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Reflections on Supervising the Postgraduate Students' Design Science Research Thesis

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ABSTRACT

Design science research (DSR) is an appropriate method for postgraduate-level (MSc) thesis work, where the students need to combine and apply theoretical knowledge and hands-on skills to solve practical problems. Students face considerable challenges, however, when applying DSR in timeboxed situations with limited competences. In this paper, I reflect on my experiences supervising more than 200 MSc theses, many using—and some that intended to use—DSR. My reflections provide teaching tips to educators and supervisors and show a need for new DSR process and evaluation methods.

Keywords: Design science research (DSR), Postgraduate education, Supervisor, Reflection, Teaching tip

1. INTRODUCTION

Engineering education aims at equipping students with both theoretical knowledge and hands-on capabilities to solve practical problems so that, after graduation, they are "ready to engineer" (Crawley et al., 2007) various societal challenges (Brophy et al., 2008). Nowadays, engineering education has moved away from "chalk and talk" to problem- and project-based learning, where students use different learning methods in their studies (Mills & Treagust, 2003).

Information systems (IS) education is no different. It shares the characteristics of solving and engineering practical problems in projects and combining theoretical knowledge with hands-on (programming and other IT-related) capabilities (King & Lyytinen, 2006). To meet these needs, the goal of gaining and combining theoretical understanding and hands-on skills in problem-based projects makes the application of design science research or its sister method, action design research, beneficial regardless of discipline (Goldkuhl et al., 2017; Hevner et al., 2004; Sein et al., 2011; Thuan & Antunes, 2022).

IS education has embraced design science research (DSR) (e.g., Goldkuhl et al., 2017; Thuan & Antunes, 2022; Winter & vom Brocke, 2021). These studies focus on using it as a means to "prepare students for professional practice or research (or both)" (Thuan & Antunes, 2022, p. 467). In other words, this method aims to provide hands-on skills for research and practice. Research orientation is emphasised, as "most studies consider DS[R] as a research tool, and thus teach students on how to integrate DS[R], in particular DS[R] methodology, in their research studies" (Thuan & Antunes, 2022, p. 468). This research orientation is also evident in Winter and vom Brocke (2021), who identified several challenges in teaching DSR. Although different approaches, such as learning principles (Goldkuhl et al., 2017), a curriculum (Hevner, 2021), and intensive industry collaboration (Knauss, 2021) have been proposed, the IS education literature on DSR mostly focuses on doctoral education and not on identifying problems or giving tips to postgraduate students or their supervisors (Thuan & Antunes, 2022).

At the same time, I have observed over the years that Master of Science (MSc) students face considerable challenges using DSR methods in their theses, ranging from inadequate methodological or contextual understanding to problems with scheduling, data access, third party communication, and writing and structuring DSR studies. Unfortunately, to my knowledge, no teaching tips, lessons learned, or studies that report and analyse challenges and propose ways forward have been reported.

This motivated my short reflection paper. I aim to provide teaching tips for dealing with the issues postgraduate students face when undergoing their MSc thesis research work. My 25 years of experience supervising over 200 MSc students in information systems sciences, in which about a fifth used DSR or the constructive research method, and about two-fifths used some characteristics of DSR in their theses, provides a good basis to reflect on the students' challenges with respect to their goals and process. I focus especially on the MSc (engineering) theses, their objectives, research settings, and limitations, and how students have carried out and reported their studies. This paper thus seeks answers to the following research questions: *What are the pitfalls in using the DSR in postgraduate education, especially in the master's thesis, and how to cope with them?*

The study provides insights and tips that are helpful for IS educators to apply the DSR approach in their students' work, and for DSR researchers and practitioners in further developing the method.

This paper is organized as follows. First, the context is described, including a short summary of Finnish university education in general, as well as the objectives and goals of an MSc thesis. Reflections follow and the paper concludes with a discussion.

2. CONTEXT: THE MSC THESIS IN FINLAND

When students enroll in Finnish universities, they are immediately granted the right to complete both undergraduate and postgraduate degrees. Consequently, all stakeholders—teaching faculty, students, and their future employees—perceive an undergraduate degree and corresponding bachelor's thesis just as a milestone towards a greater goal. This perception is evident in the curriculum, which is supposed to be completed in five years. Studies, however, are divided into two categories: a bachelor's degree and a subsequent master's degree. Usually, the bachelor's degree, composed of 180 ECTS (European Credit Transfer and Accumulation System), takes three years to complete, while the master's degree lasts two more years and is credited 120 ECTS. Theoretically, 60 ECTS corresponds to one year of full-time work, which is 1,600 hours. One ECTS is thus equivalent to approximately 27 hours of study.

In the Faculty of Management and Business at Tampere University, students must complete both the bachelor's thesis (10 ECTS) and the master's thesis (30 ECTS, which equals six months of full-time studies). The BSc thesis is usually a literature review used to teach basic academic practices, such as seeking information, writing, making citations, building an argument, and summarizing and synthesizing articles, in addition to content-related objectives. However, the goals of the MSc thesis[1] are broader and more abstract:

- The student is familiarised with his/her field and especially the field of his/her thesis topic.
- The student possesses the skills necessary for applying scientific knowledge and methods.
- The student has good communication and language skills that can be applied in his/her field and other applicable fields.

This paper finds the second goal—the ability to *apply* scientific knowledge and methods—significant. The goal does not state that students have to create new knowledge but just apply the scientific method to engineer practical problems.

Every student has formal supervisors (one for BSc and two for MSc) and possibly several informal commentators. The thesis work is supported by seminars with presentations and opponents, and by courses on information retrieval and research methods, for instance. As the BSc thesis is a literature study, I will next focus on the MSc thesis and its process.

My IS science students work towards an MSc (engineering) degree. This engineering orientation places a slight emphasis on practical contributions, for example, through practically useful or patentable results[2]. This emphasis is apparent since the vast majority (about 90%) of MSc theses are done by external companies' commissions[3]. Very often, these companies seek solutions to non-trivial problems or experiences from new technologies. For example, recent topics included requirements for data catalogues, data warehouses, document management, or enterprise systems; several data-analytics and robotic process automation (RPA) experiments; and countless business, management, administration, or reporting process improvement studies. They aim to help the companies, usually not by changing the processes or taking new technologies in use, but by making proposals for new processes or practices, for how to get the best out of certain technologies, or by introducing frameworks and models for identifying or evaluating risks or benefits. Despite these pragmatic needs and topics, the best MSc theses make theoretical contributions that may lead to academic publication (e.g., Ylinen & Pekkola, 2018; Mäki-Lohiluoma et al., 2016). Theoretical and practical orientations and contributions are thus not exclusive, although the theoretical contribution is always a nice surprise.

Although, at times, companies approach professors and seek out candidates for cheap or future labour, students themselves are responsible for finding a topic and a research setting (company) for their thesis. Sometimes, the company gives a rough idea—an experiment with RPA to see whether it has any use ([T1] in the Appendix)—without specifying any need. Sometimes the thesis is a part of a bigger project, such as a manufacturing execution system (MES) renewal where the thesis is a transition plan to minimize production breaks [T3].

After the initial topic is identified by the student and/or the company, it is sharpened in a three-party negotiation where the student, company, and supervisor(s) iterate the topic to a researchable scope that fulfils both academic criteria and the company's needs. During this discussion, the research objectives, settings, limitations, and how to carry out and report the findings are defined. This includes explicit objectives or outcomes (e.g., increased understanding or instantiated DSR artefacts such as a framework, some instructions, a check-list, or a requirement specification (Iivari, 2007; March & Smith, 1995; Offermann et al., 2010; Peffers et al., 2018; Weigand et al., 2021)), deliverables (a thesis, some presentations, executive summary, program code, etc.), research process and methods (securing data access, and data collection and analysis methods), and a schedule with milestones. All of this is written in a research plan.

Sometimes, the topic, thesis objectives, and schedule point towards the DSR being a viable methodological option. Next, I will present my reflections on supervising more than 200 engineering MSc students who have used or intended to use DSR in their IS-related MSc theses. As the topics, companies, and their needs vary a lot, no typical composition of research problems, artefacts, research strategies, evaluation methods, entry phases, or contributions can be defined.

3. SUPERVISION EXPERIENCES AND REFLECTIONS

Conducting a DSR study and reporting it in the form of an MSc thesis is not an easy task. Despite the company's given problems, the research topic usually needs to be significantly refined to fulfil scientific criteria. March and Storey (2008) argued that DSR research requires the following: "*(1) identification and clear description of a relevant organizational IT problem, (2) [where] no adequate solutions exist in the extant IT knowledge-base, (3) development and presentation of a novel IT artifact (constructs, models, methods or instantiations) that addresses the problem, (4) rigorous evaluation of the IT artifact enabling the assessment of its utility, (5) articulation of the value added to the IT knowledge-base and to practice, and (6) explanation of the implications for IT management and practice*" (p.726).

Postgraduate-level research, however, is limited by number of constraints ranging from the DSR process phases (see Peffers et al., 2007)—problem identification, objective setting, design, and development, demonstration, and evaluation—to the thesis project management—scoping, data access and adequate resources, and limited timetables.

3.1 Problem Identification

The companies seek practical and applicable solutions. They usually have problems that they want to solve. Yet, it is rarely a scientific problem, but it is the cause of some fundamental underlying issue or something they want to experiment with before making any significant investment. Consequently, there is a need to decide whether the thesis aims to solve the original problem or identify/study its root cause. This decision is usually made outside the thesis research work as a taken-for-granted starting point.

3.2 Objectives and Scope

The company thus seeks a solution—a DSR artefact that meets their needs. For example, they may want to investigate RPA potential [T1] or its governance challenges [T2] to learn how they can make the best out of new technology. The DSR artefacts are a set of RPA software prototypes and a preliminary governance model, respectively.

The topics, however, are usually not easily defined. Quite often, the topic emerges from a larger company project or development initiative with several options and needs to be defined so that the thesis can make a practical contribution to that project. This may take place by narrowing a larger problem down into a manageable topic (e.g., [T3] where the topic was narrowed down from a problem of minimizing production breaks to developing training material) or scaling a small trivial problem up into a more researchable topic (e.g., [T4] where the RPA development work (typical software development) was expanded to IS development method development). Nevertheless, the research problem is rarely an executable research topic but requires some alterations, setting of limitations, and focusing so that the thesis can make both practical and theoretical contributions.

3.3 The Artefact and Its Design

The theses aim to construct different DSR artefacts. Over the years, they have ranged from software components [T1, T2] and methods [T4] to frameworks, instructions [T3], process descriptions [T5], and business models [T6] (see also Iivari, 2007; Peffers et al., 2018; Weigand et al., 2021). This diversity parallels Baskerville et al. (2018), although the students' field of study emphasises organizational settings and their IT-related problems. This has an impact on the artefact and its scope: they are usually proof-of-concepts and models-to-be-implemented, resulting from one iteration cycle and not ready for production, nor able to change the organization or its IT landscape or various practices and processes (unlike with action design research (Sein et al., 2011)). This limitation has several reasons: the company does not want to risk their systems and processes with the students' research projects; organization-wide commitment is missing, so the artefact is made just for a department or even a person; there are no appropriate resources, data, or skills and competences; or the thesis project's schedule does not fit with the company's bigger plans. The artefact is thus just a limited proof-of-concept, serving as an example of a solution to the organization's narrowed problem.

3.4 Demonstration and Evaluation

Artefact evaluation is critical in DSR (Venable et al., 2016). According to my experiences, this is the most difficult part of the MSc thesis since companies are often just pleased with any solution, and do not care whether the artefact is the best of the breed or perfectly applicable. Quite often, companies want preliminary results in three to four months so that they can advance their plans, leaving the rest of the "academic work" to the student.

Another reason is the schedule. The thesis work usually takes place within a six- to nine-month timespan so there is no time for the artefact design, development, implementation, use, and evaluation. This issue is stressed when the thesis is supposed to contribute to a bigger project with its own commitments, schedules, resources, and partners—such as system vendors. For example, the thesis [T3] was significantly delayed due to the new system and its development challenges. The evaluation becomes very difficult due to a narrow scope or missing organisational commitment.

These difficulties may lead to the DSR theses being finally reported either as case studies with no artefact evaluation or as DSR studies with a "weak market test" (Kasanen et al., 1993). The weak market test means that key stakeholders are asked whether they would use or apply the artefact without asking them to actually use or apply it.

Under these circumstances, not much can be said with scientific confidence about the artefact and its utility, quality, and efficacy (Hevner et al., 2004; Venable et al., 2016). The artefact nevertheless provides a novel solution to a practical and relevant problem in a particular context, and the student has demonstrated the ability to apply research methods. The study may have only marginal scientific value, but it still fulfils the criteria for the MSc engineering thesis.

3.5 Data Access and Resources

Sometimes, the topic, problem, and objectives require a large set of data. This is especially the case with data-analytics theses, where data is needed as a basis for a pricing model [T7] or a customer segmentation model [T8].

Data access becomes problematic when all desired data are not accessible. This limits the artefact (model), as happened in [T7]. Similar issues may also occur in the artefact design and evaluation: there may not be enough informants to gain the requirements or validate the design. The artefact could be built for a small team or even for a person (e.g., [T5]). Data access thus shapes the artefact and its design, features, implementation, and evaluation.

Similarly, various resources, skills, and competencies influence the thesis. The company may lack the resources or commitment, or the student may not have all necessary skills (e.g., a certain programming language). This evidently limits the study and its objectives.

3.6 Time

The greatest constraint could be time. Thirty ECTS equals approximately 800 hours of work. These hours include everything: finding the thesis topic, defining its objectives, writing a research plan, studying the literature, designing, developing, demonstrating, and evaluating the artefact, reporting all this in the thesis, and holding numerous meetings with company representatives and supervisors. This is supposed to take place over a semester (five months), although the thesis project usually takes from six to nine months.

The 800-hour time allocation and the six-month timespan set quite strict boundaries for the thesis project. This is not usually a problem with case studies, surveys, or experiments, but it significantly hampers the use of DSR, especially when the

thesis topic is aligned with the organization's own development. Bigger external projects have their own schedules. Even if the schedules and project plans are aligned, any delay or problem in the bigger project evidently increases risks in the thesis project. For example, missing artefact evaluations (due to significant delays in big projects) have resulted in several last-minute changes in the thesis. These theses are then reported as case studies rather than DSR studies. Thus, the research methods are easily superimposed, not reflecting the student's in-depth methodological understanding. Under these circumstances, the student only has bad options: show an incorrect understanding of the DSR method due to missing artefact evaluation, or limited understanding about the case study method as the data is compelled into incompatible form, or prolong the thesis project, which may create problems with other studies. For the latter, it is important to note that project management is a grading criterion in the MSc thesis.

Certainly, time constraints and risks are discussed and considered at the beginning of the thesis project. The dependencies on other projects or an optimistic view on data access may later turn out to be problematic, leading to major changes in the study. To minimise the risk of subsequent changes, the appropriateness of the research questions and research methods are monitored constantly and modified accordingly. An initial DSR study may be changed to a case study without artefact evaluation, alternative data sources are considered when dependencies with other projects or partners are seen as too risky, or the scope of the artefact or the extent of its evaluations are downsized.

4. DISCUSSION, TIPS, AND CONCLUSIONS

It is indeed possible to conduct an MSc thesis project by using DSR. There are several constraints, however, that need to be considered. Supervisors may help students either by increasing their awareness of issues or by steering their research activities.

The number of working hours and the timespan limit the use of DSR. A DSR project, with its several phases, can be very time consuming and resource intensive. This is not a problem with doctoral dissertations, which usually take three or more years to complete. With lower degrees, however, such as the MSc thesis that is supposed to be finished in six months, squeezing the DSR project phases (Peffers et al., 2007) into a much shorter timespan while simultaneously maintaining high-quality research standards becomes very difficult. The rigor of the DSR project is easily cannibalized by simplifying the artefact and/or its evaluation, simultaneously ruining its possible academic value.

On the other hand, MSc-level DSR projects solve practical and relevant problems (c.f., Knauss, 2021). Sometimes, companies' needs are not very risky to fulfil when, for example, a new technology and its potential are tested. At other times, practical relevance may become a major issue when the MSc project waits for input from a bigger project or aims to contribute to it. Although the MSc theses' results are immediately capitalizable, any problem, such as delays, personnel changes, or vendor issues, will significantly influence the MSc project, often resulting in major changes. This leads to the following teaching tips:

- At the beginning of the MSc thesis project, the whole DSR process (problem identification, objective setting, artefact design, demonstration, evaluation (Peffers et al., 2007)) and its details (scope, data access, schedule, workload, relationship to other projects and the company at large, and risks) must be discussed and mutually agreed upon by all three parties: the student, company, and supervisors. By doing so, the chances of later changes are lessened considerably.
- The research process and its progress and risks need to be constantly monitored by supervisors, perhaps even more intensely than with case studies or surveys.
- When challenges or pressures for change occur, the supervisor needs to help the student solve them: adjust the research methods or the scope of the study or of the artefact, change the DSR evaluation method or settings, prolong the schedule, negotiate with the company, or do other necessary tasks.

These tips are applicable basically in any type of thesis or dissertation. Supervising the MSc-level DSR thesis, however, is different. The student may not be capable of completing some tasks within the given timeframe or with the commissioning company. This is because of lack of experience with the research methods in general and on the DSR method and MSc thesis in particular, and project management related challenges that frame possible corrective activities. Under these circumstances, the supervisor's responsibility for guiding the student through the puzzling research landscape is emphasised. It is nevertheless in everyone's interest that the students finish their studies with appropriate competencies. Sometimes, the student may gain the competencies with low grades, for example, when methodological inaccuracies are penalised.

DSR projects are heavy and time-consuming. Although I usually instruct students to follow the Peffers et al. (2007) process model and use it as a template to report their studies, students often face severe problems. The six-month timeframe and 800 hours of work are not enough for a rigorous study, especially if the implemented artefact or the research setting are complex. Thus, there is a need for a lightweight process that makes it possible to apply DSR within a tight timeframe and smaller resources. Even if some of the earlier phases (problem identification, objective setting) are taken for granted, artefact construction and its demonstration and evaluation may become extensively difficult with a company or within a company setting. Thus, there is a need for alternative evaluation methods that still provide adequate understanding about the appropriateness and utility of the artefact. Pedagogically feasible approaches to reduce the workload would be to ask for an artefact evaluation plan but not its execution, or to evaluate the design decisions leading to the artefact (c.f., Sonnenberg & vom Brocke, 2012). Under these circumstances, however, the artefact's quality in terms of appropriateness or utility is not verified.

When MSc theses are commissioned by companies, the results are practically relevant. March and Storey's (2008) relevance criterion is thus fulfilled. In addition, the DSR MSc theses develop novel solutions for that particular context. The main problem emerges with scientific quality, e.g., the rigorousness of the evaluation and contributions to the knowledge base. In this sense, I touch on the old rigor versus relevance debate (Robey & Markus, 1998; Straub & Ang, 2011). I ask for increased emphasis on relevance, in at least a company commissioned MSc thesis that solves practical

problems with scientific methods. Have we got adequate methods in our arsenal?

This paper provides two contributions. First, my reflections and lessons learned offer teaching tips and help IS educators when they supervise their postgraduate (MSc) students who utilize DSR in their theses. This context has been little studied (Thuan & Antunes, 2022). In addition, this paper contributes to the DSR community by pointing out a need for lightweight DSR process examples and lightweight evaluation methods to produce scientifically lightweight but pedagogically heavyweight results[4].

The teaching tip paper has some limitations. First, it is based on my personal experiences. Although they are extensive (25 years and over 200 theses), the theses and their processes were not systematically analysed. The former students were not interviewed. Despite this personal touch, I have tried to make the reflections as transparent and objective as possible. Second, my experiences are derived from MSc projects done for external companies. This means that industry relations had their impacts. Such close collaboration with industry, however, increases the relevance of theses. Third, the Finnish context, requirements, and traditions frame the MSc theses, their requirements, how they are supposed to be carried out, and their contributions. Thus, these contextual issues should be carefully considered when applying the teaching tips and reflections to other contexts.

5. ENDNOTES

1. www.tuni.fi/en/students-guide/handbook/uni/studying-0/thesis/masters-thesis-technologyarchitecture
2. content-webapi.tuni.fi/proxy/public/2019-08/tampereen-yliopiston-yhteiset-diplomityon-arvosteluperusteet-eng.pdf content-webapi.tuni.fi/proxy/public/2019-08/tampereen-yliopiston-yhteiset-diplomityon-arvosteluperusteet_taulukko-eng.pdf
3. This also includes public and third sector organizations. For the sake of simplicity, I just group them under the term "companies."
4. This sentence was inspired by an anonymous reviewer's statement: "Lightweight DSR could be construed as lightweight research." Indeed, the goal of teaching the MSc students to apply a method may differ from the goal of producing scientifically rigorous results.

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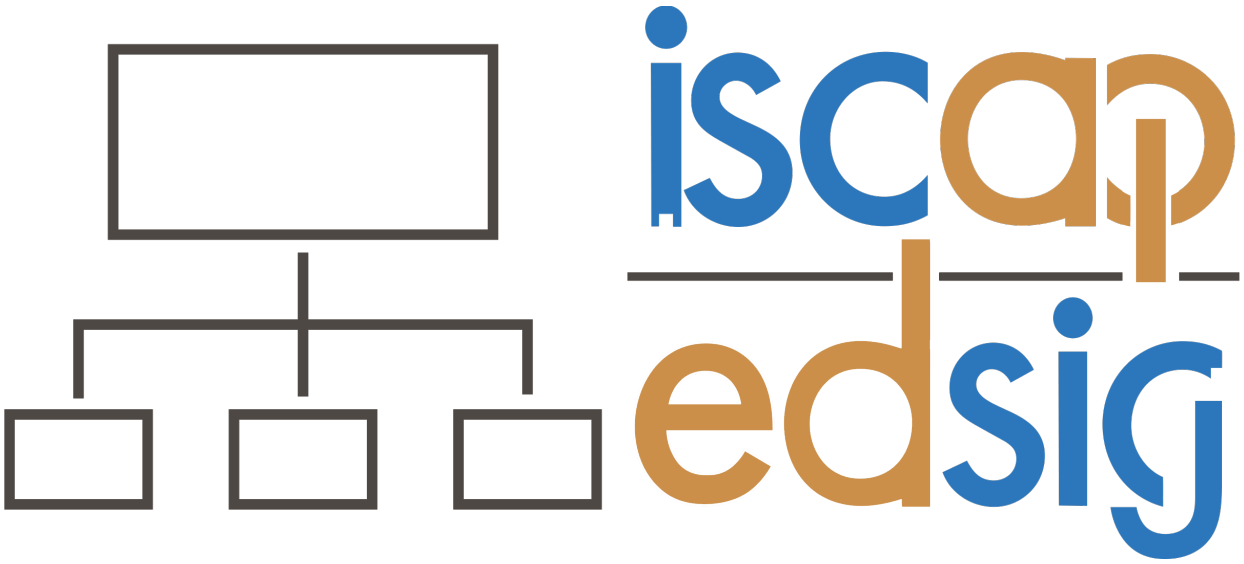
Samuli Pekkola is professor of information systems at Tampere University, Finland. His research focuses on users in different manifestations of information systems, their management and acquisition, and enterprise architectures. He is research articles have appeared in journals such as *Information & Management*, *Government Information Quarterly*, *Information Systems Journal*, *Decision Support Systems*¸ *Business and Information Systems Engineering*, *International Journal of Information Management*, and *The Data Base for Advances in Information Systems*, among other journals and conferences. He is past editor in chief of *Scandinavian Journal of Information Systems*, and past president of the Scandinavian Chapter of the AIS.

APPENDIX

The Theses Used as Examples

No.	Theses
T1	Helge Jalonen: Assessing robotic process automation potential (2017)
T2	Ville Madekivi: Governance of robotic process automation in order management communications (2021)
T3	Simo Tuupainen: MES käyttöönottoon liittyvän tuotantohäiriön minimointi ennakoivalla suunnittelulla ja koulutuksella [Transition plan to minimize production breaks in MES implementation] (in progress) (2023)
T4	Tero Mehtänen: Ohjelmistorobottien kehittäminen ja käyttöönotto ketterillä menetelmillä [Agile methods for RPA development and implementation] (2018)
T5	Kreta Korja: Developing a product master data management process (2019)
T6	Veli-Matti Uski: Industrial internet of things-driven business model for manufacturing companies (2018)
T7	Jenna Rajala: Building an agile data science process for applications in development stage (2022)
T8	Nico Ylirönni: Analysing customer data from customer relationship management system (2022)
Note: All are accessible in Tampere University digital library.	



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