AI generated document summary:

Comparative Analysis

Part 1: Comparative Analysis

Article Title: How Students Use AI Feedback Matters: Experimental Evidence on Physics Achievement and Autonomy

- **Core Problem:** The study investigates how different usage patterns of Generative AI (GAI)-powered personalized feedback—specifically compulsory personalized recommendations versus autonomous on-demand help—affect the physics achievement and learning autonomy of high school students with varying baseline academic performance.
- **Methodology:** The research employed two sequential randomized controlled trials (RCTs) in a naturalistic school setting. Experiment 1 (n=121) assessed compulsory usage of a personalized recommendation system, while Experiment 2 (n=266) investigated autonomous on-demand help. Data were collected through pre- and post-intervention physics exam scores and validated questionnaires measuring self-regulated learning (SRL) and learner autonomy (LA).
- **Key Findings:** The effects of GAI feedback are highly heterogeneous and depend on the usage pattern and students' prior achievement. Compulsory recommendations significantly improved academic performance for low-achieving students but decreased self-regulated learning for high-achieving students. Conversely, autonomous on-demand help significantly enhanced academic performance for high-achieving students but led to a notable decline in autonomy among low-achieving students.
- **Relevance to GenAI in Education:** This article provides critical empirical evidence that the pedagogical model and usage pattern of GAI tools are more critical than the technology itself. It demonstrates that a "one-size-fits-all" implementation of GAI feedback is ineffective and can be detrimental, suggesting that interventions must be tailored to the specific needs and characteristics of different learner groups to be successful.

Article Title: Teaching high school students about generative AI: Cases of teacher lesson design

- **Core Problem:** The study explores how high school teachers, with varied prior experiences and resources, design and enact lessons to teach students about Generative AI within their specific disciplines. It examines the types of lesson activities created and the factors influencing their design.

- **Methodology:** The research utilized a descriptive case study approach focusing on two high school teachers (one AP Research, one AP English) who participated in a year-long professional learning and co-design partnership named CRAFT. Data was gathered through recordings of professional learning sessions, participant interviews, and lesson design artifacts (e.g., lesson plans, slides, student activity guides).
- **Key Findings:** Teachers designed lessons that did not strictly adhere to a single approach but rather blended the positioning of GenAI as an "object-of-study" (analyzing the tool itself) and as a "subject-specific" tool (using it to support disciplinary learning). The design process was heavily influenced by each teacher's pedagogical design capacity (disciplinary knowledge, curriculum resources) and significantly mediated by the co-design experience, which provided peer feedback and structured activities that helped build confidence and refine lesson plans.
- **Relevance to GenAI in Education:** This paper provides concrete examples of how teachers can integrate GenAI into their classrooms. It highlights that co-design partnerships are a crucial support mechanism for developing teachers' "pedagogical design capacity" for GenAI, enabling them to create innovative and relevant lessons regardless of their initial technical expertise. It offers contrasting models of pedagogical approaches for GenAI integration.

Detailed Summaries

Part 2: Detailed Article Summaries

Article Title: How Students Use AI Feedback Matters: Experimental Evidence on Physics Achievement and Autonomy

This study investigates the nuanced impacts of Generative AI (GAI)-powered feedback on high school students' physics learning. The authors address a gap in existing literature, which often focuses on the technical precision of AI systems while overlooking how students' usage patterns affect outcomes. The core research questions examine how compulsory versus autonomous use of GAI feedback influences academic achievement and learner autonomy across students with different prior performance levels (low, medium, and high achievers).

The methodology consists of two five-week randomized controlled trials (RCTs) involving 387 tenth-grade students.

- **Experiment 1 (Compulsory Usage):** 121 students were randomized into three groups. Group A received personalized problem recommendations with GAI-powered heuristic hints. Group B received the same recommendations but with conventional workbook answers. Group C1 was the control. Students in the treatment groups were required to use the system to review errors from their daily homework.

- **Experiment 2 (Autonomous Usage):** 266 students were randomized into three groups. Group D had access to an on-demand help system with full student control, allowing them to request specific feedback types (hints, concept explanations, practice problems). Group E used a shared-control system where students could ask for help, but an algorithm determined the feedback type. Group C2 was the control.

The key findings reveal significant heterogeneous effects. In Experiment 1, compulsory GAI hints significantly improved test scores for low-achieving students (d=0.673), while conventional answers negatively impacted medium-achievers (d=-0.539). Notably, high-achieving students saw a significant decline in self-regulated learning (d=-0.477) with no academic benefit. In Experiment 2, autonomous on-demand help significantly improved achievement for high-achieving students (d=0.378) without harming their autonomy. However, this same model caused a significant decline in autonomy for low-achieving students (d=-0.383), particularly in the technical-psychological dimension related to self-regulation.

The study concludes that the educational effectiveness of GAI systems depends critically on the alignment between the usage pattern and student characteristics. The authors propose a design principle: provide more compulsory, structured support for lower-achieving students while offering greater autonomy and on-demand assistance to higher-achieving students. This approach may maximize academic benefits while minimizing the risk of fostering technological dependence and undermining learner autonomy.

Article Title: Teaching high school students about generative AI: Cases of teacher lesson design

This paper addresses the challenge teachers face in integrating Generative AI (GenAI) into their classrooms by examining how they design and implement relevant lessons. The research focuses on understanding the pedagogical approaches teachers take and the resources that shape their curriculum design process. The study was conducted through a year-long co-design partnership called CRAFT (Classroom-Ready AI resources For Teachers), which provided professional learning and collaborative support.

The methodology is a descriptive case study of two high school teachers with 3-4 years of experience: June, an AP Research teacher, and Margot, an AP English Language and Composition teacher. The researchers analyzed data from multiple sources, including recordings of the six CRAFT professional learning sessions, semi-structured interviews with the teachers, and their complete lesson design artifacts (lesson plans, slide decks, and student handouts). The analysis focused on identifying the role of GenAI in the lesson activities and the resources that influenced the teachers' design choices.

The findings reveal that teachers do not adopt a simple, binary approach to GenAI integration. Instead, their lessons combined two strategies: treating GenAI as an **object-of-study** (e.g., analyzing the features, biases, and

limitations of an image generator) and using it as a **subject-specific** tool (e.g., using a chatbot to critique and improve argumentative writing).

- **June's (AP Research) lesson** was more exploratory, positioning GenAI as an object-of-study. She had students experiment with text and image generators to evaluate their usefulness for research, which led to organic student-led discussions on ethics, bias, and data privacy. Her design was heavily influenced by feedback from the CRAFT cohort, which helped her organize and refine her lesson sequence.
- **Margot's (AP English) lesson** was more structured and focused on using GenAI as a subject-specific tool to enhance writing skills. She had students analyze and compare human- vs. AI-generated essays to identify the qualities of "great writing," thereby positioning students as having expertise and agency over the AI. Her design was primarily informed by her deep pedagogical content knowledge and curriculum design experience, though she made key adaptations based on peer suggestions from CRAFT.

The study concludes that co-design partnerships like CRAFT are a vital mechanism for building teachers' pedagogical design capacity for GenAI. These collaborations provide the necessary support, peer feedback, and structured exploration to help teachers, regardless of their prior AI knowledge, build the confidence and skill to design and enact meaningful GenAI lessons. The cases illustrate that effective GenAI integration is not a one-size-fits-all approach but is shaped by teachers' unique knowledge, disciplinary goals, and supportive professional communities.