Ethnographic Research in Software Engineering: A Critical Review and Checklist

He Zhang
Xin Huang
hezhang@nju.edu.cn
njuhx16@qq.com
State Key Laboratory of Novel Software Technology, Software Institute, Nanjing University
China

Xin Zhou
Huang Huang
job@wetist.com
njufrankhuang@gmail.com
State Key Laboratory of Novel Software Technology, Software Institute, Nanjing University
China

Muhammad Ali Babar
ali.babar@adelaide.edu.au
School of Computer Science, University of Adelaide
Australia

ABSTRACT

Software Engineering (SE) community has recently been investing significant amount of effort in qualitative research to study the human and social aspects of SE processes, practices, and technologies. Ethnography is one of the major qualitative research methods, which is based on constructivist paradigm that is different from the hypothetic-deductive research model usually used in SE. Hence, the adoption of ethnographic research method in SE can present significant challenges in terms of sufficient understanding of the methodological requirements and the logistics of its applications. It is important to systematically identify and understand various aspects of adopting ethnography in SE and provide effective guidance. We carried out an empirical inquiry by integrating a systematic literature review and a confirmatory survey. By reviewing the ethnographic studies reported in 111 identified papers and 26 doctoral theses and analyzing the authors' responses of 29 of those papers, we revealed several unique insights. These identified insights were then transformed into a preliminary checklist that helps improve the state-of-the-practice of using ethnography in SE. This study also identifies the areas where methodological improvements of ethnography are needed in SE.

CCS CONCEPTS

• **General and reference**;

KEYWORDS

Ethnography; qualitative research; empirical software engineering; systematic (literature) review

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1 INTRODUCTION

Qualitative research methods have gained significant role in Software Engineering (SE) research [40, 79]. Along with case study [87] and grounded theory [79], ethnography is one of the main qualitative research methods, originally developed and popularized in social sciences. Ethnographic research is considered an appropriate approach to understanding people, cultures and their associated social and work practices [2]. Ethnographic research is able to provide an in-depth understanding of the socio-technical realities surrounding everyday software development processes, practices, and tools. The use of ethnographic methods contributes to the development of Empirical Software Engineering (ESE) by enabling researchers to: 1) focus on the members' point of view to understand the rationalities of the used practices to be made explicit, and hence exposes why software engineers do what they do; and 2) focus on the ordinary detail of software developers' work life emphasizes the role of local context and expertise which can be overlooked when using other research methods [73]. Whilst the literature reporting studies that claim the use of (or appear to have used) ethnographic methods is increasing, there has been little effort on systematically studying and understanding the ways and the challenges of adopting ethnography in SE. An evidence-based research on the advantages and challenges of using ethnography in SE is important in supporting its wider and correct adoption in this community.

We have carried out an empirical inquiry that has used Systematic Literature Review (SLR) and complementary email survey. Our literature search identified 111 papers and 26 doctoral theses published by 2018 for review that (appear to) report ethnographic studies. To confirm some aspects of our findings from the SLR, we also sought and analyzed the authors' responses from 25 reviewed papers. Our study revealed that most of the ethnographers in SE are often software engineers at the same time. It is possible that ethnographers in SE can have the member's point view even when they do not conduct participant observations.

While there are potential advantages for researchers in SE to adopt ethnographic methods [73], unlike other disciplines, ethnographic research has not gained popularity in this community until recently. In order to enable SE research to benefit more from ethnography, this study is the first to offer a comprehensive understanding of how researchers have conducted ethnographic studies and what

major challenges they have faced while adopting ethnographic research in SE. Based upon the understanding, a checklist with the concerns of the specific research context in SE is proposed to support the novice ethnographers. It provides a common set of recommendations along the process of ethnographic studies and helps SE researchers to make decisions on whether to adopt ethnographic methods in their work.

We have identified that the ethnographic studies in SE have generally covered four dimensions: *interactions between human and process*, *human and technology*, *human and environment*, and *within human*. We have realized that some challenges in adopting ethnographic methods over the four stages of an ethnographic study: choice of method, design phase, execution phase, and reporting phase. We have also observed that the methodological support for successfully adopting ethnography in SE is far from adequate compared to other disciplines. Many of the definitive works on ethnography in SE focus more on study design, data collection and analysis without paying sufficient attention to the intrinsic nature and context of SE compared with the disciplines from where ethnography originated, i.e. social sciences. Based on the findings from our study, we therefore provide SE researchers with a set of preliminary guidelines, organized as a checklist.

The objective of our work in this paper is neither to criticize the reviewed studies, nor to criticize their authors. Instead of giving a new definition of ethnography in SE, we intended to establish an evidence-based understanding of using ethnographic methods in SE. We assert that this work would make important contributions in improving the current state-of-the-practice of adoption and adaptation of ethnographic methods in SE.

2 BACKGROUND

2.1 Ethnography, Ethnographic Methods and Ethnographic Research

Ethnography is used to explore the organization of everyday life and reveal the processes and meanings of the underpinning social actions in certain cultures [15, 24, 35, 42]. Ethnographers try to describe a socio-cultural scene from insider's perspective, in order to make readers closer to the native's point of view [27]. Ethnographers should keep an open mind about the culture they are studying [25, 84]. An open mind can give ethnographers the ability to explore rich, untapped sources of data during the fieldwork, which is the heart of an ethnography [25, 34].

Ethnographic methods mainly use field studies for collecting data [69]. Ethnographic observations and interviews need a panoramic view of the culture at the beginning, a microscopic focus on the details after entering into a culture, and the larger picture with new insight into minute details in the end [25].

Ethnographic research, which takes place in the field, uses all or part of the *ethnographic methods*, reports on the status of a culture, is a means of forming *ethnography*. This means being there, living and working with group members for a relatively long period (often 6 months or longer [25]) to learn and understand different things about the studied group by observing and asking seemingly novice questions, is the most important element of ethnographic research [38]. Besides the field work, ethnographic research [34] also involves:

(1) Selecting and sampling the cases: choose who and what not to study or select who and what to study.
(2) Thinking about how to access the site for the field work: find a member of a group to introduce a researcher to the culture or perform a nonthreatening role in a group.
(3) Recording and filing data: lists and forms, which usually contain the major topics and questions the ethnographers plan to cover in the fieldwork and report.
(4) Analyzing data: data analysis begins as early as during the fieldwork, but formal analysis starts when the ethnographers leave the field.
(5) Writing report: verbatim quotations are extremely useful and the findings can be communicated through many ways such as media releases, photographs and a variety of electronic communications.

2.2 Ethnography in Qualitative Methods

Some researchers argue that it is useful to think of ethnography as a series of partially unified methodological strategies [6]. To some extent, ethnographic methods seem similar to some other qualitative research methods, even few methods are unique to ethnographic research. Among such qualitative methods, case study is likely to be easily confusing with ethnographic methods. Some researchers may claim their method as 'ethnographic case study'. Nevertheless, Yin presented an exhibit about illustrative variation in qualitative research and made a brief explanation of each method [87], where ethnography is considered different from other qualitative inquiries. For instance, case study focuses on the particular phenomenon or the case but the ethnographic methods need to describe the people's everyday norms, rituals, and routines. For more detail, an ethnographer not only focuses on the phenomenon or the case itself, but pays more attention to the link between macro- and micro-perspectives [25].

Table 1 presents a concise comparison by highlighting their distinct concerns between some popular research methods dealing with qualitative data. Take eXtreme Programming (XP) as an example, an *ethnographic research* on this topic may contain the working detail of software engineers, e.g., the environment they worked in, the meeting they attended, and their story cards to understand their real ideas. By relating the life-details to XP practices, more characteristics about developer and organization such as 'both individuals and the team are respected' and the hidden theme which may be inconsistent with the accepted official views found in public [74]. Whereas a *case study* of XP may focus more on the practice itself which contains the tools or methods in the XP practices such as what technology can be used and how to prepare for XP practices. As a result, good examples, suggestions, or issues when doing the XP practices may be proposed as the outcome of a case study, e.g., writing test cases before coding is not easily adopted and is sometimes impractical [54]. When studying XP using *grounded theory*, researchers may pay attention to the practices that emerged from the studied XP teams or projects and the relations between these practices, e.g., between the emergent customer practices and the XP practices [53]. A *survey* on XP may contain many questions about a project and gather the answers from most participants in the project so that some statistics can be drawn to show the information about

Table 1: A comparison of empirical methods for qualitative research

Research inquiry	A brief description	Concerns	Examples
Ethnography	Examines the details of a person, an organization or a culture from both a macro- and micro-perspective.	The link between natural setting and a phenomenon.	[25, 28, 33–35, 80]
Case study	*Focuses on a phenomenon or case itself in the real world context.*	*How a phenomenon be aroused and developed?*	[4, 19, 67, 86]
Grounded theory	*Involves the construction of theory based on the inductive operation of a phenomenon.*	*What theory a phenomenon can produce?*	[7, 12, 29, 79]
Interview	*Seeks to understand how people think of a phenomenon by their words and actions.*	*Interviewees' inspiration for a phenomenon.*	[17, 39, 60, 65]
Survey	*Assesses thoughts, opinions, and feelings of a population about a phenomenon by answering some questions.*	*Population's rational understanding of a phenomenon.*	[14, 26, 30, 37]

the adopted XP practices [66]. Alternatively, researchers may use *interviews* to directly contact the practitioners being studied to find their views on XP practices, which is instantaneous [16].

2.3 Ethnography and Software Engineering

Ethnographic research has been successfully applied in many other disciplines outsides its origin disciplines—social sciences, where a large majority of ethnographic studies have been reported [34]. Compared to other disciplines such as education or law, ethnography is still in its early stage of adoption in SE yet, it is recognized that this method can greatly help SE researchers in many ways, for example, uncovering not only what practitioners do, but also why they do it [73]. In practice, some SE specific issues may arise when undertaking ethnography in SE. First, how to deal with 'long-term', one of the features of traditional ethnography [32, 33]? The rapid and unpredictable changes in business become a common challenge, and in order to adjust to this situation, a multitude of organizations started applying agile methodologies to accelerate the development process [10, 23, 82]. It might be possible that the reality allows no time for a 'long-term' data collection. Next, how to define 'natural environment', another important element in normal field studies? Can the community online be the 'natural environment'? If not, how can we observe the daily life of software engineers? Also, what exactly is the 'larger picture', the groups, the organization, the state, or the world, that must be encompassed? Although there are no definitive answers to the questions as above yet, SE researchers may carry out ethnography in their own styles, for example, becoming a member of an online organization or community and using network and computers to reduce the time and economic burden brought by the defined ethnography [17, 49].

3 RELATED WORK

3.1 Qualitative Research in Software Engineering

Qualitative methods, which are most used for the investigation of social phenomena, have attracted much attention from many researchers in SE [21].

Hove and Anda identified four important areas when plan and conduct interviews by reflection upon the reported experiences of conducting interview based studies in SE and relating their observations with other disciplines [39]. They concluded that the necessary effort, the required skills, the interactions between interviewers and interviewees, and the appropriate tools are the four challenging areas of doing interview based studies in SE. They also claimed that project artifacts such as code, UML diagram, and other visual items can be usable when interviewing software developers.

Ciolkowski et al. analyzed the state of the practice of survey, listed some lessons in SE surveys, and then introduced a progress for preparing, conducting, and analyzing a survey in SE [14]. They asserted that the focus of a survey in SE is to get information from the identified sources of information so that surveys and their reports focus only on the results obtained during a survey study. They also pointed that the challenges of surveys stem from the complex topics and considerable amount of time to develop conceptual models in survey studies.

Runeson et al. discussed the motivation, background, terms, design, data collection, data validation, analysis and some different uses of case studies in SE [67]. They also provided several examples of case study research taken from five research areas in SE so that researchers can learn from their experiences.

Stol et al. compared three main strands of Grounded Theory (GT), i.e. classic/glaserian GT, straussian GT, and constructivist GT, and offered the guidelines for conducting and reporting GT in SE after analyzing 98 articles that mention GT [79]. They also enumerated the challenges when applying GT in SE, including managing large amounts of heterogeneous data, coding unconventional texts, and cross-referencing participant statements with records.

3.2 Ethnography in Software Engineering

Although many researchers have realized the importance of human and social aspects in SE research, ethnography has not been widely adopted in SE [5, 70].

Sharp et al. pointed out this situation and generalized four features of ethnography—the members' point of view, the ordinary detail of life, the analytical stance and thick descriptions for academic accountability [73]. They further proposed four roles of ethnographic studies in SE: *strengthening investigations into human and social aspects*, *informing tool design*, *improving software development process*, and *informing research programs*. Some examples on agile methods, architecture, bug report, and coordination, were enumerated to support the proposed features and roles of ethnography in [73]. However, they based the proposed roles of ethnography largely on their own experiences and knowledge, the resulting four roles are an unbalanced set. For instance, '*investigations into human and social aspects*' can be identified in almost all studies in our review. In contrast, we systematically developed the role dimensions of ethnography by following a grounded theory approach, which was based on an exhaustive set of ethnographic studies in SE.

Passos et al. discussed the methodological challenges reflected in their study of agile software development, and identified five key challenges of ethnography in SE [59]: *collaboration with participating company*, *insider/outsider dynamic of participant observation*, *balance between listening and observation*, *relationship between researchers and participants*, and *rigor in qualitative work*. They argued that ethnographers in SE should not only study the participating companies but also support and collaborate with them. They also claimed that ethnographic research is necessary in SE as the SE contexts require an approach which can analyze, improve the practices

and share process with practitioners. As the challenges discovered by them came from their experiences from a single study (project), some of them may not be representative in the larger SE community. Despite we mentioned a selective set of challenges of ethnographic research in SE in this paper, the identified challenges are solidly based on most of the identified ethnographic studies in SE.

4 RESEARCH METHOD

The protocol of this study was initially developed in the middle of 2016, followed by a pilot study search and selection by two student researchers. According to the pilot study's results, they received an extensive training on ethnographic methods in general and conducted intensive readings of typical ethnographic studies in SE. Later they were also involved in an online ethnographic study of the phenomena in SE in industrial environments. Based on the knowledge and hands-on experiences gained, the protocol was revised in the early of 2018. This study was resumed by three student researchers (with their research topics in Empirical Software Engineering) and their supervisors in two stages, i.e. an SLR and a survey inquiry. The SLR followed Kitchenham and Charters' guidelines [47]. All the involved researchers had prior experiences with empirical methods, in particular SLR and survey. This section describes the research method and the process of this study (as shown in Figure 1).

4.1 Research Questions

This study aims at addressing three research questions as below:

RQ1. *How did SE researchers use ethnographic methods in their research?*

RQ2. *What roles did the ethnographic research play in SE?*

RQ3. *What are the major challenges of conducting ethnographic research in SE?*

*RQ*1 aims to address the characteristics about how researchers adopted ethnographic methods in SE. *RQ*2 steered our investigation of the roles of ethnographic research in SE to inspire future research. The findings (challenges) for *RQ*3 may drive the development of the methodological recommendations and guidelines of doing ethnographic studies in SE.

4.2 Search Process

The search of ethnographic studies was redone in 2018 by extending the time span of the pilot search (2016) until the end of 2017. Since it is hard to determine the exact year when ethnographic research was introduced into SE, we did not set the starting year for automatic retrieval. The five major SE literature databases, i.e. IEEExplorer, ACM DL, SpringerLink, ScienceDirect and Wiley Online, were searched using the following search string:

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software AND (ethnography OR ethnographic)
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In the beginning of 2019, the search was further extended until the end of 2018. We excluded the retrieved short papers from the review, which describe little of the specifics and the detailed process of ethnographic methods applied. Such details are important in reporting an ethnographic study and also may affect the answers to the research questions raised in this study. Apart from the peer-reviewed papers, we expanded the search scope by searching doctoral theses (PhD dissertations) based on ethnographic research in SE. The search of doctoral theses was done through an open dissertation database[1] using the same string as above.

Table 2: Study inclusion and exclusion criteria

	Inclusion criteria
IN1	The authors adopted (claimed) ethnographic method (study) in their papers
IN2	The papers were peer-reviewed and published in a conference or journal
IN3	Doctoral dissertation
IN4	The full-text of the paper can be accessed
	Exclusion criteria
EX1	The papers are not written in English
EX2	The papers are explicitly short papers, position papers, and editorials

Table 3: Data items extracted from the identified studies

RQ	Data item
1	Year
1	Topic of the studies
1	To what extent are description of ethnographic studies discussed?
1	How was data collected and analyzed?
2	What was claimed concerning the use of ethnographic methods?
2	What are the roles of the ethnographic studies?
1,2,3	What specific ethnographic techniques and practices were used?
2,3	What did ethnographic studies produce and how were they presented?

4.3 Study Selection

By the end of 2018, 16000+ papers and 332 theses were retrieved as the result of our search. To ensure the selected studies were relevant to our research questions, we formulated the inclusion/exclusion criteria as shown in Table 2. The study selection was done in two phases, i.e. the identification of ethnographic studies from peer-reviewed papers and from doctoral theses, the results are shown in Figure 1. In the former phase (Rp), three student researchers independently screened 16000+ hits from the published literature by reading their titles, abstracts, and keywords; then these researchers cross-checked their selected studies. If a selection decision could not be made, the study's full-text was further checked. The final consensus was reached on 111 peer-reviewed papers reporting ethnographic studies. In the latter phase (Rt), these researchers read the 332 retrieved doctoral theses in parallel, with the special attention on the description of their research methods. The ethnographic studies were identified by applying the selection criteria as well as referring to the featured characteristics of ethnographic methods defined in social sciences and other disciplines. During the selection process, any disagreements were collectively discussed with their supervisor, and even escalated to consult experienced ethnographers until a satisfactory decision was made. The search and selection process took approximately nine weeks in total.

4.4 Data Extraction

The data items shown in Table 3 were extracted from the identified ethnographic studies and theses. The column '*RQ*' on the left indicates the research questions that are expected to be answered with the extracted data items on the right.

At the beginning of the data extraction, three student researchers randomly selected 15 studies and conducted independent reviews as a pilot data extraction exercise. The review team held frequent meetings to cross check and thoroughly discuss any disagreements on the extracted data. Accordingly, the protocol was refined to reflect the consensus made. After the pilot data extraction, these researchers read the full text of all the identified ethnological studies

[1] OATD (Open Access Theses and Dissertations) at http://oatd.org/

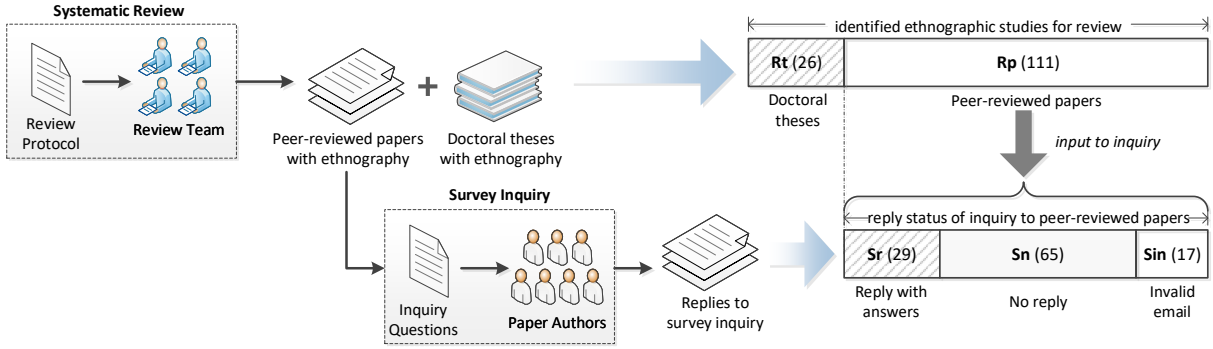

Figure 1: The research process of this study

Table 4: Questions in survey inquiry

SQ1	*When you collected ethnographic data, was there someone introducing you into the project? If any, what role did he/she play in the project?*
SQ2	*What role did you play in the project reported in your paper?*
SQ3	*How much time did you spend on collecting ethnographic data?*
SQ4	*Which method(s) did you use to collect ethnographic data?*
SQ5	*How do you understand ethnography (e.g., as a method for planning, data collection, data analysis or reporting)?*

and extracted the data (stored in spreadsheets) independently following the refined protocol. The extracted data was cross-checked together after independent extractions. Any disagreements were resolved in consensus meetings or by consulting their supervisor or an experienced ethnographer. Sometimes it was difficult to extract the information needed about the process of the ethnographic methods used in the reviewed papers because there was no sufficient or explicit description about the applied methods. In such cases, we carefully analyzed how the authors described their ethnographic methods and presented their results, as well as sought supplementary resources (e.g., follow-up papers, reports and blogs). The data was extracted and our assessment was made based on as much information as we could gather. It took about ten weeks to complete the data extraction (including iterations and some rework).

4.5 Survey Inquiry

Because some of the authors did not provide the details of the ethnographic methods used in their papers, we decided to survey the authors of all the identified peer-reviewed papers via e-mail to further gather the details of their research. Note that this inquiry survey intended to just collect supplementary data for the confirmatory purpose, rather than as a standalone research method that is able to generalize the findings from a sample set [26]. Compared to the limited space of the reviewed papers, all the identified doctoral theses had provided detailed descriptions of the used ethnographic methods; hence there was no need to survey the authors of the identified theses. Our email-based survey consists of five questions listed in Table 4.

4.6 Data Analysis and Synthesis

We employed both quantitative and qualitative methods for data synthesis in order to comprehensively answer the research questions. For *RQ*1 the data was synthesized using *descriptive statistics* and presented in charts. To answer *RQ*1 and *RQ*3, we used *thematic analysis* in combination with *narrative summaries*. These analysis methods helped us to extract the important features of ethnographic research in SE with a limited set of illustrative studies for demonstrating how ethnographic research was performed in SE, and to distill the common challenges of the methodological adoption of ethnography in SE that are reflected in most of the identified studies. For some papers that do not explicitly claim the challenges of adopting ethnographic methods, we translated the descriptions of their ethnographic approaches to uncover the possible challenges by setting up the analogy to others. For example, when an ethnographic study is conducted in a company, there may be a risk that ethnographers are not able to do participant-observation as they want. This risk is a challenge associated with ethnographic observations: the difficulty to perform a complete participant-observation. For *RQ*2, a set of techniques from *grounded theory*, e.g., coding and constant comparison, were applied to progressively discover what typical roles ethnographic studies can play in SE research, and then to develop a conceptual model with the role dimensions. By coding the reviewed studies was marked with labels, such as 'online community', based on their topics, purposes, adopted methods and so on. Several iterations took place in this process to get high-level codes (themes). The replies from the survey inquiry (`Sr` in Figure 1) were incorporated with the extracted data from the review to collectively support the data synthesis.

5 RESULTS AND SYNTHESIS

This section first describes the results from the review and email inquiry, followed by the discussion on the research questions.

We identified 111 peer-reviewed papers and 26 doctoral theses[2] published by 2018 that report ethnographic research in SE. Figure 2 shows the number of the reviewed studies per year. Overall the adoption of ethnographic methods in SE has been about two decades since the first round ethnographic studies published in 1990s, and the number of the published studies has been significantly increasing since 2004. In particular, there were 108 studies published after 2007 (the later half of 12 years), which is nearly four times of the (29) studies published before 2007 (the earlier half). This indicates that SE researchers have been increasingly realizing and leveraging the potential value of ethnographic methods. As shown in Figure 3, the ethnographic research in SE is clustered into 11 topics such as Computer-Support Co-operative Work (CSCW), Global Software Development (GSD), and Agile Development.

[2]The review protocol and the complete list of the ethnographic studies are available at http://softeng.nju.edu.cn/tech-reports/TR-19-003-ETH.pdf

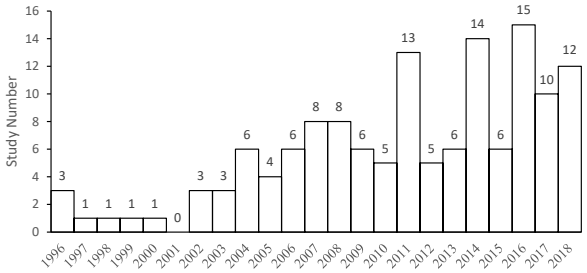

Figure 2: Distribution of ethnographic studies over years

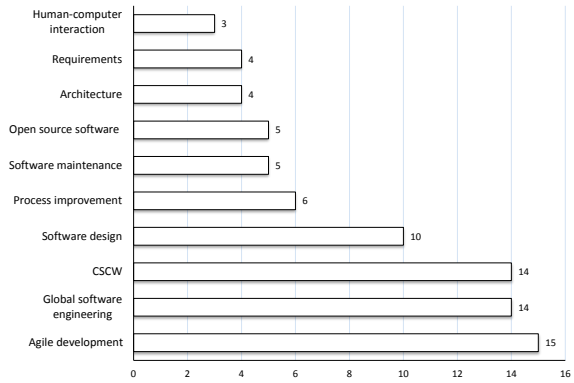

Figure 3: Distribution of topic areas in software engineering

Whilst all the identified studies claim their work as ethnographic research or indicate they used ethnographic methods, there are several papers that did not describe the process of the used research methods. In order to address this situation, we emailed the authors of all the 111 papers to ask the details of the used research process and their understanding of ethnography. We first emailed the first authors of all these papers and received 14 valid replies. Some emails were bounced back. A reminder was sent to the authors with no reply one week before the due date. After the first round expired, we emailed to the co-authors of the papers whose first authors did not reply. We received 15 more valid replies (9 from the second and 6 from the third authors). In total, we received the replies from the 29 papers' authors (`Sr`). We failed to contact any of the authors of the 17 papers (`Sin`) due to their invalid email addresses. The final response rate of our survey inquiry is 30.9%.

Through the initial analysis of the identified ethnographic studies, it is observed that the levels of detail vary much when it comes to the process of the used ethnographic methods. As our synthesis is mainly based on the papers reporting ethnographic studies, the reported details are likely to influence the outcome of the synthesis. In particular, the information needed for *RQ*2 requires more details than other RQs. Accordingly, we differentiated the reviewed studies into two sets in terms of the levels of detail reported, i.e. claim in citation (title, abstract or keywords), definitive references to ethnography, and the richness of the description, which could be easily identified from the reviewed papers. This classification helps explore whether SE researchers have a profound understanding of ethnography. As a result, 53 out of 111 (47.7%) reviewed papers and 17 out of 26 (65.4%) doctoral theses were classified into the selected set of 70 ethnographic studies with relatively rich detail for understanding how the ethnographers in SE understand ethnographic methods (*RQ*2). Whereas, the complete dataset which contains all the 137 studies can reflect the overall state of the adoption of ethnographic methods in SE (*RQ*1 and *RQ*3).

5.1 Use of Ethnographic Methods (*RQ*1)

Based on the thematic synthesis of the complete set of the 137 reviewed studies, we investigated how researchers used ethnographic methods in SE in terms of the characteristics of ethnography. Instead of the enumeration of all the methodological characteristics, this subsection focuses our description on the features of ethnography with new variations in SE.

5.1.1 Immersion. Given a practitioner's viewpoint is a signature of ethnography [73], a researcher should be considered as a member of the project that is being studied when using ethnographic methods. A researcher (or research team) can carry out two types of observations: *participant* observation and *independent* (non-participant) observation. The member's viewpoint can be incorporated through the participant observation. The review identified 83 (out of 137) ethnographic studies involving the participant observations, and 12 studies conducted independent observations. We also identified the cases for which the author(s) combined (independent) observation and participation as the observations were supplemented with limited participation in certain project activities [78]. Seven of the reviewed studies did not explicitly report their observation styles.

5.1.2 Environment. Unlike the other disciplines, SE researchers also used ethnography in conducting studies of virtual environments [50, 57, 77] such as global software development or open source software. Given the business organizations and the software development environments cannot be considered at the same time, researchers use special types of ethnography in SE: online ethnography and virtual ethnography, which were investigated in 8 reviewed studies. For an online environment, ethnographers do not need physical participation at a project's site. Rather they may observe the developers through dedicated channels [57, 58] and attend project meetings using online social media approaches (e.g., Skype [61]). The virtual ethnography [36] studies Internet communities based on archived texts (from repository). According to the replies to our survey, some researchers even took the lead roles in online projects, which also confirms that the ethnographers in SE are able to take the member's point of view in considerations.

5.1.3 Duration. In social sciences, a duration of at least 6 months is recommended for traditional ethnography [25]. In contrast, it is argued that shorter term ethnographic studies also make sense in SE [73]. The durations of the identified ethnographic studies were also collected. Among the 88 studies reporting their study durations (with the median of 8 months), 63.6% (56) of them spent 6 months (8) or longer (48) on collecting ethnographic data (as shown in Figure 4). This may be caused by the properties of the studied projects (e.g., project size). The significant variation of the lifecycle of software projects may make it hard to conduct a long term ethnographic study [74]. It is noticed that the real time for collecting ethnographic data that also depends on the observation frequency can vary a lot even when their durations are similar. For instance, two or three times a week over a period of 3 months [51] and once or twice a week over a 18-week period [13].

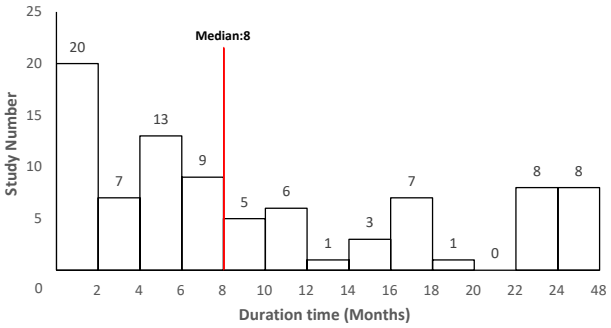

Figure 4: Distribution of study duration

5.1.4 Description and Analysis. As ethnography aims at 'writing a culture' in which observation is the key, its result is often detailed and comprehensive. To propose a big picture, thick and detailed description is often necessary in ethnography, which in some researchers' point of view may make ethnography relatively weak at generalization [73]. Methodologically ethnography contributes more to analytical generation than statistical generation. Therefore, analytical feature is equally important with description in ethnographic studies. When being applied to SE, it is observed that not many SE ethnographers presented a thick description in their studies [6, 18, 41, 58]. According to our research, only 70 out of 137 included ethnographic studies appear to have the feature 'thick description' to some extent. Raw ethnographic data was described with further analysis in these ethnographic studies. We found the percentage (65.4%) for doctoral theses is obviously higher than the percentage (47.4%) for peer-reviewed papers. This can indicate page limit has a great influence on the feature of 'thick description'. Researchers were inclined to use the ethnographic data collected from ethnographic methods but without 'thick description'. We observed that 21 reviewed studies claim to have conducted a case study with ethnographic methods [1, 81, 85] or 'ethnographic case study' [3]. It is also noticed that some other qualitative research methods are often combined with ethnographic methods in SE, such as grounded theory [20, 48, 63], in which ethnographic data is used as a stepping stone for the researchers' next step of analysis [68].

5.2 Roles of Ethnographic Studies (*RQ2*)

SE is an interdisciplinary field where human and social factors play an important role in software development. Ethnographic investigations in SE produce a social and cultural scene from the insider's perspective. When recognizing the roles of ethnography in SE, we first attempted to adopt the categorized roles proposed in [73]. However, we quickly realized that their role category does not match the published ethnographic studies, e.g., almost all the studies taking the role '*on social and human aspects*'. Then we started identifying and synthesizing the roles from the reviewed studies for systematically developing a conceptual model in a grounded theory manner. We contextualized the identified studies into question words, i.e. *whom*, *where*, *when*, *what* and *how*, to better understand the current state [22]. By instantiating these words within the practices of SE, a conceptual model with four roles (Figure 5) that can cover the most phenomena investigated in the ethnographic studies gradually emerged: human with process (*how to develop*), human with technology (*what to create*), human with environment (*where and when development happens*), and human with human (*whom to collaborate*). Note that one study may play multiple roles simultaneously. The selected set of the 70 studies that provide the detailed information were synthesized for *RQ2*.

Figure 5: Dimensions of ethnography's roles in SE

5.2.1 To Inform How Practitioners Perform Software Practices Following Processes, Methods and Practices. There are 42 (out of 70) studies that address this role. SE is a rapidly evolving discipline in which many methods and technologies are proposed over years. How these methods and technologies make effects on the SE practices can interest ethnographers in gaining the insights into culture and community levels. For instance, Agile methods were proposed to meet the need for addressing the problems of change, speed, and uncertainty. To be specific to the practices of eXtreme Programming (XP), Sharp and Robinson [74] proposed an overview of the process with XP practices and further concluded some characteristics of XP culture based on the ethnographic data collected from daily activities such as attending meetings, pair programming, lunch and so on. Different human actions between XP team and non-XP team were generated and the advantages of XP for software process were identified [13]. The significance of physical artefacts is emphasized based on how the story card and the Wall, two key artefacts in XP practices, can benefit [75]. We found 52 ethnographic studies investigated the effects of agile methods and other software methods or practices, such as test-driven development [64], copy-and-paste programming [46]. There are 19 studies that address this role with concerns on process adopting technologies (including models, frameworks, systems and so on). The use and evolution of software quality management systems [76] and knowledge management systems [31] can contribute to the evolution of process.

5.2.2 To Propose New Technologies or Evolve Technologies (E.g., Model, Architecture and Algorithm). We identified 28 selected studies taking this role. These studies focus on creatively producing something new with technologies. Ethnography enables researchers to obtain relevant and sufficient data in real environment to propose new techniques or make improvements. For instance, developing cultural models that can cover different factors of a global software organization [72]. Also new approaches can be proposed by combining other techniques based on the ethnographic data. For example, Amorim and Mendonça [1] proposed a new approach which supports the reuse of technology in large software companies through being immersed in the daily activities of a project group.

5.2.3 To Inform the Impact of Environment (E.g., Geography, Specific Time and So On) on Human. This role is supported by 28 selected ethnographic studies. Ethnographic methods are able to collect rich data from the real environments where the development takes place from the insider's perspective, which can be of great help to understand the impact of environment. Ethnographers are able to take a variety of issues into account. For example, geographical issues (e.g., whether the distance matters in a distributed software project [8]), the issues related to specific time (e.g., the impact of deadline pressure on testing [71]), and the issues related to organization scale (e.g., assessing the HCI practices in small-medium companies [56]).

5.2.4 To Inform the Behaviors or Interactions of Human in the Collaborative Team Work. This role is observed in 29 selected ethnographic studies. As SE is a human-centric undertaking, the behaviors of and interactions among practitioners can result in a significant impact on projects. By taking the dual-role as participant and observer, SE ethnographers can experience these activities to reveal an in-depth understanding of their behaviors and interactions. For example, the ethnographic studies on the impact of disruptions between project manager and developers [44] and how to construct a collaborative ecology in a team [55].

5.3 Challenges of Doing Ethnography (*RQ*3)

Ethnography originated in anthropology and sociology. When adopting this research method in SE, some issues and challenges emerging from experiences were mentioned in the reviewed studies. We aggregated the challenges of performing ethnography in SE and discuss the majors in four phases of an ethnographic study: choice of method, design phase, execution phase, and reporting phase. To gain an overall understanding of the challenges in adoption, the complete set of the 137 studies was synthesized for *RQ*3.

5.3.1 Choice of Method. The divergence at study scope between SE and social sciences. The original definition of ethnography may confuse SE researchers to mistakenly ignore its value in researching SE practices. When it originated in anthropology, ethnography was defined as a method with the aim at obtaining a big picture of a culture, in which its research object can be a country or a race. Obviously, this is not a common case of interest in SE. Zieris and Prechelt [88] address their understanding of ethnography in reply to our inquiry: *"To me, 'ethnography' is about understanding the 'culture' of a group of people, ... We, in contrast, didn't care much about the bigger picture of the culture of the team's we recorded sessions in."* (Sr in Figure 1) They claimed that ethnography is not a good characterization for their research to some extent as they have a different purpose from the original ethnography. This implies the intrinsic differences between SE and anthropology may lead to the difficulty in adopting ethnography in SE. When coming to SE, ethnography tends to study its research objects in a relatively constrained and smaller scope, e.g., a project and a software company. In such cases, a panoramic vision may turn to be not a pursuit.

5.3.2 Design Phase. How to select a case with proper duration in an ethnographic study in SE. Traditionally, a long-term participation is necessary in an ethnographic study to discover the environment and obtain enough data for research. It is recommended that a period of at least 6 months is necessary for an ethnography [35]. As shown in Figure 4, although the median of durations of ethnographic studies in SE is 8 months, the distribution is significantly wide ranging from 1 to 48 months, with 32 (36.4%) studies significantly shorter than 6 months. We noticed that in some short-term (less than 6 months) ethnographic studies, the project duration became the constraint against a long-term ethnographic study. For instance, a 3-week ethnographic study in which the iterations of the agile projects only last 3 weeks [74]. As a result of the short period, some elements of practice may be missed though the ethnography covered a broad range of typical activities. Moreover, ethnography is time-consuming on both data collection and analysis. An ethnographic study which spent 5 weeks on collecting data lasted over 3 months [9]. Some researchers confirmed that an ethnographic study is too time consuming for practitioners, which makes it hard to be interested and focused [9].

5.3.3 Execution Phase. We identified three challenges associated with ethnographic observation, which is the key to ethnography: 1) *the difficulty to perform a complete participant-observation*; 2) *the effect of ethnographer's participation on other members*; and 3) *the trade-off between the insider's and outsider's perspectives.* Ethnographic studies in SE are generally based on the investigation on activities of practices in software projects [73]. To implement the member's point of view, participant-observation is emphasized in ethnography. When ethnographers from outside conduct an ethnographic study in a company, there is a risk that they may not be able to do participant-observation study as they want. Sometimes they can participate in activities only by invitation, which is called limited participation [78]. Limited participation can help get an insight of insider, but may lead to lack of enough ethnographic data from a limited insider's perspective. Besides, the newcomer's participation and observation inevitably has certain effects on other's activities to some extent, then affect the quality of the collected data. In contrast, ethnographers can be a real insider in their ethnographic studies [11]. They are the members of the studied projects before an ethnography study. While ethnography emphasizes the importance of the member's point of view, it aimed at revealing the insights from both insider's (practitioner) and outsider's (researcher) perspectives. SE ethnographers may lose the outsider's view if they have an insider's insight before the ethnographic study [59].

5.3.4 Reporting Phase. The level of detail and completeness of the description. Thick description is a signature feature of ethnography. An ethnography is often reported as a story in which a detailed description of what the ethnographers observe is included. When it comes to the most important data, quoting word by word is necessary. From the review, 43% (59) reviewed studies quoted the collected ethnographic data in their reporting, e.g., conversations in interviews [83], word by word to different extent. However, too much information collected may also introduce much noise data and make analysis hard and time consuming.

6 DISCUSSION

Our study has provided empirical evidence that whilst there are an increased trend of ethnographic studies as well as an increased recognition of their potential value in SE, the adoption and the

Table 5: The checklist of specific considerations for doing ethnography in software engineering

Design Phase

- □ What *organizations* or *teams* will you study? What *environment* do they have? Why do you study them?
- • Describe the research *object* (e.g., what kind of *culture* the organization claims it has, the ongoing *software projects* in the organization, *who* is involved in the organization and what *links* do they have outside the organization)
- □ *What things* and *who* will you focus on during your study?
- • State the *key person*(e.g., Project Leader, DevOps Consultant) you studying in the organization and explain the *relationship* between you and him/her.
- □ *How much* do you know about the organization before your study? How much *effort* will you spend on *learning* the organization?
- • State the *way* you getting the *knowledge* of the organization (e.g., by *official document, network, others' introduction*).
- □ *How long* will your study last? Is it *enough*?
- • State the duration of your study. *8 months* is the median of the duration in SE, *check* whether your statement use the range time or not if your duration is far less than it.
- • If your duration is still far less than the proposal, studying *more examples* in the similar environment (e.g., the same team's different project) is necessary.
- • Or explain *in details* why your study can support the *result* of the human aspects in the *software projects*.

Execution Phase

- □ How will you *enter* the organization (e.g., *introduced* by a member, *on your own*)? Will your entering disturb others' normal work? If so, how big is the impact?
- • State the *way* you enter the organization, and analyze the *effect* by the way. If you become a member of the project you study, describe your *contribution* to the project.
- □ *Who* will collect and analyze the data, one researcher or more? If the latter, who will do what and how can their work be *coordinated*?
- • Detailed instructions are needed in the ethnographic research. The participation of researchers in the project will affect data collection.
- □ What *data* will be collected (e.g., the *recording* of interviews, the application *log*, daily *documents*, *videos* of meetings)? *How* and *when* will the data be collected? What is the *connection* between these data and the environment?
- • The data generated by the software organization is huge, you need to explain what you need and make a full record.
- • Describe the data collection *methods* you used in your study (e.g., interview, participant-observation, questionnaires).
- • If interview was used, the *recording* should be transcribed and the *voice speed, tone, emotion, and background* of the interviewee should be recorded.
- • If participant-observation was used, *every detail* of the *participant's daily life* should be recorded (e.g., *when, where, and where* an observation began and ended).
- • Software logs should be considered if necessary.
- □ How many *aspects* of the organization can your data show? What are they and why these aspects can be shown?
- • Describe how your data reflect the organization and explain the *meaning* of the data.
- • *Triangulation* is an important strategy of the traditional ethnography. You need to find aspects as many as possible to understand *more completely* the part a member plays in *software projects*.
- □ Will you put your own experience into the analysis? Are you *biased* against data when analyzing?
- • If you are a software engineer at the same time as an ethnographer, you will be *biased* against some data (e.g., missing some *important* but *unmarkable* details).
- • State what may *influence* your analysis and give an *explanation*.

Reporting Phase

- □ *Where* do you need to *quote word for word*? How much should this part be?
- • Thick description should be used to portray a variety of scenes and episodes during a software *process*. But *verbatim quotations* should *not* be used everywhere, limited verbatim quotations should be used in some uncommon details.

methodological improvement of ethnography in SE are still immature compared to other disciplines. Many definitive works on ethnography focus more on study design, data collection and analysis in its origin and closely related disciplines, e.g., social sciences, but such studies did not consider and effectively support the intrinsic nature and context of SE different to other disciplines. We therefore provide some guidance organized as a checklist to help better design, execute, and report ethnographic studies in SE.

6.1 Understanding of Ethnographic Research

Based on our SLR, we can assert that ethnography has contributed to the development of empirical software engineering. As an interdisciplinary field, human takes the central role in software development. Ethnography provides effective lens to research on human, no matter in society or in software development. That is why the trend of ethnographic studies in SE is growing rapidly as shown in Figure 2.

Our analysis of the combined data reveals that there is incomplete understanding of ethnography in the SE community. Runeson et al. [67] consider ethnographic study as a type of case study. Their point was observed in 19 ethnographic studies too, in which the researchers claimed that they conducted a case study and ethnographic methods were adopted as data collection tools. There are also some replies which claim ethnography is a method for data collection and analysis. Such claims ignore some unique aspects of ethnography. To be specific, the understanding of ethnography as merely a data collection method overemphasizes 'thick description' of ethnography. On the other hand, taking it as a method only for data analysis does not help understand ethnography. As what the authors of one ethnographic study replied to us: "*Ethnography is the approach that helps to plan your study, collect the data, interpret the data, and uncover the insights...a researcher can use different frameworks and models to execute the specific steps.*" Analytical stance is also an important feature of ethnography, but missing in many studies. To improve the data analysis, some techniques from the other qualitative research methods, e.g., techniques from grounded theory can also be incorporated with ethnographic methods. In reporting ethnographic studies, we observed that the level of thick description may be directly limited by the page limitation. Doctoral theses and journal articles usually offer good and rich descriptions of the used methods and processes. Hence, ethnographic studies can be better reported in journal articles.

6.2 Considerations for Doing Ethnography

The intrinsic differences on the nature between SE and other disciplines have to be seriously considered when adopting ethnography in SE. We discussed the major challenges in *four phases* of an ethnographic study extracted from the reviewed studies. When adopting ethnography, different researchers may possess different ideas and different projects would encounter different problems. To avoid method slurring and support the novices in SE, we offer three broad recommendations.

First, *be prepared to conduct a long-term ethnographic study*. As several authors have noted (cf. Section 2), to write a culture, researchers need a relatively long period (often for many months) to study it [73]. When comes to some software projects with short cycles, such as agile projects, researchers should not focus only on

single project itself, more stuff (e.g., pre-projects, post-projects and the team's other projects) should be considered too [13, 52].

Second, *pay more attention to the use of single ethnographic method.* Ethnography can discover a deeper understanding from human aspects to participant's experience in SE [38]. However, it might be difficult for an ethnographer to apply multiple ethnographic methods at the same time. In order to achieve the purpose for a deeper understanding, a single ethnographic method like participant-observation or interview can be used as a preliminary attempt in ethnographic studies [43, 45, 62, 72].

Third, *consider online ethnography or netnography seriously as options.* In SE, online environment has become common in global and open source software development. Although ethnography is traditionally recognized as a method based on face-to-face interactions, under certain circumstances, the online environment can be also defined as the natural setting of an organization [50, 57, 77].

6.3 Checklist for Doing Ethnography in Software Engineering

When doing ethnographic research, some featured properties of traditional ethnography (cf. Section 2) have to be considered in advance, such as *when and where the study should take place? what should be studied? how they should be recorded? how different researchers work together? what should be report?* and *how the report should be organized?* Seeking the answers to these questions can help understand ethnography and pave a basis for further learning. For beginners of ethnographic research, it could be extremely important to know more about with the background of ethnography. Some textbooks from social sciences (e.g., [25, 32, 34]) would be more persuasive if researchers want to conduct a full ethnographic research. For SE researchers who want to use ethnographic methods as a component of their research strategy, our findings about the roles of ethnographic studies (Section 5.2) might be more relevant.

By combining our findings (Section 5) with the featured properties defined in traditional ethnography, we made adaptable changes specific to SE and provide a preliminary checklist of the systematic considerations for doing ethnographic research in SE (Table 5) in terms of the three phases of an ethnographic study (design, execution, and reporting). The changes come from our findings about the use of ethnographic methods (Section 5.1) and challenges of doing ethnographic research (Section 5.3), for example, giving a median duration (8 months) in SE as a reference instead of the recommended minimal duration (6 months) in social science.

6.4 Limitations

We have identified some potential limitations of this study. We strove to mitigate the potential impact of the identified limitation. To reduce the threat of inclusion and exclusion criteria that may directly affect the quality of our data, we firstly defined a rigorous search strategy and kept improving it several times during the review, then applied the multi-steps selection process done by three researchers working independently.

During the pilot data extraction, we found that the authors of some studies did not describe the details of how they had used ethnographic methods and their understanding of ethnography. In order to remedy this issue, we adopted two strategies: to enquire the authors of the reviewed studies via email to supplement the data extracted from the reviewed papers; to include doctoral theses for review as they offer more details of the used ethnographic methods. The real time for collecting the ethnographic data also depends on the observation frequency that varies a lot among the reviewed studies. In calculating the observation time, a clear explanation of the actual working time is missing in many of the reviewed studies.

7 CONCLUSIONS

Ethnography has demonstrated its potential as an important component in SE research. While ethnography is aimed at studying culture, ethnographic methods can be adopted as a supplement technique for data collection and analysis. However, ethnographic methods have not been widely adopted in SE as there is an absence of guidelines on how to conduct ethnographic research. This study aims to establish a systematic understanding of the state-of-the-practice of ethnographic research in SE, to call the community's attention to the use of ethnographic methods, and to offer methodological support to improve the quality of ethnographic studies in SE. Through providing a primary view on the ethnographic methods, this paper can help researchers better understand ethnographic research with the support of experts in ethnography from other discipline, especially social science.

Based on the synthesis of the data extracted from 137 ethnographic studies in SE, this paper reports on how SE researchers used ethnographic methods in terms of the four signature features, i.e. the member's point of view, thick description, analytical stance, and study duration. It is noticed that most ethnographic studies in SE are related to investigating human and social factors. We identified the fine-grained four roles of ethnographic studies in SE by contextualizing the central concepts of the reviewed studies: 1) to inform how practitioners perform software practices following process, method and practices; 2) to propose new technologies or evolve technologies; 3) to inform the impact of environment on human; and 4) to inform the behaviors or interactions of human in the collaborative team work. Corresponding to the features of ethnography, the major challenges across the process of ethnographic study have been discovered. Additionally, we noticed and discussed the lack of consistent understanding of ethnography in SE.

Whilst our findings may raise the awareness about the current state of the use of ethnography in SE, our effort also contributes to the methodological improvements in empirical software engineering in general, and qualitative research in SE in particular. The findings from this study have enabled us to propose a checklist of considerations and recommendations for conducting ethnographic research in SE. This checklist can offer a general view of an ethnographic study while researchers consider ethnography as an option of their qualitative inquiry. We expect that this checklist will help improve the state of the use ethnographic research methods in SE.

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