

1. Motulsky, H.: Intuitive biostatistics: a nonmathematical guide to statistical thinking. Oxford University Press, USA (2014)