Structured Peer-Feedback as a Catalyst for Evaluative Judgment in Thesis Supervision

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Introduction & Context

A central challenge in BSc chemistry thesis supervision is student passivity and supervisor dependency. Their transition from structured, "recipe"-based laboratory exercises to managing a research project represents a major shift in knowledge acquisition and generation. The students no longer execute predefined protocols; they now must design synthetic pathways, troubleshoot negative results, and construct coherent scientific arguments based on complex, and sometimes ambiguous analytical data. My previous supervisory approach, relying entirely on unilateral, supervisor-to-student feedback, did not facilitate this transition optimally. While efficiently correcting technical errors, it inadvertently fostered a more passive dynamic. Students frequently waited for supervisor validation rather than developing independent evaluative judgment. To foster academic independence, this pedagogical intervention was intended to shift this dynamic. The project required students to evaluate, critique, and troubleshoot a peer's related research project. The primary goal is deeper, self-regulated learning, with secondary objectives of facilitating collaboration and increasing ownership of their thesis projects.

Theoretical Framework

According to Biggs's principle of Constructive Alignment, a course Teaching and Learning Activities (TLAs) must logically support its Intended Learning Outcomes (ILOs) (Biggs, 1996, 1999). The specific ILOs of the BSc in Medicinal Chemistry program at the SCIENCE faculty require students to perform laboratory syntheses of drug-like

molecules, critically interpret their own data, and communicate findings in a structured scientific context (*Den Uddannelsesspecifikke Del Af Studieordningen for Bacheloruddannelsen i Medicinalkemi Ved Det Natur- Og Biovidenskabelige Fakultet, Københavns Universitet*, 2020). Relying solely on supervisor-centric feedback creates a misaligned TLA that keeps the focus on the teacher rather than the student. It creates a "hidden curriculum" where the implicit goal is validation by the supervisor rather than mastering a scientific method, trapping students in a dependency-driven approach to learning. Restructuring the supervision framework to mandate structured peer feedback realigns the TLAs with the ILOs. Furthermore, this shift guides students through Biggs's SOLO taxonomy (Structure of the Observed Learning Outcome) (Biggs, 1996, 1999). Receiving feedback solely from a supervisor often halts students at the "multistructural" level. In chemistry, this manifests as reporting isolated data points, i.e. listing reaction yields, melting points, and NMR peaks, without constructing a broader narrative. Requiring students to defend synthetic choices to a peer forces them into the "relational" level, such as combining unexpected TLC results, NMR peaks of impurity, and specific reaction conditions to diagnose a side-reaction, rather than simply stating a synthesis failed. Ultimately, it pushes them toward the "extended abstract" level, generalizing specific laboratory findings to defend the overarching thesis narrative against broader scientific literature.

This shift anchors in Social Constructivism, utilizing the Zone of Proximal Development (ZPD). As Harland details, cognitive development accelerates when learners collaborate with a "More Knowledgeable Other" (MKO) to solve problems they cannot solve independently. In traditional supervision, the power imbalance dictates the supervisor permanently holds the MKO role. This permanent asymmetry suppresses student initiative and causes cognitive bottlenecking. As Boud, Cohen, and Sampson argue, peer learning flattens these power dynamics, encouraging students to take responsibility for their learning (Boud et al., 1999). In Peer Assisted Learning (PAL), as Topping highlights, the MKO role becomes fluid (Topping, 1998). Because the paired students tackle different but related synthetic targets, one student acts as the MKO regarding NMR

interpretation on one day, while the other assumes that role on another, while discussing air-sensitive reactions, for example. This fluid dynamic forces students to engage in continuous cognitive elaboration: reorganizing, simplifying, and articulating internal knowledge to make it comprehensible to an external audience. This aligns with the finding that peer assessment facilitates student learning through interaction and autonomy promotion (Marcuccio & Silva) (Marcuccio, 2019). Additionally, this structure leverages Wenger's theory of Communities of Practice (Wenger, 2000). BSc students are transitioning from novice learners to peripheral participants in the professional scientific community. By engaging in peer review, they mimic professional practices of academic chemists, accelerating their identity shift from passive students to active scientists.

Implementation of Peer Feedback

To translate these principles into practice, the intervention utilized three scaffolded peer-to-peer activities sequenced throughout the BSc project of two students. Their research projects were closely related: their target molecules were structurally similar natural products, but the synthetic pathways toward them were distinctly different. This specific design provided a shared chemical context that enabled them to effectively comprehend and evaluate one another's work, while the divergent synthetic routes preserved the necessity for independent problem-solving.

1. **Bimonthly "Peer Consultant" Meetings:** Every other week, the students required meetings acting as peer consultants. Because their synthetic approaches and target molecules differed, they could not plagiarize; instead, they had to justify choices of reagents, solvents, work-up procedures, etc. from fundamental chemical principles. During these meetings, I attended strictly as a silent moderator, withholding solutions even when students struggled.

2. **Cross-Data & Experimental Audit:** At the end of each week, the students randomly picked one of their peers' experiments and performed an audit. They performed blind checks on experimental

write-ups, verifying written procedure clarity and accuracy of the characterization data. This exercise compelled them to cross-reference raw analytical files with their peer's conclusion, bridging practical laboratory work and academic writing. Importantly, implementing this audit required careful learning environment consideration, as Edmondson emphasizes collaborative environments function optimally only if participants feel psychological safety (Edmondson, 1999). I explicitly instructed students to approach the task not as "inspectors" assigning blame, but as "collaborators" stress-testing the conclusions to ensure it will survive the final external examiner's rigorous scrutiny.

3. **Thesis Draft Review**: At the end of their BSc project, the students provided structured written feedback on the "Results and Discussion" section of their peer's initial thesis draft before I, as the supervisor, reviewed it. As Lai notes, providing suggestions or solutions during peer-review is more effective for assisting peers in revising work than merely pointing out problems (Lai, 2011).

Evaluation & Outcomes

Measuring the efficacy of this approach requires documentation aligning with formative assessment, self-regulated learning, and evaluative judgment development. Tai et al. define evaluative judgment as the capability to make decisions about the quality of work of oneself and others (Tai et al., 2018). By reviewing a peer's experimental section, the students utilize, deconstruct, and internalize assessment criteria for high-quality scientific writing, subsequently applying them to their own drafts. Nicol and Macfarlane-Dick emphasize effective formative assessment must clarify good performance and facilitate self-reflection (Nicol & Macfarlane-Dick, 2006). To capture this metacognitive development, I designed a specific post-meeting questionnaire (Appendix I). This questionair functions as an ongoing reflection paper, prompting internal dialogue rather than merely summarizing meetings. For example, one prompt asks: *"Reflect on where your peer's feedback caused you to abandon an unproductive line of thinking. What was the specific logic*

that improved your insight?" Another targets self-regulation and error detection: *"Identify a specific moment where you caught your own error while explaining something to your peer. What does this tell you about your growing ability to self-monitor?"* By prompting students to articulate a technical hurdle where they disagreed and explain how debating different perspectives led to a common solution, the documentation renders underlying cognitive processes visible and measurable.

Furthermore, this questionnaire incorporated a 1-to-10 scale rating, allowing systematic progress monitoring and tracking confidence trajectories across the thesis project. The students rated how effectively they resolved technical hurdles without supervisor intervention, how the extent peer discussion improved understanding of foundational principles, and built confidence in justifying empirical results to an external examiner. Tracking this data revealed distinct, positive trends validating the theoretical framework. Initially, students reported lower scores (3 – 5 out of 10) regarding independent consensus-reaching abilities (Appendix II). They exhibited hesitation challenging a peer's analytical data interpretation, indicating a lack of "feedback literacy" (Carless & Boud) and a fear of damaging social cohesion by appearing overly critical. However, as meetings progressed and the routine normalized, qualitative feedback indicated growing comfort with objective scientific debate. Quantitative scores regarding independent problem-solving climbed to 7s and 8s (Appendix II). Realizing they could catch mechanistic errors simply by explaining a pathway aloud constituted an "aha"-moment in several instances. In one instance, one of the students realized their proposed reaction mechanism violated the octet-rule, solely because they were encouraged to draw it on a whiteboard for their peers. This directly illustrates Topping's concept of cognitive elaboration and the power of making implicit knowledge explicit (Topping, 1998).

Implementing and moderating this intervention required adjusting my supervisory habits. Stepping back, suppressing the urge to provide immediate answers, and allowing students to debate technical hurdles and struggle productively within their ZPD proved challenging but necessary for their development. The underlying pedagogical premise holds that

evaluating a peer's work helps students internalize strict criteria for high-quality scientific research, simultaneously improving their capacity to spot methodological inconsistencies in their own narratives. Consequently, my role shifted from manager of daily laboratory procedures to facilitator of overarching scientific strategy. Because students resolve foundational technical hurdles, basic stoichiometry calculations, and procedural errors during peer sessions, our formal one-on-one supervision meetings elevate significantly in complexity. We spend less time correcting basic data misinterpretations and more time discussing chemical reasoning, literature comparisons, and on the structural flow of the final thesis narrative. This shift improved the students' learning experience and optimized my (supervisor) resource allocation, i.e. transitioning my input from basic proofreading to high-level academic mentorship.

Conclusion

This pedagogical project provided a practical, structured, and theoretically grounded solution to student passivity and supervisor dependency in BSc thesis supervision. By designing and evaluating a formalized peer-feedback intervention, I shifted the supervisory dynamic away from unilateral instruction toward a model demanding collaborative cognitive engagement and shared responsibility. Integrating bimonthly peer-consultant meetings and experimental audits required students to continuously externalize their chemical reasoning. This applies Constructive Alignment principles, forces progression through the higher levels of the SOLO taxonomy and leverages Social Constructivism to help students reach deeper levels of learning.

The ongoing formative evaluation via targeted reflective questionnaire demonstrated that as the students practiced defending synthetic choices and reviewing complex spectral data, their scientific independence, feedback literacy, and self-monitoring capacity increased dramatically. Furthermore, this intervention supported the final summative examination by preparing students to articulate and defend their "Results and Discussion" logic during the final oral defense, which reduced their anxiety and improved performance. Ultimately, this

teaching experiment proved highly relevant and transformative to my teaching practice. It successfully redefined my role, as the supervisor, from primary problem-solver and error-checker to facilitator of independent scientific identity development. I intend to integrate this peer-feedback framework as a permanent component of my supervision practices in future courses.

References

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education*, *32*(3), 347–364. https://doi.org/10.1007/BF00138871

Biggs, J. (1999). What the Student Does: teaching for enhanced learning. *Higher Education Research & Development*, *18*(1), 57–75. https://doi.org/10.1080/0729436990180105

Boud, D., Cohen, R., & Sampson, J. (1999). Peer Learning and Assessment. *Assessment & Evaluation in Higher Education*, *24*(4), 413–426. https://doi.org/10.1080/0260293990240405

Carless, D., & Boud, D. (2018). The development of student feedback literacy: enabling uptake of feedback. *Assessment & Evaluation in Higher Education*, *43*(8), 1315–1325. https://doi.org/10.1080/02602938.2018.1463354

Den uddannelsesspecifikke del af studieordningen for bacheloruddannelsen i medicinalkemi ved Det Natur- og Biovidenskabelige Fakultet, Københavns Universitet. (2020).

Edmondson, A. (1999). Psychological Safety and Learning Behavior in Work Teams. *Administrative Science Quarterly*, *44*(2), 350–383. https://doi.org/10.2307/2666999

Harland, T. (2003). Vygotsky's Zone of Proximal Development and Problem-based Learning: Linking a theoretical concept with practice through action research. *Teaching in Higher Education*, *8*(2), 263–272. https://doi.org/10.1080/1356251032000052483

Lai, K.-W. (2011). Using collaborative peer feedback and supervision to support doctoral research at a distance. *ASCILITE Publications*, 747–757. https://doi.org/10.14742/apubs.2011.1740

Marcuccio, M. ; S. L. (2019). Peer feedback as assessment practice in doctoral programs: a systematic review of empirical research. *Italian Journal of Educational Research*, 85–100.

Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: a model and seven principles of good feedback practice. *Studies in Higher Education*, *31*(2), 199–218. https://doi.org/10.1080/03075070600572090

Tai, J., Ajjawi, R., Boud, D., Dawson, P., & Panadero, E. (2018). Developing evaluative judgement: enabling students to make decisions about the quality of work. *Higher Education*, *76*(3), 467–481. https://doi.org/10.1007/s10734-017-0220-3

Topping, K. (1998). Peer Assessment Between Students in Colleges and Universities. *Review of Educational Research*, *68*(3), 249–276. https://doi.org/10.3102/00346543068003249

Wenger, E. (2000). Communities of Practice and Social Learning Systems. *Organization*, *7*(2), 225–246. https://doi.org/10.1177/135050840072002

APPENDIX I

Questionnaire for after the bimonthly meeting:

Describe a specific technical hurdle where you and your peer initially disagreed. How did the process of debating different perspectives help you arrive at a more robust solution than you would have found alone?

On a scale of 1 – 10, how much did today's discussion improve your understanding of the chemical principles you are applying? (1 = No change; 10 = Significant new insight).

Reflect on where your peer's feedback caused you to abandon an unproductive line of thinking. What was the specific logic that improved your insight?

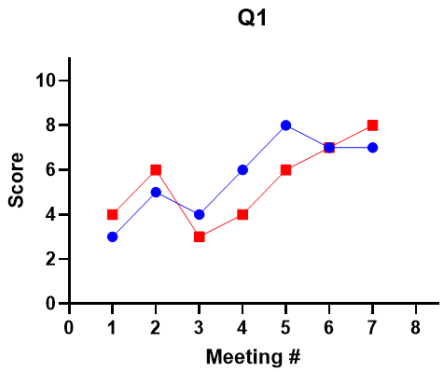
How effectively were you and your peer able to reach a consensus on a specific technical hurdle discussed, without seeking supervisor intervention? (1 = We needed the supervisor; 10 = We resolved it entirely ourselves).

Can you identify a moment where you caught your own error while explaining something to your peer? What does this tell you about your growing ability to self-monitor?

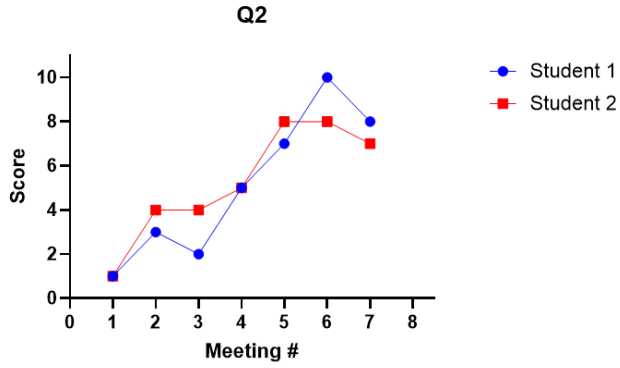
How confident do you feel in your ability to justify your current synthetic results and "Results & Discussion" logic to an external examiner? (1 = Very uncertain; 10 = Completely confident)

APPENDIX II

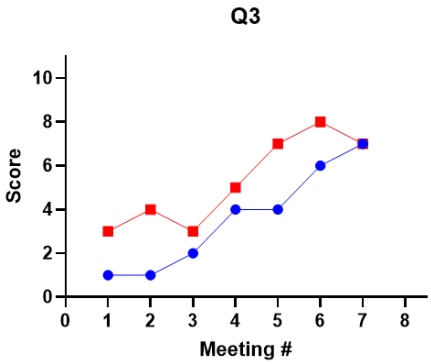
Self-reported rating of the questions in the questionnaire



Question 1: On a scale of 1 – 10, how much did today's discussion improve your understanding of the chemical principles you are applying? (1 = No change; 10 = Significant new insight).



Question 2: How effectively were you and your peer able to reach a consensus on a specific technical hurdle discussed, without seeking supervisor intervention? (1 = We needed the supervisor; 10 = We resolved it entirely ourselves).



Question 3: How confident do you feel in your ability to justify your current synthetic results and "Results & Discussion" logic to an external examiner? (1 = Very uncertain; 10 = Completely confident)