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Practical Study on Software Requirements Specification and Modelling Techniques

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ABSTRACT The quality of specified and modeled requirements is critical for IT project success. A significant number of specialized techniques are used for documenting the requirements. The selection of the appropriate technique considerably influences a project plan and the success of a change as a whole. This paper aims to examine practitioners' industrial standards and experience in the requirements specification activities and identify factors influencing the choice of specific techniques. To get the data from business analysis practitioners, we carried out a survey involving 328 specialists from Ukrainian IT companies and a series of interviews with experts. A list of specification and modelling techniques is selected based on international standards and bodies of knowledge. Project context and participants' background influence on the probability of particular technique selection are analyzed. A set of dependencies are identified using the Chi-Square test for association and Cramer's V. Results can be used as guidelines for building a framework for business analysis techniques selection in IT projects.

KEYWORDS Software Requirements Engineering; Requirements Specification and Modelling Techniques; Project Factors; Chi-Square Test; Cramer's V.

I. INTRODUCTION

According to the Project Management Institute (PMI) definition in [1], Business analysis is a set of tasks and techniques used to engage stakeholders to understand the structure, policies, and activities of an organization and make decisions that enable an organization to achieve its goals. Business analysis-related activities could be organized into six areas: Business Analysis Planning, Elicitation, Requirements Life Cycle Management, Strategy Analysis, Requirements Analysis and Design Definition (RADD), and Solution Evaluation, where RADD are the main activities that support the delivery phase of the project as stated by Gobov et al. in [2]. The quality of specified and modelled requirements is stressed as critical for project success by Emam and Birk [3], Sanchez and Terlizzi [4]. Business analyst defines the set of techniques as a part of a business analysis approach. Choosing the proper techniques and ensuring each technique is used correctly according to the project context is extremely important to the project's success and RADD in particular. The best practices and recommendations regarding specification and modelling techniques were defined in international standards by the International Institute of Business Analysis (IIBA), ISO/IEC/IEEE. Among other analyzed problems are the following ones: systems and software engineering [5], industrial bodies of knowledge, e.g., PMI [1], BABOK [6], and books describing requirements engineering fundamentals, principles, and techniques like in Pohl [7] or Paul et al. [8].

Sources mentioned above give a wide range of techniques that a business analyst may utilize. Each of them has its advantages and limitations. Usually, multiple techniques are used for requirements analysis in software projects. A decision about the set of techniques depends on time and cost constraints, the business analyst's experience, stakeholders' preferences, selected SDLC, and other project context elements [9].

This study is conducted to analyze the current preferences of business analysts and requirement engineers regarding requirements specification and modelling for software development projects. We wish to test the hypothesis that project context and specialist's experience and the techniques used influence the probability of choosing a particular technique. Our approach involves studying the experience of specialists from Ukrainian and international companies with branches in Ukraine who are engaged in the analysis of requirements for IT projects. The primary research method is a survey and statistical analysis. The paper is the extension and continuation of paper [10] originally presented at the International Conference on Computer Science, Engineering and Education Applications in 2022. Research findings have been expanded by the results of the "technique-technique" pair analysis and more detailed statistical analysis. The association nature interpretation is performed for statistically significant dependencies based on the Standardized Pearson Residual values. The Chi-Square-based measure of the effect size – Cramer's V – is used to define the strength of the found associations.

The paper is structured as follows. Section 2 contains a review of the related works on requirement specification and modelling activities and survey studies regarding requirement engineering and business analysis. Additionally, we provide background information on requirements specification and modelling techniques collected from industrial bodies of knowledge and study materials prepared by leading international organizations in the business analysis area. Section 3 contains the survey results and dependencies identified based on the statistical analysis of the received data. Section 4 concludes the paper with a discussion of the findings of our study and future work.

II. RELATED WORKS

Most related works are dedicated to analyzing requirements specification and modelling techniques, their applications, and techniques selection approaches. Soares and Cioquetta [11] studied eight user requirement documenting techniques and assessed them based on the proposed characteristics (Human readable, Independent towards methodology, Identify and represent types of requirements, etc.). The evaluation source was a literature review, a series of interviews, and action research on two companies. Jiang et al. [12] developed an approach for assessing a technique's potential based on project characteristics and business rules. The research thoroughly investigated the advantages and disadvantages of different requirement engineering techniques, not only for specification and modelling, and their applicability in practice. The analyzed techniques in this research contained methodologies like Extreme Programming or Object-Oriented Analysis that are not techniques in the modern understanding of this word. Jarzębowicz and Połocka [13] surveyed 42 Polish IT industry specialists, asking them to select techniques applicable to different projects. Each survey participant was allowed to choose any number of techniques from the list of 15 techniques they considered applicable in a given context. The number of respondents did not allow for evaluation of the results statistical significance. In addition, survey participants shared their preferences but not current practices. Perkusich et al. [14], and Ochodek and Kopczyńska [15] studies were focused on analyzing modern requirements specification techniques such as User Stories and other agile-oriented methods. Armal et al. [16] surveyed 251 software engineering researchers, asking them about the notations they had used. Use Case, Class Diagram, and User Stories were defined as preferred notations. However, Use Case and User story are not a notation but requirements specification techniques. Ali, Rafiq, and Majeed studied requirement modelling techniques used in small and medium companies in Pakistan [17] and confirmed that Use Case, Data Flow Diagram, and Class Diagram were widely used for requirement elicitation and analysis. Vega-Márquez et al. [18] and Ivanchikj et al. [19] reviewed the usage of modelling techniques like BPMN or DMN.

The main limitations of the above mentioned researches are:

- the set of the analyzed techniques was not synchronized with the modern understanding of usable requirement specification techniques according to the recommendations of specialized institutions and organizations (International Institute of Business Analysis, Project Management Institute, Requirement Engineering Board, British Computer Society);
- dependencies between project context and choosing a particular technique were not analyzed with the use of statistical methods;
- dependencies between techniques were not analysed with the use of statistical methods.

Survey preparation involved three steps:

- analysis of practical guidelines and bodies of knowledge to define a long list of requirement specification and modelling techniques;
- analysis of IT industry trend reports to define attributes that characterize the context of software projects;
- preliminary interviews with five business analysts from Ukrainian IT companies to check a list of techniques and project characteristics.

The specification and modelling techniques long list was created based on the techniques from different sources (see Table 1), namely PMI [1], IIBA [6], Pohl [7], and Paul [8].

Table 1. Requirement specification and modelling techniques in main industrial guidelines

Technique name	IIBA	PMI	BCS	IREB
Acceptance and evaluation criteria	+	+	+	-
Activity diagrams	+ (Process modelling)	+ (Process model)	+	+
Business model canvas	+	-	-	-
Business process models	+	+ (Process flow)	+	+
Class/Entity relationship diagrams	+ (Data modelling)	+	+	+
Data dictionary	+	+	-	-
Data flow diagrams	+	+	+	+
Goal models	-	+	-	+
Prototypes	+	+	+	+
Natural language / informal (plain) text	+	+	+	+
Roles and permissions matrix	+	-	+	-
Sequence diagrams	+	+ (Process model)	-	+
State machines	+ (State modelling)	+	+	+
Functional decomposition	+	+	+	+
Use cases	+	+	+	+
Use case diagrams	+ (Use cases and scenarios)	+	+	+
User stories	+	+	+	-

III. SURVEY

A. QUESTIONNAIRE OVERVIEW

The authors developed a questionnaire to analyze specifics of Ukrainian IT companies. The target respondents were IT specialists from Ukraine, mainly business analysts and other roles involved in business analysis or requirements engineering activities. Overall, 328 participants took part in the survey. Details were described by Gobov and Huchenko in [20], with a focus on the Elicitation and Collaboration topic. This article briefly describes the questionnaire design and concentrates on its Analysis and Design section.

The questionnaire basis was taken from the NaPIRE initiative described in detail by Fernandez and Wagner [21, 22] and reworked considering sources from Section 2. Related works. 43 questions were divided into the following categories:

- Q1: General Information
- Q2: Requirements Elicitation and Collaboration
- Q3: Requirements Analysis and Design
- Q4: Requirements Verification and Validation
- Q5: Requirements Management
- Q6: Attitude to Business Analysis in the project
- Q7: Problems, Causes, and Effects

Q1: General Information. Q1 covers the project context and participants' background, which are crucial for analyzing the results obtained for other questionnaire sections. Questions in this section were intended to give the context, such as:

- Project size.
- The industrial sector of the current project. The draft set of industrial sectors was taken from the study by Jarzębowicz and Połocka [13] and reworked to domain areas within which most Ukrainian IT Companies offered services.
- Company type: IT or non-IT. The separation was made among Outstaffing, Outsourcing, and Product companies for IT companies.
- Company size.
- Class of systems or services such as business, embedded, scientific software, etc.
- Team distribution (co-located or dispersed).
- Role in the Project.
- Business analyst (BA)/requirements engineer (RE) activity.
- Certifications.
- Way of working on the project (adaptive vs. predictive).
- Project category for most of the participant's projects (e.g., greenfield engineering).
- BA/RE activities, which the respondent is usually involved in.

Q2: Requirements Elicitation and Collaboration. This section was described in [20]. We are interested in elicitation sources, techniques, and project roles within the given questions category, which has primary responsibility for the solution requirements (functional, non-functional requirements) elicitation on the respondent's ongoing project.

Q3: Requirements Analysis and Design. Questions and answer options included in this section are listed in Table 2. We used the following abbreviations for the question types: SC – single-choice, MC – multiple-choice, OE – open-ended, LS – Likert scale.

Table 2. Requirements Analysis, Design: Questions and answer options

#	Question	Answer options	Quest. type
1	How do you use documented requirements?	• As a basis for implementation • As a source for tests • They are used in customer acceptance • They are part of a contract • As a reminder for further discussions with stakeholders	MC
2	Which information do you usually put as a separate section/subsection in your documents (could be different documents)?	• Assumptions • Background (rationale) • Business requirements • Business rules • Constraints • Cost-benefit analysis • Data models • Dependencies/Integrations • Deployment specifics • Functional requirements • Glossary • Goals & Objectives • Non-functional requirements • Open questions • Problem statement • Risks • Stakeholder analysis • Success metrics • Technical interfaces • Usage scenarios • User interfaces • Other	MC
3	Which requirements specification and modelling techniques do you use?	• Acceptance and Evaluation Criteria • Activity diagrams • Business model canvas • Business process models • Class/ER diagrams • Data dictionary • Data flow diagrams • Goal models • High-fidelity prototypes • Low-fidelity prototypes • Natural language/plain text • Roles and permissions matrix • Sequence diagrams • State machines • Functional decomposition • Use Cases • Use Case diagrams • User journey map/User flow diagrams • User Stories • Other	MC
4	Do you use templates for requirements specifications?	• Company templates based on best practices • Standards • We do not use templates • Own, customized for the project • Other	SC
5	Which class of non-functional requirements do you explicitly consider in your requirements documentation?	• Compatibility • Maintainability • Performance efficiency • Portability • Regulatory compliance • Reliability • Safety • Security • Usability • We do not specify NFRs • Other	MC

The list of techniques defined in Table 1 was updated based on the feedback received from business analysis experts from Ukrainian IT industry leaders during the survey validation procedure in the following way: technique "Prototyping" was divided into "High-fidelity prototypes" and "Low-fidelity prototypes."; technique "User journey map/User flow diagrams" was added.

B. DATA CLEANSING

The first results of the Q1 section analysis (project factors and participants' background) were described by Gobov and Huchenko in [20]. For the given article, some additional data cleansing actions were done to further possible usage of the log-linear analysis for multiple associations identification and Chi-square analysis for pairs of categorical variables based on the recommendations of Camilli and Hopkins [23].

Firstly, records with zero experience as a business analyst (BA) and a few with the "I don't know" answer about team distribution were removed. Those were the outliers. The number of records for further analysis was decreased to 324.

Secondly, some answer options were merged to have the expected count for variables combinations of more than 5, namely:

- Experience value "Up to 1 year" was merged with "1-3 years" and resulted in "Up to 3 years".
- Ways of working were split into three groups instead of 5: agile, hybrid, and plan-driven.
- Company sizes were merged to get three groups instead of 5: up to 200 members, 201- 1500, and over 1500 members.
- Outsourcing and Outstaffing were merged into one answer option for Company type questions.
- Survey results allowed us to make the following conclusions:
- Business analysis has become a popular job in Ukrainian IT companies. 35,6% of specialists have experience of up to 3 years.
- Agile methodologies are used in almost 60% of projects.
- Over half of the respondents work for big companies with over 1,500 specialists.
- Only one-third of respondents work in IT Product and in-house development companies, and others are employed in outsourcing/outstaffing companies.

C. SURVEY RESULTS

Participant's background. Questionnaire answers analysis allows us to make the following observations about the typical environment for the Ukrainian business analyst in terms of company, team, project role and type, experience, etc.:

- 41% of respondents work in project groups of up to 15 members, and less than 13% participate in projects with over 100 people.
- 49% of the survey participants are employed in IT outsourcing companies while IT outstaff, product, and inhouse development are represented in almost the same amount within left 51% of respondents.
- About 59% of respondents are specialists with experience of up to 5 years.
- Predictive/rather predictive methodologies (e.g., RUP, Waterfall) are used in less than 15% of the projects.
- Most of the participants have a Business Analyst role on the project. However, quite often, this role is combined with product ownership.
- The TOP 3 popular industry sectors are Finance/Banking, e-Commerce/Retail, and Healthcare/Pharmaceuticals. A variety of domains is represented in Fig. 1.
- Only 13% of respondents have certifications, and 5% have more than one certificate.

Requirements Analysis and Design: simple statistics. We summarized the preferences of Ukrainian business analysts for the questions mentioned in Table 2. Note that the total number of respondents after data cleansing is 324. Multiple choices were possible for some questions.

- 18,9% of respondents use requirements documentation as part of the contract. In 53,25% of cases, documentation is considered during customer acceptance.
- The information types included in the documents are cost-benefit analysis – 7,74%, deployment specifics – 13%, and success metrics – 14,86%. The problem statement is considered by 31,27% of respondents, stakeholder analysis – only by 22%, and technical interfaces – by 24,77%.
- The following specification and modelling techniques are rarely used: goal models – 1,24%, business model canvas – 12,38%, and data dictionary – 23,22%. The most popular techniques are User Stories – 79,26%, Use Cases – 65,63%, and Activity diagrams – 63,16% (see Fig. 2).
- As for template usage, 50,15% of respondents use company templates, 4,64% – standards, 8,36% – own templates, and 36,84% answered that they do not use templates at all.
- Regarding the types of NFRs specified in the document, the following results were obtained: 9,29% of respondents do not specify NFRs at all; portability is considered by 14,55%; safety – by 17,03%. The most popular NFRs are usability – mentioned by 64,07%, security – 60,06%, and performance efficiency – 57,28%.

The datasets generated and analyzed during the current study are available from the authors at a reasonable request.

Check for associations. Hierarchical log-linear model selection. Gobov and Huchenko [20] described applying the Chi-Square test of independence for checking the associations for each pair of the "elicitation technique – background factor". This article concentrates on specification and modelling techniques, namely: "technique – background factor" and "technique – technique" associations analysis. Other questions from Table 2 are out of this paper's scope.

The log-linear analysis is usually employed when dealing with three or more categorical variables instead of two variables, whereas a chi-square test for an association is usually conducted instead. It allows us to check the associations between different combinations of variables. For study purposes, data were transformed so that every Participant ID usage of the particular specification/modelling technique was set to "1" if the technique was selected and "0" if it was not, i.e., the observations were classified into mutually exclusive classes. Thus, the first assumption for the log-linear analysis is confirmed – we have categorical variables with two levels (also known as dichotomous variables).

However, we were interested in determining an unsaturated model – a log-linear model that does not include all possible interactions in the analysis. The reason for this is that the goal was to find the most parsimonious model that fits the data (i.e., the simplest model that still represents the data satisfactorily). As the number of variables increases, the analysis complexity can become overwhelming with a seemingly monstrous number of possible interaction effects. Hierarchical log-linear modelling helps choose the parsimonious model and understand which interaction effects to keep. It is a statistical technique that attempts to find the best log-linear model (from a parsimonious perspective) to keep. Once this model is found, it is necessary to enter these terms into the log-linear model and get results, including additional steps to verify that this is indeed a good fit for the data. Using these two hierarchical model selection methods, followed by the general log-linear procedure, we attempted to fit a model that explains our data in a parsimonious manner.

We limited our results to the hierarchical log-linear model to determine the primary associations between the "factor-specification/modelling technique" and "technique-technique" pairs of variables. Other interaction effects (e.g., associations between 3 variables, etc.) are out of this paper's scope.

The log-linear analysis was executed with the SPSS tool based on the instructions provided by Morgan et al. [24]. Hierarchical model selection was run for each specification/modelling technique and other background factors from Q1. Partial associations tables were checked for two-way associations with a significance level larger than 0.05 ($p < 0.05$). It is important to note that this information in a table relies on the saturated and unsaturated models. After that, the simple Chi-Square test was done for each found two-way association.

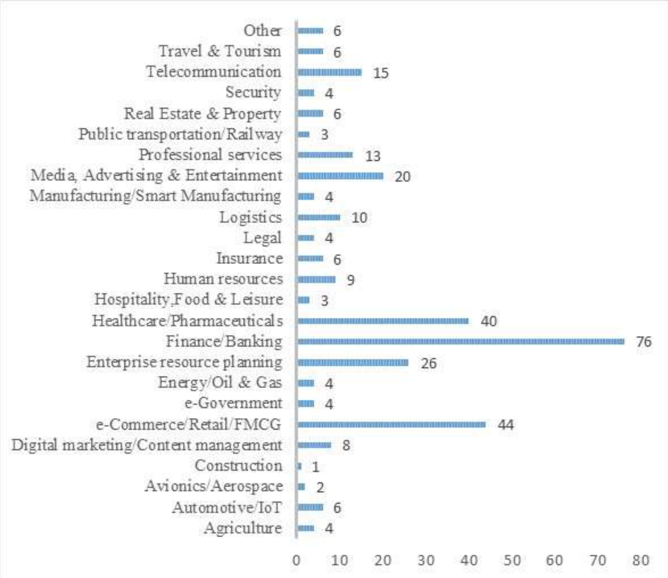

Figure 1. Industrial sector

Basic assumptions for the Chi-Square test were checked and confirmed, namely:

1. Both variables are categorical. In our case, they are nominal.
2. Observations in groups/levels inside the variable are independent. As mentioned above, data were transformed to classify observations into mutually exclusive classes.
3. All cells should have expected counts greater than 5. The Crosstabs procedure in the SPSS produces the expected count value for each variable, so it is easy to check this assumption.

While the Chi-Square test is advantageous for testing relationship, it has several weak points. One of the difficulties with the test is that it does not indicate the nature of the relationship. It is impossible to determine the extent to which one variable changes as the values of the other variable change. The only way to do this is to carefully assess the table to ascertain the relationship between the two variables. Standardized Pearson Residual (further SPR) was used to identify those specific cells that contributed most significantly to the Chi-square test results. According to Agresti [25], a cell-by-cell comparison of observed and estimated expected frequencies is used to assess the evidence nature. SPR having an absolute value that exceeds +/- 2 when there are few cells or +/- 3 when there are many cells indicates a lack of fit of H0 in that cell:

- If the residual is less than -2 or -3, respectively, the observed frequency is less than the expected frequency.
- If the residual is greater than 2 or 3, respectively, the observed frequency is greater than the expected frequency.

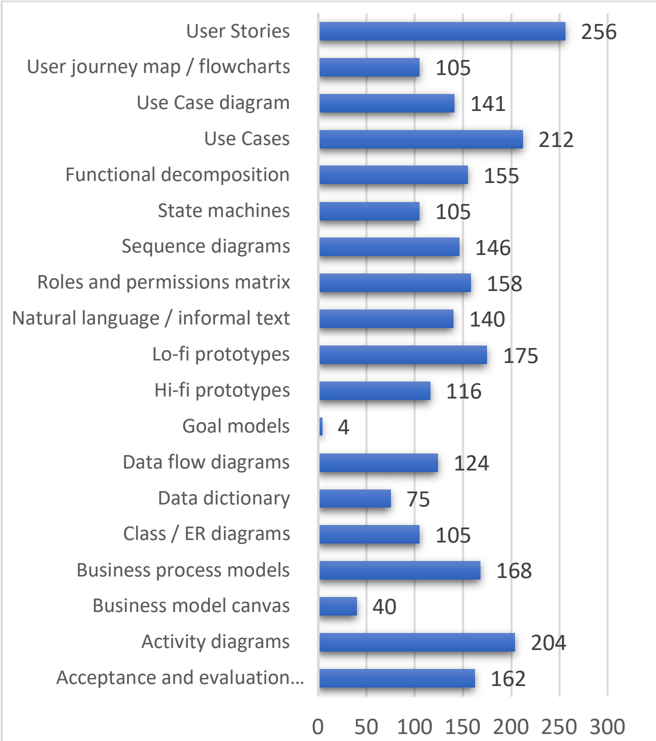

Figure 2. Requirements specification and modelling techniques (frequencies)

Considering the above, SPRs were used to interpret the identified dependencies between background factors and specification/modelling techniques.

The second issue with the Chi-Square independence test is that the chi-square statistics value may vary based on the number of cells in the table. It may be misleading to compare the chi-square statistics for two tables of entirely different dimensions (i.e., different numbers of rows and columns in the table). Cramer's V – chi-square-based association measure – was used to adjust the Chi-Square test results and consider differences in table size. Different sources give a different interpretations of Cramer's V value. Rea and Parker [26] proposed the following interpretation:

- $V < 0.1$ – negligible association.

- $0.1 \le V < 0.2$ – weak association.
- $0.2 \le V < 0.4$ – moderate association.
- $0.4 \le V < 0.6$ – relatively strong association.
- $0.6 \le V < 0.8$ – strong association.
- $V \ge 0.8$ – very strong association.

As we used the IBM SPSS tool for analysis, we refer to their stricter definition of effect size, namely:

- $V \le 0.2$ – week association.
- $0.2 < V \le 0.6$ – moderate association.
- $V > 0.6$ – strong association.

	Company Type	*Company Size*	*Experience*
Acceptance and Evaluation Criteria	0,325	0,279	
Data flow diagrams		0,168	0,26
State machines			0,25
User Stories	0,316		

Figure 3. Cramer’s V for "technique-background factor" pairs

	Acceptance and Evaluation Criteria	*Activity diagrams*	*Business model canvas*	*Business process models*	*Class/ER diagrams*	*Data dictionary*	*Roles and permissions matrix*	*Sequence diagrams*	*State machines*	*Use Cases*
Class/ER diagrams	0,18	0,277	0,161	0,267						
Data dictionary	0,167	0,175	0,15	0,174	0,308					
Roles and permissions matrix	0,12		0,213	0,236	0,151	0,252				
Sequence diagrams	0,114	0,379			0,256	0,161	0,11			
State machines	0,139	0,356	0,161	0,161	0,324	0,23	0,283	0,23		
Functional decomposition		0,114	0,129	0,15		0,236	0,321	0,12	0,208	
Use Case diagrams	0,129	0,339	0,198	0,186	0,292	0,135	0,178	0,257	0,266	0,315
User journey map/User flow diagrams	0,226	0,19	0,298		0,136		0,21	0,144	0,192	0,133
User Stories	0,409									0,145

Figure 4. Cramer’s V for "technique-technique" pairs

The conclusion about statistical significance, based on the Chi-square test and Cramer’s V (Fig. 3), was made for the following "background factor-specification/modelling technique" pairs:

- Company type – User Stories, p = 6.9158E-8 (Fig. 5). This technique is used widely within IT Outsourcing/Outstaffing companies, less actively – in IT Product companies, and rarely in non-IT companies. Moreover, the gap between "Yes"/"No" answers is minimal for in-house development.
- Experience – State machines, p = 0.000067 (Fig. 6). State machine diagrams are used almost 50/50 after five years of experience in business analysis. Respondents with experience of up to 3 years use this technique in 24,3% of cases, and those with 3-5 years of experience – in 19,2% of cases.
- Experience – Data flow diagrams, p = 0.000079. Participants with more experience in business analysis tend to use these diagrams more often.
- Company size – Acceptance and evaluation criteria, p = 0 (Fig. 7). This technique is more prevalent in large companies with over 1,500 specialists: the "Yes" answer exceeds "No" three times. In smaller companies, the number of those who use acceptance criteria is almost the same as those who do not.
- Company type – Acceptance and evaluation criteria, p = 2.8186E-8. This technique is used by 75% of respondents from IT Outsourcing/Outstaffing companies. Only around 40% of survey participants from other company types use it daily.

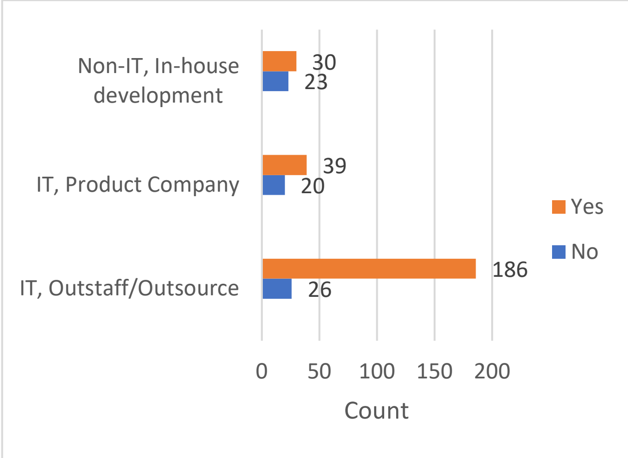

Figure 5. Association between Company Type and User Stories technique usage

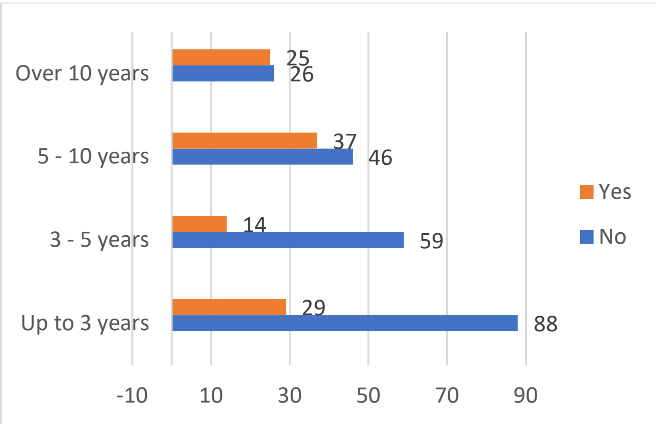

Figure 6. Association between Experience and State machines usage

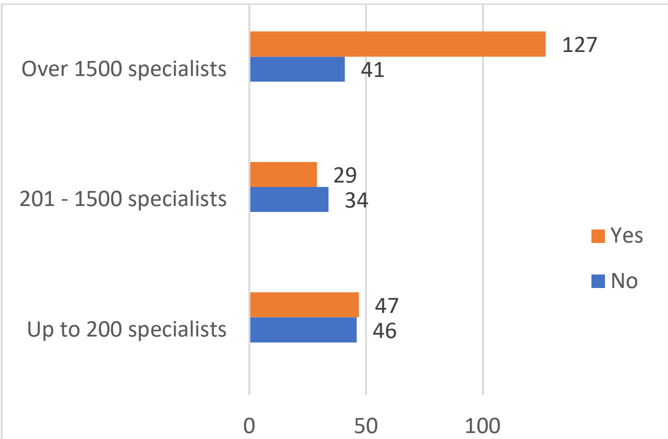

Figure 7. Association between Company size and Acceptance and evaluation criteria technique

The conclusion about statistical significance, based on the Chi-square test and Cramer’s V (Fig. 4), was made for the following "technique- technique" pairs:

- User Stories – Acceptance and evaluation criteria, p = 1.8562E-13. The majority of respondents (57%) use the User Stories along with acceptance criteria. 21% of specialists use only User Stories, i.e., without acceptance criteria.

- Activity diagrams – Class/ER diagrams, p = 6.3071E-7. Almost 38% of survey participants do not use either Activity or Class/ER diagrams. Only 24% of respondents use both diagram types in their daily work, and 30% – use Activity diagrams but do not use Class/ER diagrams.
- Activity diagrams – Sequence diagrams, p = 8.8025E-12. Almost 35% of survey participants do not use Activity and Sequence diagrams. About 34% of specialists use both diagrams, and about 20% – use Activity diagrams but do not use Sequence diagrams.
- Activity diagrams – Use Case diagrams, p = 1.0579E-9. About 35% of specialists do not use these diagrams, and 32% use both.
- Activity diagrams – State machines, p = 1.4621E-10. 40% of survey participants do not use either Activity diagrams or State machines, and 26% – use both techniques. Almost 28% use Activity diagrams but no State machines.
- Business model canvas – User journey map/User flow diagrams, p = 7.9524E-8. Only 9% of survey participants use both techniques, and 64% of specialists use none of them (Fig. 8).
- Class/ER diagrams – Data dictionary, p = 2.98E-8. A combination of these techniques is not used by 58% of specialists, and only around 14% use both Class/ER diagrams and Data dictionaries.

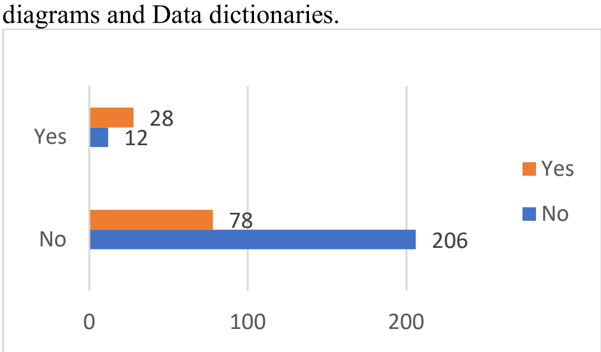

Figure 8. Association between Business model canvas and User journey map/flowcharts techniques

- Class/ER diagrams – Sequence diagrams, p = 0.000004. Around 43% of respondents do not use either Class/ER diagrams or Sequence diagrams. Almost 21% use both diagrams. About 25% use Sequence diagrams but do not use Class/ER diagrams.
- Class/ER diagrams – Use Case diagrams, p = 1.4508E-7. About 45% of specialists do not use Class/ER diagrams and Use Case diagrams. Only 21% use both. Almost 23% prefer Use Case diagrams and do not use Class/ER diagrams.
- Class/ER diagrams – State machines, p = 5.6696E-9. 53% of respondents do not use these techniques in pairs at all. Around 17% use both. 15% of survey participants use either Class/ER diagrams or State machines.
- Sequence diagrams – Use Case diagrams, p = 0.000004. 37% of specialists use none of these techniques, and only 25% use Sequence and Use Case diagrams.
- State machines – Use Case diagrams, p = 0.000002. 44% of respondents do not use either State machines or Use Case diagrams. 20% use both techniques. 23% prefer Use Case diagrams and do not use State machines.
- Use Cases – Use Case diagrams, p = 1.4226E-8. Around 27% of respondents use none of these techniques. 36% of survey participants use both of them, 29% use only Use Cases without Use Case diagrams, and almost 8% work with Use Case diagrams without Use Cases.
- Data dictionary – Roles and permissions matrix, p = 0.000006. 44% of specialists do not use these techniques together, and only 17% do. 32% of respondents use the Roles and permissions matrix but do not use the Data dictionary technique (Fig. 9).

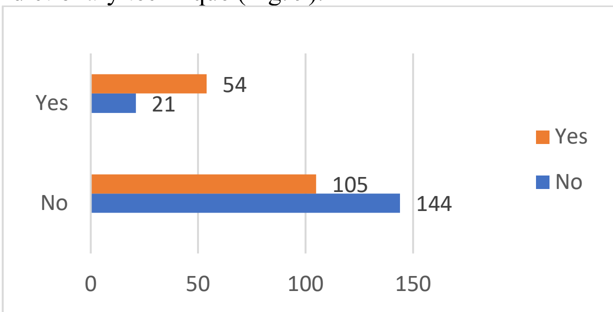

Figure 9. Association between Data dictionary and Roles and permission matrix techniques

- Roles and permissions matrix – Functional decomposition, p = 7.9388E-9. Almost 35% of survey participants do not use these techniques in pairs, and 31% – do. Around 17% of specialists use Functional decomposition or Roles and permissions matrix.

Associations were found, based on the Chi-square test, but not confirmed by Cramer's V value for the following "factor-specification/modelling technique" pairs:

- Project category – User Stories, p = 0.025. User Stories are more prevalent in greenfield engineering and reengineering projects than in user interface engineering or product/platform customization.
- Ways of working – User Stories, p = 0.002. This technique is unlikely to be used in plan-driven methodologies, with a high probability in hybrid, and is actively used in agile projects. Interestingly, almost 9% of respondents working on agile projects do not use User Stories.
- Company type – User journey map/Flowcharts, p = 0.023. This technique is used mainly within IT Outsourcing/Outstaffing companies, less actively – in IT Product companies, and rarely in non-IT companies. However, even in IT Outsourcing/Outstaffing companies, only 65% of survey participants use the mentioned techniques.
- Project category – User journey map/Flowcharts, p = 0.008. This technique is used mainly in greenfield engineering and user interface engineering projects. Only 20-26% of survey participants, who work in reengineering or product/platform customization, use this technique.
- Project category – Use Case diagrams, p = 0.023. This kind of diagram is actively used in greenfield engineering projects.
- Project category – Sequence diagrams, p = 0.008. Sequence diagrams are popular mainly in greenfield engineering, less in reengineering and product/platform customization, and rarely in user interface engineering.
- Project category – Roles and permissions matrix, p = 0.000477. This technique is more likely to be used in greenfield engineering projects.

- Experience – Roles and permissions matrix, p = 0.014. The probability of using the mentioned technique is higher if the business analyst is more experienced.
- Company size – High-fidelity prototypes, p = 0.004. The technique is used 50/50 in companies with up to 200 specialists and around 30% of cases within larger companies.
- Team distribution – Activity diagram, p = 0.000273. The technique is much more popular within distributed teams.
- Experience – Activity diagram, p = 0.014. This kind of diagram is used actively starting from junior positions. However, business analysts with experience of more than five years use the technique much more frequently.

IV. CONCLUSIONS

A survey study was conducted to analyze current specification and modelling techniques practices in different software projects. The survey structure was built based on the worldwide known industry standards and was validated in the Ukrainian IT realities. The questionnaire was spread among specialists from Ukrainian IT and non-IT companies, and 328 specialists (mainly business analysts and product owners) took part in the survey. The following requirements specification and modelling techniques were defined as the most commonly used: User Stories, Use Cases, Activity diagrams, Low-fidelity prototypes, Business process models, Acceptance and Evaluation Criteria, Roles and permissions matrix, and Sequence diagrams. The more frequent use of User Stories and Acceptance and Evaluation Criteria techniques in outsourcing companies can be explained by a greater focus on requirements as a task statement rather than a project knowledge base, as opposed to product companies and internal development, which are more focused on accumulating knowledge about IT solutions. The influence of experience on using a State Diagram can be explained not only by the more profound knowledge of the UML among experienced specialists but also by the complexity of the tasks they are more likely to deal with.

After survey data cleansing, the log-linear hierarchical model selection algorithm was used for defining the two-way associations between project factors/participants' background (later "background factors") and usage of the specification/modelling techniques. A set of statistically significant dependencies was found for the following techniques: Acceptance and evaluation criteria, Activity diagrams, Class/ER diagrams, Data dictionary, Roles and permissions matrix, Sequence diagrams, State machines, User Stories, and Use Cases. The hypothesis regarding dependencies between project context and requirements specification and modelling techniques was confirmed only for company type (influences Acceptance and Evaluation Criteria, and User stories), specialist's experience (Data Flow Diagram and State Machines), and company size (Acceptance and Evaluation Criteria, and Data Flow Diagram). The influence of ways of working (Predictive VS Adaptive approaches), team distribution, and project category has not been confirmed by Cramer's-V measures.

The study results analysis described in this paper is limited by two-way associations only, which were additionally checked with the Chi-Square test. This result was adjusted using Cramer's V effect size measure to define the strength of the association. Considering that the survey was limited to one country only, its results cannot be extrapolated for the worldwide software industry.

Future research could be devoted to creating a detailed framework for requirement specification and modelling techniques selection in IT projects based on the initially pre-selected set and the project context.

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