Making Laboratory Supervision Explicit: An Exploratory Pedagogical Case Study

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Abstract

This report presents a small-scale pedagogical development project examining whether explicit learning outcomes, early expectation alignment, and reflective supervision can support the development of an MSc student during the practical laboratory phase of a Master's thesis project. The intervention was implemented in the context of an integrated Master's thesis involving experimental work, including cell culture, protein expression and purification, formulation, conjugation, quality control analysis, animal immunization, ELISA, and related laboratory methods. The pedagogical approach combined an initial expectation-alignment exercise with continuous face-to-face supervision, monthly oral reflection on progress and expectations, formative feedback, and a gradual transfer of responsibility from supervisor-led instruction towards student-led experimental decision-making.

The project was evaluated through start- and end-of-project student self-assessment questionnaires, focusing on understanding of expectations, research independence, laboratory skills, confidence, supervision, and reflective learning. The questionnaires were not used solely as evaluation instruments: the initial responses were discussed with the student and used as a basis for negotiating expectations, identifying areas for development, and establishing an approach to increasing independence. During the project, these themes were revisited orally in regular supervision conversations.

The case study shows substantial self-reported development in core practical research skills. The student also reported increased

confidence in independent research, laboratory work, handling uncertainty, and learning from mistakes. The progression of supervision itself followed a gradual movement from demonstration and direct correction, through guided problem-solving, towards student-proposed solutions, independent experimental decisions, and increasingly limited supervisory intervention.

The findings suggest that explicit learning outcomes and structured, dialogical supervision may help students understand what is expected of them in laboratory-based thesis work, especially in relation to independence, troubleshooting, and the pedagogical value of negative or incomplete results. The project further suggests that the pedagogical value of expectation alignment and self-assessment lies not only in documenting student development but in using these tools as starting points for continuing dialogue about responsibility, feedback, and increasing independence. However, the single-student design and the practical limitation that only few students can be accepted into the laboratory mean that the findings should be interpreted as exploratory rather than generalizable.

1. Introduction

Master's thesis projects in molecular biology, biomedical science, and other laboratory-based disciplines often involve a transition from structured coursework to open-ended research practice. Students are expected not only to produce a written thesis, but also to learn how to function within a research environment where experimental uncertainty, failed assays, changing protocols, and practical constraints are normal parts of scientific work. Learning therefore includes disciplinary knowledge as well as research independence, methodological judgement, troubleshooting, time management, scientific communication, and the ability to interpret inconclusive or negative results.

The pedagogical development project evaluated in this report was designed to make such expectations explicit. The project focused on the practical part of an MSc thesis in Human Biology and/or Molecular Biomedicine, where students conduct laboratory work before writing the final thesis. The intervention consisted of a short explicit learning

outcomes document, an early supervision discussion, and reflective check-ins designed to align expectations between student and supervisor.

The motivation for the project was that students may understand what a good thesis should look like structurally, but expectations concerning independence, troubleshooting, negative results, and research thinking often remain implicit and develop gradually during supervision. This is especially important in laboratory-based projects, where much learning occurs through daily practice, observation, feedback, correction, and informal face-to-face supervision. The student is not simply writing about science but learning to perform science under uncertain and time-constrained conditions.

The present project therefore considered supervision itself as part of the pedagogical intervention. Rather than treating the questionnaire, learning outcomes, and supervision meeting as separate activities, the intention was to use them to establish a shared understanding of the student's role and then revisit that understanding as the student's competence developed. In particular, the project sought to move the student progressively from following demonstrated procedures towards proposing solutions, making experimental decisions, and taking responsibility for the practical research process.

This approach is consistent with research suggesting that master's supervision is not necessarily characterized by one fixed supervisory role. Harwood and Petrić (2020), found that supervisors may move between teaching, apprenticeship, partnership, and other supervisory roles at different points in a dissertation, depending on the student's needs and the task. In laboratory-based research education, this adaptive element is particularly relevant because some situations require direct instruction while others provide opportunities for independent judgement.

This report analyses the development of one MSc student from the beginning to the end of the practical project period. Because laboratory capacity limits the number of students who can be accepted and supervised intensively, the project is framed as an exploratory single-case study rather than as a generalizable empirical study.

2. Theoretical framework

The intervention is grounded in three overlapping areas of university pedagogy: constructive alignment, expectation negotiation in supervision, and partnership-oriented laboratory supervision.

2.1 Constructive alignment

Constructive alignment emphasises the relationship between intended learning outcomes, teaching and learning activities, and assessment. The development project explicitly sought to formulate learning outcomes that describe student performances such as designing and revising experimental strategies, interpreting negative or inconclusive results, and demonstrating increasing independence through decision-making and troubleshooting. This approach is consistent with Biggs' concept of alignment, where learning objectives should guide educational activity and assessment expectations (Biggs, J. 1996). For the present project, alignment was treated as an ongoing supervisory task rather than a one-time exercise: the learning outcomes informed feedback and the allocation of responsibility as the student moved from observing and practising techniques to planning experiments and making decisions.

2.2 Expectation negotiation and meta-communication

The supervision literature emphasises the importance of early negotiation of expectations. Wichmann-Hansen and Jensen identify one of the central challenges of supervision as the allocation of responsibility and roles between student and supervisor, including the balance between support and management. They argue that students and supervisors often hold different expectations regarding work process, independence, academic level, and responsibility. The chapter therefore recommends early written agreements, expectation forms, and recurring expectation matching, particularly in long-term supervision. The questionnaires used in this project functioned in a similar way: they created a structured opportunity for the student to articulate baseline expectations, self-assessed skills, worries, and understanding of independence at the start, and then to evaluate development at the end (Wichmann-Hansen & Jensen, 2015).

Research on supervisory expectations likewise highlights that alignment is developed through ongoing dialogue and the negotiation of mutual expectations, rather than through the provision of written information alone (Palmer et al., 2023)

The questionnaires used here asked about expectations, prior experience, skills, confidence, concerns, and understanding of independence. Their pedagogical purpose was twofold: they gave the supervisor an initial picture of the student's starting point, and they provided a shared basis for discussing differences in expectations and clarifying how supervision would work. The initial discussion and subsequent monthly oral conversations also served as meta-communication: they made the supervision process itself discussable, including how much guidance was needed, what independence meant in practice, and how responsibility would change.

Meta-communication is especially relevant in laboratory supervision. Wichmann-Hansen and Jensen (2015) describe meta-communication as communication about the supervision process itself, including how the supervisor and student communicate, how supervision is conducted, and how their respective roles are understood. (Wichmann-Hansen & Jensen, 2015). Applied to laboratory supervision, this perspective suggests that explicit discussion of expectations and feedback practices can help prevent students from interpreting direct correction as personal criticism or experimental setbacks as evidence of personal inadequacy. By discussing the learning value of failed or inconclusive results, supervisors can frame laboratory uncertainty as a normal and potentially productive part of scientific development.

2.3 From apprenticeship towards partnership

Apprenticeship-like supervision is common in laboratory environments, where students learn through observation, participation in established practices, demonstration, repeated performance, and correction. Applied to laboratory supervision, Wichmann-Hansen and Jensen's (2015) perspective suggests that such guidance should not merely lead students to reproduce the supervisor's actions. It should also help them develop professional judgement and assume increasing responsibility for research

decisions. Accordingly, supervision should balance necessary supervisor direction with the student's active participation, ownership, critical thinking, and reflection. (Wichmann-Hansen & Jensen, 2015).

The project used apprenticeship and partnership as complementary modes rather than as mutually exclusive alternatives. Direct demonstration and correction remained necessary when a technique was new or when safety and experimental quality required it. As the student gained experience, the supervisor increasingly used questions and discussion to invite the student to diagnose problems, propose solutions, justify choices, and decide on next steps. This approach is consistent with research on scaffolding in degree-project supervision. Zackariasson (2020) discusses how questions, instructions, and the gradual transfer of responsibility can support student independence, while also warning that supervisors may become more directive under time pressure. The appropriate level of guidance therefore needs to respond to the student's competence and the circumstances of the project.

In this report, increasing independence means more than performing a laboratory technique without assistance. It includes planning experiments, troubleshooting, modifying protocols when justified, interpreting results, suggesting subsequent experiments, and organising laboratory work. These forms of responsibility provide observable ways to connect the theoretical idea of partnership with everyday supervision practice.

3. Methods

3.1 Design and context

The project was designed as a small-scale pedagogical development project and exploratory case study involving one MSc student undertaking the practical part of a laboratory-based thesis. The experimental workflow included cell culture, protein expression, protein purification, formulation, conjugation, quality control analysis, animal immunisation, ELISA, and related methods.

The intervention consisted of an explicit learning-outcomes document, an initial expectation-alignment discussion, start- and end-of-project questionnaires, and ongoing face-to-face laboratory supervision.

During the initial discussion, the student's questionnaire responses were reviewed together with the supervisor's expectations. The conversation addressed the student's prior experience, concerns, understanding of independence, and expectations of supervision. It was used to clarify roles and establish a shared understanding of the learning aims and the gradual development of responsibility.

The student and supervisor also revisited progress orally on a monthly basis. These conversations provided opportunities to discuss confidence, difficulties, learning needs, feedback, and the level of independence appropriate for upcoming tasks. There was no formal midpoint questionnaire; the midpoint element of the intervention consisted of ongoing oral dialogue rather than a repeated numerical assessment.

3.2 Supervision progression

A central feature of the intervention was a gradual transition from apprenticeship-oriented instruction towards partnership-oriented supervision. The level of guidance was adjusted as the student gained experience. The progression stages were not rigid phases with fixed dates. Direct guidance remained available whenever the task, risk, or experimental situation required it. The progression is summarized in Table 1.

Table 1. The stages of the supervision progression

Stage	Supervisor role	Student role
Early	Demonstrates experiments and explains rationale, procedures, and quality considerations.	Observes, follows procedures, and asks questions.
Developing	Guides performance, observes, and corrects	Performs tasks with support and begins to

	technique where needed.	explain the rationale for steps.
Intermediate	Uses questions and prompts rather than immediately supplying solutions.	Diagnoses problems and proposes possible solutions.
Advanced	Provides targeted feedback and limited supervision where appropriate.	Plans experiments, troubleshoots, modifies protocols when justified, and makes experimental decisions.
Proficiency	Acts mainly as a consultant while remaining available for guidance and oversight.	Takes responsibility for experimental planning, interpretation, next-step suggestions, and organisation of laboratory work.

A technically unfamiliar or high-risk procedure could require direct demonstration even after the student had become independent in other areas, whereas familiar experimental tasks could be delegated more fully. The intended endpoint was not absence of supervision, but the ability to make and justify decisions while recognising when consultation was needed.

3.3 Data collection

Two questionnaires were used in this project.

1. Start-of-project questionnaire, completed during weeks 1–3. recorded the initial expectations, prior experience, self-assessed skills, confidence, motivation, and concerns of the student.

2. End-of-project questionnaire, completed in the final weeks of the practical project. This questionnaire recorded the final reflections, perceived development, skill levels, supervision evaluation, confidence, satisfaction of the student and advice to future students.

Both questionnaires used a 1–10 scale, where 1 represented very low, unclear, or not confident and 10 represented very high, completely clear, or very confident.

The questionnaires were supplemented by the initial expectation-alignment discussion and monthly oral conversations. These conversations were part of the supervision process, not a separately recorded qualitative dataset. The student's development was also observed through the changing level of responsibility undertaken during laboratory work and through the regular supervisory conversations. Consequently, the report describes their pedagogical function but does not present them as systematically coded interview data or quote specific dialogue that was not documented.

3.4 Analytical approach

The analysis compares numerical self-assessment scores from the start and end questionnaires and interprets these data in relation to the written reflections of the student. Since the project includes only one student, the quantitative scores are treated as descriptive indicators of perceived development rather than statistically generalisable evidence. The qualitative reflections are used to contextualise the scores and to identify themes related to independence, uncertainty, time pressure, laboratory learning, and supervision.

The analysis also considers the pedagogical process itself: specifically, how the supervisory role changed as the student's competence increased, how expectations were discussed and revisited, and how responsibility for experimental decisions was progressively transferred to the student.

4. Results

4.1 Development in laboratory and research skills

The student's self-assessed skills showed clear improvement in several practical laboratory competencies (Figure 1). At the beginning, the student rated experience in cell culture as 5/10, protein expression as 2/10, and protein purification as 1/10. At the end, these ratings had increased to 10/10, 9/10, and 10/10, respectively. These changes indicate substantial perceived development in hands-on experimental competence, especially in methods that were initially unfamiliar.

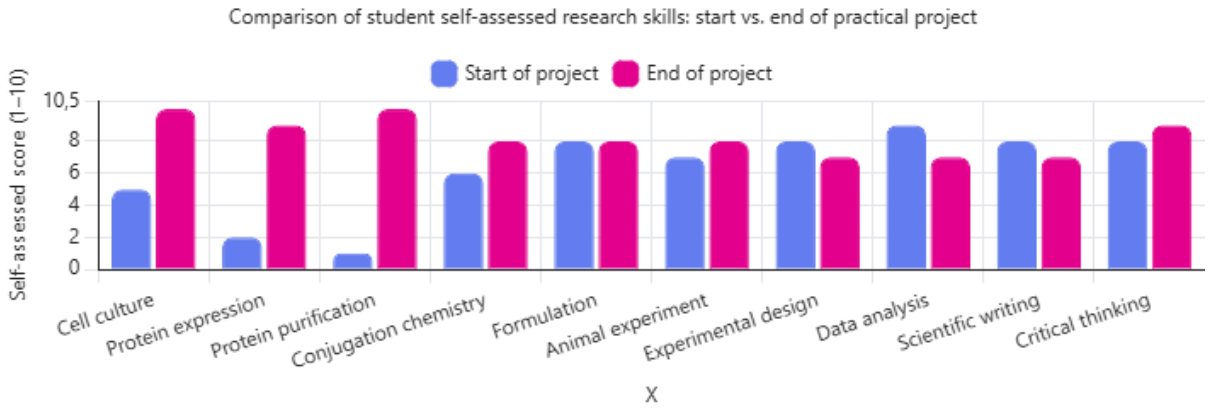


Fig. 1. Comparison of the self-assessed research skills of the student at the start and end of the practical MSc project.

The strongest improvements were observed in protein purification (+9), protein expression (+7), and cell culture (+5). Conjugation chemistry increased from 6/10 to 8/10, animal experiment understanding from 7/10 to 8/10, and critical thinking from 8/10 to 9/10. Formulation skills remained stable at 8/10, suggesting that this was already a perceived strength at the beginning.

Some areas decreased slightly: experimental design changed from 8/10 to 7/10, data analysis from 9/10 to 7/10, and scientific writing from 8/10 to 7/10. These decreases should not necessarily be interpreted as regression. A plausible pedagogical interpretation is that increased exposure to real research complexity may have made the student more aware of the difficulty of experimental design, data interpretation, and

scientific writing. This interpretation is supported by the final reflection of the student that science is not "fast" as he expected and that six months is short for a project of this type.

Table 2. Comparison of the self-assessed research skills of the student at the start and end of the practical MSc project.

Skill area	Start	End	Change
Cell culture techniques	5	10	+5
Protein expression	2	9	+7
Protein purification	1	10	+9
Conjugation chemistry	6	8	+2
Formulation skills	8	8	0
Animal experiment understanding	7	8	+1
Experimental design	8	7	-1
Data analysis	9	7	-2
Scientific writing	8	7	-1
Critical thinking	8	9	+1

Overall, the mean score across the ten comparable research skills increased from 6.2 at the start to 8.3 at the end, corresponding to an average increase of +2.1 points on the 1–10 scale.

4.2 Development in independence, confidence, and research identity

At the beginning, the student already reported a relatively high understanding of research independence, scoring 9/10. The student also rated responsibility for planning experiments as 9/10 and comfort in asking the supervisor for help as 8/10. These scores suggest that the student entered the project with a clear initial understanding of independence and of help-seeking.

By the end of the project, the student rated the ability to design experiments more independently as 9/10 and the ability to troubleshoot experiments logically as 8/10. The student also rated confidence for independent research as 9/10 and confidence in laboratory work and methods as 9/10. These end-point scores indicate that the practical laboratory period contributed not only to technical competence but also to research identity formation.

Final written reflection of the student supports this interpretation. The student reported learning the “full pipeline from protein to vaccine design to immunisation and analysis” and stated that the project involved learning “to work independently on new original science.”

The development of independence was also evident in the changing nature of the student's laboratory responsibilities. In the early phase, the supervisor demonstrated procedures and the student followed established protocols. As familiarity increased, the student performed procedures with guidance and correction. In the intermediate phase, supervision increasingly involved questions intended to prompt the student to analyse experimental problems and propose possible solutions rather than receiving an immediate answer. In the later phase, the student was able to independently plan experiments, troubleshoot experimental problems, modify protocols, interpret results, suggest or decide on subsequent experiments, and organise laboratory work.

This progression is important because independence was therefore not defined simply as “working without the supervisor being present.” Instead, independence was understood as the ability to make informed research decisions while knowing when and why supervisory input was required. The supervisor's role consequently shifted from direct instruction towards consultation and critical discussion.

4.3 Expectation Alignment and Ongoing Supervision

The initial expectation-alignment exercise was followed by direct discussion with the student. The purpose was to compare the student's expectations with those of the supervisor and to establish a shared understanding of independence, responsibility, support, and the nature of laboratory research. The questionnaire therefore functioned as a starting point for dialogue rather than simply as a baseline measurement.

These expectations were not considered fixed after the initial meeting. They were revisited through approximately monthly oral discussions and through day-to-day laboratory interactions. As the student's competence increased, the appropriate level of supervisory involvement changed. For example, a task that initially required demonstration and close correction could later be delegated to the student, while the supervisor's questions became increasingly focused on the reasoning behind experimental choices.

At the end of the project, the student rated expectations as clear throughout the project at 7/10, feedback as improving research thinking at 8/10, and reflective check-ins as improving learning at 7/10. Overall satisfaction with the project was rated 8/10.

These scores should therefore be interpreted together with the ongoing dialogue. The fact that expectations were rated 7/10 rather than 10/10 may indicate that expectations in an open-ended research project cannot be completely fixed in advance. As the project develops, new experimental problems and opportunities change what independence and responsibility mean in practice. Continuous expectation matching may therefore be more appropriate than treating expectation alignment as a one-time agreement.

4.4 Development in Independence Through Laboratory Decision-Making

A particularly important element of the supervision process was the gradual transfer of experimental decision-making. In the early phase, the supervisor determined the appropriate procedure and demonstrated its execution. During the developing phase, the student increasingly performed procedures independently but received direct correction when necessary. As the student gained experience, the supervisor increasingly used questions to encourage the student to diagnose problems and propose possible solutions.

In the later stages, the student was able to take responsibility for experimental planning, troubleshooting, protocol modification, interpretation of results, suggestions for subsequent experiments, and organisation of laboratory work. The supervisor's role consequently became less about determining the next experimental action and more about discussing the student's reasoning, challenging assumptions where appropriate, and providing advice when the consequences of a decision required additional experience or expertise.

This progression provides a concrete example of the transition from apprenticeship towards partnership. The student did not simply acquire technical skills but increasingly participated in the decision-making processes through which experimental research is conducted.

4.5 Understanding of Uncertainty, Failure, and Time

At the start of the project, the main concern of the student was whether the project could be completed within the available time, especially given potential experimental setbacks. The student also defined a successful thesis as a final product that felt complete, without shortcuts, and as a process involving academic and personal improvement.

At the end, the reflection of the student showed a more mature understanding of research temporality and uncertainty. The student identified the biggest lesson as realising that science is not “fast” and that patience and perseverance are essential. The advice of the student to future students was not to be afraid of mistakes or incomplete data

because the purpose of the project is learning and not everything has to be perfect.

This shift is pedagogically important. It suggests movement from an initial concern with completion and avoiding setbacks toward a more research-oriented understanding of uncertainty, incomplete data, and learning through mistakes. This aligns with the intention of the project to make the pedagogical value of experimental uncertainty explicit.

The progression towards independence also changed how uncertainty could be handled pedagogically. Rather than immediately resolving an unexpected result for the student, supervision increasingly involved asking the student to consider possible causes, evaluate available evidence, and suggest the next experiment. In this way, troubleshooting became both a scientific activity and a learning activity.

4.6 Supervision and Reflective Learning

At the end of the project, the student rated expectations as clear throughout the project at 7/10, feedback as improving research thinking at 8/10, and reflective check-ins as improving learning at 7/10. Overall satisfaction with the project was rated 8/10. These scores indicate a generally positive evaluation, while also suggesting room for further development in making expectations and reflective structures even more explicit.

The supervision literature recommends establishing clear frameworks, negotiating expectations early and revisiting them regularly as students' needs and projects develop. Supervisors may also invite students to summarize meetings to clarify agreements, responsibilities, and subsequent actions. (Wichmann-Hansen & Jensen, 2015).

In the present project, reflective supervision was integrated into the ongoing relationship rather than being limited to the final questionnaire. The monthly oral discussions provided opportunities to consider progress, difficulties, confidence, responsibility, and the appropriate level of supervisory support. The student's developing ability to work independently was therefore discussed alongside the practical progress of the project.

The final reflection of the student identified an important area for improvement: experimental results could have been documented and connected to thesis writing earlier in the project. Future versions of the intervention could therefore include structured writing activities during the laboratory phase, encouraging students to record new findings, preliminary interpretations, discussion points, and methodological considerations as the practical work progresses. This would help create a clearer connection between daily experimental work and the final thesis, while also supporting a smoother transition from laboratory practice to scientific writing.

5. Discussion

The case study suggests that explicit learning outcomes and structured reflective supervision can support student development in a laboratory-based MSc thesis project. The most visible development occurred in practical laboratory skills, particularly in techniques that were initially unfamiliar. This is consistent with the nature of laboratory apprenticeship, where students learn through observation, repetition, feedback, and increasingly independent performance within a research environment.

Wichmann-Hansen and Jensen (2015) describe apprenticeship-oriented supervision as particularly relevant in the natural and health sciences, where laboratory-based work may require directive instruction, practical demonstration, and close interaction within a research community (Wichmann-Hansen & Jensen, 2015). However, the project did not rely only on apprenticeship. By using questionnaires, explicit learning outcomes, and reflective check-ins, the supervision practice also incorporated elements of partnership supervision.

The present case provides a more concrete understanding of this combination. Apprenticeship was particularly important when the student encountered an unfamiliar technique or needed direct correction. Partnership became increasingly important when the student had acquired sufficient knowledge to analyse problems, propose solutions, and make experimental decisions. The pedagogical challenge was therefore not to choose between apprenticeship and partnership, but to recognise when each form of supervision was appropriate.

This interpretation is supported by Harwood and Petrić's (2020) finding that supervisory roles can change during master's dissertation work according to the needs of the student and the task. Their study is particularly relevant to the present case because it illustrates that supervision may be adaptive rather than consistently directive or consistently non-directive.

The progression observed in this project also corresponds with the principle underlying the ESRA model, in which structured supervision is used to escort students progressively towards responsibility and autonomy. Jordal et al. (2021) emphasise that partnership does not mean simply leaving the student alone; rather, autonomy is developed through continued dialogue, support, and reflection. This distinction is particularly important in laboratory education, where complete withdrawal of the supervisor could be inappropriate or unsafe.

The final reflections of the student suggest evidence of this development, as the student emphasised patience, viewed incomplete data as a normal part of the learning process, and encouraged future students not to be discouraged by mistakes. The slight decreases in experimental design, data analysis, and scientific writing are particularly interesting. Rather than indicating failure, these changes may represent a recalibration of self-assessment. At the beginning, the student rated data analysis and scientific writing highly. After exposure to real experimental complexity, the student may have developed a more realistic understanding of what high-level design, analysis, and academic writing require.

The decrease in some self-assessment scores also illustrates why repeated dialogue can be pedagogically valuable. A student may initially rate a competence highly because the task appears familiar, and later rate it lower after experiencing the complexity of authentic research. Such a change can represent increased metacognitive awareness rather than loss of competence. In future projects, discussing such changes explicitly could help distinguish between genuine difficulty, increased awareness of complexity, and areas requiring further development.

The results also support the importance of face-to-face supervision in laboratory settings. Daily laboratory supervision allows the supervisor to provide immediate technical correction, model scientific reasoning,

support troubleshooting, and discuss experimental uncertainty as it emerges. Nevertheless, daily supervision can also remain implicit unless the supervisor deliberately names the learning process. The value of the intervention lies in combining informal laboratory guidance with explicit pedagogical framing.

This point is particularly relevant to laboratory research education. Clement et al. (2020) argue that research faculty perform distinct educational and supervisory roles that often remain implicit or insufficiently recognized in research laboratories. Applied to laboratory teaching, their argument suggests that clear learning goals and formative feedback are needed to help students understand what they are expected to learn and how their competence is developing.

In the present case, the expectation-alignment exercise and learning outcomes provided an explicit framework, while the ongoing conversations translated that framework into everyday laboratory supervision. Thus, the pedagogical intervention was not the questionnaire itself. Its value came from what the questionnaire enabled the supervisor and student to discuss and subsequently change.

A key limitation is the single-case design. Because the laboratory can accept only a small number of students due to capacity, safety, supervision intensity, and resource limitations, this type of pedagogical project cannot easily generate large datasets. The findings should therefore be understood as exploratory, context-specific, and practice-oriented. The purpose is not to prove effectiveness statistically, but to generate evidence-informed improvement in supervision practice.

A second limitation is that the start- and end-questionnaires provide only two formal measurement points. Although monthly oral discussions were used to revisit expectations and development, these conversations were not systematically recorded or converted into numerical measurements. Consequently, the progression towards independence is supported by the student's self-assessments and the documented description of supervision practice, but cannot be analysed quantitatively over time.

For projects lasting more than six months, a formal midpoint self-assessment could strengthen this approach. Such an assessment could repeat selected questions from the initial questionnaire and be discussed

jointly by student and supervisor. The purpose would not simply be to produce a third measurement point, but to identify areas in which the student's confidence, competence, or understanding of responsibility had changed and to agree on specific development goals for the remaining period.

Future iterations could therefore strengthen the intervention by adding a midpoint questionnaire for longer projects, brief written laboratory reflection logs, and structured writing integration. For example, after each major experimental phase, the student could write a short reflection addressing: What was attempted? What worked or failed? What was learned? What is the next decision? This would connect laboratory learning more directly to thesis writing and support the transition from practical work to scientific documentation.

A further development would be to make the progression towards independence explicit from the beginning of the project. Instead of simply stating that the student should become independent, supervisor and student could identify examples of what increasing independence means in practice: performing a procedure without assistance, identifying the likely cause of an experimental problem, proposing alternative approaches, selecting a subsequent experiment, justifying a protocol modification, and organising laboratory work. This would make “independence” a more observable and discussable learning outcome.

The project therefore suggests that effective laboratory thesis supervision may be understood as a gradual transfer of responsibility rather than a simple reduction in supervisor contact. The supervisor remains involved throughout the process, but the nature of involvement changes: from demonstrating and correcting, to questioning and discussing, and finally to consulting while the student assumes responsibility for research decisions.

6. Conclusion

This exploratory case study indicates that explicit learning outcomes, early expectation alignment, and reflective supervision can support MSc students during laboratory-based thesis projects. The student within this laboratory project showed substantial self-reported improvement in core

practical skills, especially cell culture, protein expression, and protein purification. The student also developed confidence in independent research and a more mature understanding of scientific uncertainty, failed experiments, and the time required for experimental work.

An important finding of the pedagogical development was that these tools were most useful when integrated into an ongoing supervisory dialogue. The initial expectation questionnaire used in this project provided a basis for discussing expectations and responsibility with the student; the learning outcomes provided reference points for feedback and assignment of responsibility; and regular supervision conversations allowed the level of support to change as the student's competence developed.

The progression from demonstration and correction towards questioning, student-proposed solutions, independent decision-making, and consultation illustrates how an apprenticeship-based laboratory environment can gradually incorporate partnership-oriented supervision. By the later stages of the project, the student could independently plan experiments, troubleshoot problems, modify protocols, interpret results, suggest subsequent experiments, and organize laboratory work.

The project demonstrates the pedagogical value of combining daily face-to-face laboratory supervision with explicit reflective tools. In laboratory-based thesis education, students need not only technical instruction but also clear expectations regarding independence, responsibility, troubleshooting, feedback, and the meaning of incomplete or negative results.

The central pedagogical implication is therefore not that supervisors should supervise less, but that they should change how they supervise as the student develops. Early close guidance can provide the foundation for later independence, while continued dialogue ensures that responsibility is transferred deliberately rather than assumed.

The intervention appears promising as a practical, low-cost supervision framework for research laboratories that can only host a limited number of thesis students. Future projects, particularly those lasting more than six months, could strengthen the approach through a formal midpoint self-assessment, documented development goals, and brief reflective records linked directly to the learning outcomes.

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