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ENHANCING DOCTORAL SUPERVISION AND RESEARCH PRODUCTIVITY THROUGH OVERALL RESEARCH EFFECTIVENESS (ORE): A FRAMEWORK INSPIRED BY MAINTENANCE ENGINEERING

Hatem Algabroun
Departement of Mechanical Engineering, Linnaeus University, hatem.algabroun@lnu.se

Abstract

Doctoral research is a complex and non-linear process that requires effective supervision, time management, and continuous quality assurance. This paper introduces the Overall Research Effectiveness (ORE) framework – adapted from Overall Equipment Effectiveness (OEE) in maintenance engineering – as a conceptual model to enhance doctoral research productivity and support structured supervision. The purpose is to examine how supervisors can use ORE to structure and guide doctoral supervision in ways that enhance time use, task efficiency, and research quality. ORE adapts principles from maintenance engineering to doctoral research supervision by treating supervision as a central mechanism to improve research time usage (availability), efficiency (performance), and scholarly outcomes (quality). Although the paper is conceptual, the framework is illustrated using a hypothetical example informed by typical supervisory challenges observed in doctoral education, particularly within mechanical engineering contexts. This example demonstrates how ORE helped the supervisory team improve workflow visibility, identify delays, and enhance the quality and frequency of feedback. The paper argues that ORE enables a more transparent and adaptive supervisory process, helping both supervisors and students better navigate the non-linear and iterative nature of doctoral research.

Keywords: Doctoral Research Efficiency, Lean Research Methodology, Overall Research Effectiveness (ORE), PhD Supervision and Productivity, Time Management in Academia.

Hatem Algabroun

Sammanfattning

Doktorandforskning är en komplex och icke-linjär process som kräver effektiv handledning, god tidshantering och kontinuerlig kvalitetssäkring. Denna artikel introducerar ramverket Overall Research Effectiveness (ORE) – anpassat från Overall Equipment Effectiveness (OEE) inom underhållsteknik – som en konceptuell modell för att förbättra forskningsproduktivitet och stödja en mer strukturerad handledning. Syftet är att undersöka hur handledare kan använda ORE för att strukturera och vägleda handledningen på ett sätt som förbättrar tidsanvändning, arbetsflödets effektivitet och forskningens kvalitet. ORE anpassar principer från underhållsteknik till handledning inom forskarutbildning genom att betrakta handledning som en central mekanism för att förbättra forskningens tidsanvändning (tillgänglighet), effektivitet (prestation) och vetenskapliga resultat (kvalitet). Även om artikeln är konceptuell illustreras ramverket med ett hypotetiskt exempel som bygger på typiska utmaningar i handledning inom doktorandutbildning, särskilt i mekaniktekniska sammanhang. Exemplet visar hur ORE hjälpte handledarteamet att förbättra synligheten i arbetsflödet, identifiera förseningar och höja kvaliteten och frekvensen i återkopplingen. Artikeln argumenterar för att ORE möjliggör en mer transparent och adaptiv handledningsprocess som hjälper både handledare och doktorander att bättre navigera i den icke-linjära och iterativa forskningsprocessen

Nyckelord: Doktorandhandledning och produktivitet, Effektivitet i doktorandforskning, Lean forsknings-metodik, Overall Research Effectiveness (ORE), Tidsplanering inom akademin.

Introduction

Doctoral research is a complicated process that requires effective time management, resource allocation, and consistent quality output. However, it might be challenging for PhD candidates to balance these aspects due to the intrinsic complexity of research and the varied responsibilities they have (Stigmar & Edgren, 2017). Many PhD candidates encounter persistent challenges that inhibit their productivity and progress, including unstructured supervision, unclear goals, administrative delays, and poor time management. These issues often result in inefficient research workflows, extended timelines, and in some cases, compromised research quality (Al et al., 2014; Auer, 2023; Stigmar & Edgren, 2017). Despite widespread awareness of these difficulties, supervision practices and doctoral support structures often lack the tools and frameworks needed to manage and respond to these challenges systematically. As a result, supervisory support remain largely informal and highly variable across institutions and disciplines.

In maintenance engineering, structured frameworks like Overall Equipment Effectiveness (OEE) have long been used to systematically assess and improve productivity. This paper proposes that a similar logic can be applied to doctoral education by introducing a framework that supports both structured supervision and research progress. Hence, the purpose of this paper is to introduce Overall Research Effectiveness (ORE) as a conceptual framework for enhancing the availability, performance, and quality in doctoral research, factors that collectively support higher research productivity. While the framework

focuses on improving doctoral research outcomes, its practical implementation centers on supervisors, who are positioned to identify inefficiencies, support time planning, and promote reflective progress through the application of ORE. The research question is formulated as follows: *How can principles derived from Overall Equipment Effectiveness be adapted to the supervision of doctoral research to improve availability, performance, and quality, while maintaining the flexibility necessary for academic inquiry?*

Overall Research Effectiveness (ORE) Framework

OEE measures the effectiveness of production process by evaluating the uptime, operational speed, and output quality. Translating these principles into the production process of doctoral education, ORE aims to help doctoral candidates increase their research productivity (process) while maintaining a high standard of quality (product). Drawing on OEE, ORE emphasizes three key dimensions: availability (time dedicated to research), performance (efficiency of research tasks), and quality (rigor and impact of research outputs).

The ORE framework consists of three core components derived from Overall Equipment Effectiveness (OEE) (Al-Najjar, 1996; Ylipää et al., 2017), see Figure 1.

1. Availability: Refers to the time PhD candidates can dedicate to research tasks, excluding periods of inactivity caused by external delays (such as waiting for feedback and administrative delays).

2. Performance: Considers how efficiently doctoral students complete research tasks, from literature reviews to data collection and writing.

3. Quality: Assesses the quality of research outputs, including peer-reviewed publications and the final dissertation.

Each component provides a critical lens for evaluating the doctoral research process. While ORE offers a diagnostic model for students, it is primarily designed to support supervisors in identifying bottlenecks facilitating structured discussions, and aligning expectations. The supervisory role is essential in contextualizing ORE, interpreting patterns, and adjusting strategies as needed. In this sense, ORE supports a mindset of ongoing reflection and adaptation, a process of continuous evaluation that aligns with Schwartz (2008) observation that productive research involves dealing with uncertainty and making incremental improvements over time.

Availability: Optimizing Research Time

According to Brodin et al. (2020), procrastination is a widespread phenomenon, particularly among higher education students. Data suggests that as many as 80 to 95 percent of students in higher education procrastinate in some form. This loss in availability might also be due to other factors, such as the inability to organize and plan work, incorrect prioritization, or low motivation. In addition, delays in providing feedback and postponing meetings by supervisors exacerbate the problem. (Auer, 2023) highlights that PhD candidates often struggle with poor planning and a lack of clarity in their research objectives, which can lead to inefficiencies and delays in progress. Additionally, Brodin et al. (2020) emphasize that inconsistent supervision, such as delayed feedback and inadequate communication, can

create long periods of inactivity for students, significantly impacting their research timelines. These factors, coupled with administrative hurdles, present significant challenges to effective time management for doctoral candidates.

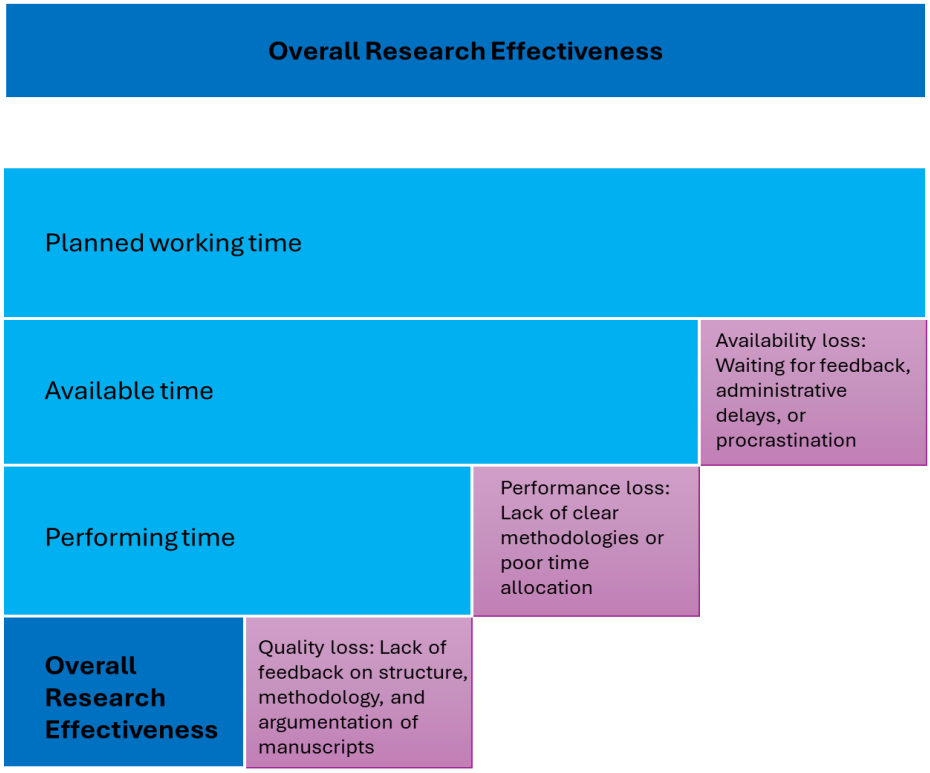

Figure 1: Overall Research Effectiveness

The application of time management tools, such as Gantt charts or weekly progress reviews that is accessible to student and supervisors, can help address these challenges by setting clear goals and tracking progress against them. In addition, providing transparency may help to organize and plan work and avoid issues with procrastination (Auer, 2023).

Furthermore, preventive maintenance concepts from maintenance engineering can be applied here. Just as production process require regular check-ups to remain functional, the process of doctoral education benefit from regular meetings with supervisors to review their progress, address potential issues early, and recalibrate their goals as needed. Auer (2023) emphasizes that effective supervision requires regular monitoring of progress and the provision of clear guidance to ensure that doctoral candidates remain focused on their research objectives and achieve their learning outcomes.

In summary, optimizing availability involves using structured time management practices, such as progress tracking tools, short-term goal setting, and regular supervisory check-ins. These strategies not only increase visibility into how time is used but also enable both students and supervisors to take

proactive steps when disruptions or delays occur. By creating shared routines and expectations, supervision becomes a key driver of research continuity.

Performance: Enhancing Research Efficiency

Performance in ORE refers to the efficiency with which doctoral students complete their research tasks. This component mirrors OEE's focus on optimizing the speed and efficiency of production process. In the context of doctoral research, this means streamlining processes such as data collection, literature reviews, and writing. Inefficiencies in doctoral research can arise from unclear methodologies or poor time allocation (Brodin et al., 2020), which can lead to delays in the completion of critical research tasks and slow overall research progress.

Lean principles commonly used in industrial engineering can be applied to the doctoral research process to minimize inefficiencies. Lean methodology, originally developed in manufacturing, refers to a systematic approach for eliminating waste, optimizing workflows, and continuously improving processes to enhance efficiency and value. In the context of doctoral research, systematic approaches may include structured data collection protocols, standardized naming conventions for digital files, workflow templates for writing or analysis, and checklists to reduce task redundancy and ensure consistency across research activities. By eliminating redundant tasks and improving communication between students and supervisors, doctoral candidates can streamline their work and maintain continuous progress. This mirrors the idea in Lean R&D, where the removal of barriers results in faster project completion and higher quality outcomes (Al et al., 2014). Through identifying inefficiencies in the research process and removing unnecessary steps, PhD candidates can work more efficiently and deliver high-quality outputs in less time. For example, using digital tools for literature management or automating repetitive data analysis tasks can reduce time spent on routine activities. However, even with efficient processes in place, clear communication between supervisors and PhD candidates remains essential. Reitsma, (2023) discusses the complexities of co-supervision, particularly in interdisciplinary contexts, where clear communication of roles and expectations between supervisors and PhD candidates is critical to ensuring smooth research progress.

In summary, improving performance involves streamlining the doctoral research process through a combination of Lean research techniques, automation, and iterative feedback. Lean methods include systematic approaches such as structured data collection protocols, standardized file management, and workflow templates for writing and analysis to minimize redundancy and improve consistency. Examples of automation tools include reference managers, data processing scripts, or project tracking software, which help reduce manual workload and increase efficiency. Finally, ongoing feedback from supervisors allows for continuous refinement of methods and processes, ensuring that research tasks remain aligned with both academic standards and project goals. Together, these strategies enhance the overall efficiency of research while fostering a more structured and collaborative supervisory relationship

Quality: Ensuring High Quality Research Outputs

The final component of ORE is quality, which focuses on the rigor and impact of research outputs. For doctoral candidates, quality is measured not only by the number of publications or the completion of the dissertation but also by the originality and significance of their research. Brodin et al. (2020) discussed

that the involvement of multiple stakeholders in doctoral education leads to differing perceptions of what constitutes quality in the doctoral process, creating variability in how doctoral education is assessed and understood.

Just as academic development centers struggle with unclear research methodologies, PhD candidates may face similar challenges in their own research. Addressing these inefficiencies through structured guidance and clearer methodological frameworks can improve the quality and efficiency of doctoral research. Although formal learning outcomes for doctoral education exist in national regulations, such as the Högskoleförordningen, Stigmar and Edgren (2017) highlight that university centers for academic development often operate without a shared methodological base. This absence can lead to ambiguity in how research is conducted and supported. While their observations are context-specific, the parallel with doctoral supervision is noteworthy: formal structures alone may not provide the operational clarity needed to translate general goals into day-to-day research practice..

Maintaining high-quality research requires regular supervision, peer reviews, and iterative feedback on written work (Brodin et al., 2020). Schwartz (2008) suggests that quality improvement in research often comes from embracing the uncertainty inherent in scientific inquiry and making incremental progress despite challenges. Supervisors play a critical role in guiding students through the process, ensuring that their research meets academic standards and contributes meaningfully to their field.

To further enhance quality, doctoral students should be encouraged to present their work at conferences, internal and external seminars or submit papers to peer-reviewed journals throughout their PhD journey. This exposes their research to external feedback and helps them refine their arguments and methodologies. Tucker (2023) adds that tools such as the Futures Cone can be used to plan for potential outcomes and assess the quality of research at different stages.

Supervisors and research environments can foster high-quality outputs by emphasizing structured peer review, timely feedback, and consistent quality monitoring. Presenting research at seminars, workshops, or conferences, as well as participating in peer review groups, allows students to receive constructive input from a broader academic community. Supervisory guidance remains central in this process, particularly in providing detailed feedback on dissertation drafts and research outputs to maintain alignment with academic standards. Finally, embedding quality checkpoints throughout the research timeline ensures that progress is not only consistent but also rigorous.

Implementing ORE in Doctoral Programs

To maximize the benefits of ORE, institutions can integrate this framework into their doctoral supervision practices. For example, supervisors could be trained to use ORE principals and metrics (availability, performance, and quality) through structured workshops, case-based seminars, and hands-on exercises using progress dashboards. These training sessions could include simulated supervision scenarios, review of anonymized case studies, and collaborative discussions on interpreting ORE indicators. Such training equips supervisors with practical tools to monitor progress more effectively and foster constructive dialogue with their doctoral students. In this context, Brodin et al. (2020) emphasize that supervisors who engage in regular assessments and structured discussions contribute to environments where research progress is consistently supported and improved.

Additionally, implementing tools such as research progress dashboards to help students and supervisors to visualize and track their progress across availability, performance, and quality dimensions. This data-driven approach aims to provide insights into where a student may need additional support and ensures that research productivity remain high throughout the doctoral journey. In summary, targeted training for supervisors -delivered through workshops, guidelines, or peer-led sessions- can enhance their ability to apply ORE principles in practice amd recognize patterns in doctoral progress. The digital dashboards and related tools serve to make research progress visible, support informed supervision, and help supervisors and students address emerging challenges early.

A Practical Illustration of ORE in Doctoral Supervision

To illustrate how the Overall Research Effectiveness (ORE) framework can enhance doctoral supervision, consider the following constructed example based on typical challenges observed in a doctoral program in mechanical engineering. The case focuses on a project involving predictive maintenance of industrial rotating machinery, using sensor data to build machine learning models for failure prediction. The doctoral candidate in the second year was developing algorithms to analyze vibration and thermal monitoring data from an industerial equipment. Despite promising initial results, progress slowed due to inconsistent feedback, difficulty accessing industrial datasets, and limited communication between the academic supervisor and the industry partner. The supervision structure involved an academic supervisor and an industry partner, with different expectations and infrequent technical feedback, that contributed to bottlenecks in research progress.

ORE Framework Application:

Availability: A structured time audit was introduced using a research diary tool, which showed frequent interruptions due to disorganized access to industrial datasets and delays in response from the industry co-supervisor. To mitigate this, bi-weekly tri-partite meetings were established among the student, academic supervisor, and industrial partner. A shared document was created to log meeting action and follow-ups, to minimize downtime due to ambiguity or miscommunication as well as keep actions aligned with the goals.

Performance: The student's process for preparing data and training machine learning models was carefully analyzed using principles from Lean methodology. Each step was reviewed to identify inefficiencies, such as redundant manual data cleaning and re-training models from scratch, and improvements were introduced by streamlining workflows and applying automation where possible. For example, repetitive preprocessing scripts were automated, and data ingestion was standardized. A Git-based version control system was implemented to systematically track changes in scripts, facilitating reproducibility and reducing confusion when switching between model versions.

Quality: To enhance quality, the student implemented monthly self-evaluation reports focusing on model accuracy trends, feature relevance, and method justification. These were supplemented by quarterly review sessions with peers from the industrial partner’s analytics team. Feedback from these sessions helped the student refine model interpretability and align evaluation metrics with operational relevance. In parallel, the academic supervisor also introduced a publication roadmap, that integrate journal and conference deadlines with internal submission checkpoints.

Outcomes: After implementing the ORE-driven supervision model, the student achieved several key milestones; the first journal submission was submitted in time, and system downtime in the test lab was reduced due to better coordination between academic and industrial teams. The student also reported a higher sense of ownership over the research process and a clearer understanding of expectation and project timelines.

Conclusion and reflections

This paper has introduced the Overall Research Effectiveness (ORE) as a structured, data-driven approach to improve doctoral research productivity by adapting principles from maintenance engineering. This framework aims to help PhD candidates and their supervisors by focusing on three core dimensions: availability, performance, and quality.

The practical example, based on a hypothetical scenario informed by supervisory challenges in a doctoral project in predictive maintenance illustrates how ORE can be applied in real-world supervision. However, while ORE provides structure, it must not become rigid. Doctoral research is not a production line; it is a creative, emergent, and highly individual effort. Academic inquiry often requires space for reflection, exploration, and failure which consumes time and challenge linear planning. As such, balancing the structural approach of ORE with the flexibility required in academic research is crucial.

Moreover, doctoral research is inherently shaped by uncertainty, ambiguity, and the possibility of failure. These are not anomalies to be eliminated but essential aspects of scholarly growth. Within the ORE framework, moments of stalled progress or deviation from planned trajectories should not be viewed solely as inefficiencies but as learning opportunities. Recognizing failure as a formative part of the doctoral journey aligns ORE with a more holistic and human-centered view of research development; one that values not only structured output but also adaptability, intellectual emergence and the ability to navigate complexity. While this paper touches on the role of failure as a constructive element in doctoral education, future work may further develop this perspective by exploring how supervision can more explicitly support students in navigating and learning from academic setbacks.

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