ORIGINAL IDEA

Puzzle-based Inquiry (PBI)

Engaging Students through Reflection, Trade-offs, and Play

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Received: 2025-09-13; Accepted: 2025-10-5; Published 2026-02-18
Editor: Robert Kordts

Abstract

Puzzle-based Inquiry (PBI) is an active learning method where students collaboratively assemble “puzzle pieces” such as research design elements into plausible configurations. Unlike traditional card-sorting tasks, PBI emphasizes reflection, negotiation, and weighing trade-offs over finding one correct solution. For instance, in a quantitative methods course, students may design a study under point-based resource limits, balancing rigor and feasibility. PBI is flexible, adaptable across disciplines, and fosters connections between theory, methodology, and practice. Its tangible, game-like format enhances engagement, recall, and curricular integration without relying on technology. However, it must align with course learning outcomes and is less effective without prior instruction. Best used as a supplement, PBI encourages deeper reflection and application once foundational knowledge is established.

Keywords: *Puzzle-based Inquiry, active learning, reflection, gamification*

Introduction

Engaging students in meaningful discussion and critical reflection is a central aim of higher education (Ananiadoui & Claro, 2009). To achieve this, educators have developed a range of instructional approaches designed to move beyond passive transmission of knowledge. Active learning strategies (Bonwell & Eison, 1991), in particular, have gained prominence for their ability to promote collaboration, deeper understanding, and the

Publisher: Research group “Teaching and Learning in Higher Education” at the University of Bergen & Research group “University Pedagogy” at the Western Norway University of Applied Sciences (HVL)

DOI: https://doi.org/10.15845/norsotl.v1.4725

application of concepts in practice (Doolittle et al., 2023). However, many active learning methods do not explicitly require students to weigh and compare different options or to make prioritized decisions under resource constraints, even though such trade-offs closely resemble real-life scenarios. In addition, there is a growing tendency to digitalize education, sometimes driven more by the availability of technology than by clear benefits for student learning. The current paper introduces a novel approach to active learning that builds on the established strengths of existing active learning methods while adding a stronger emphasis on realistic trade-offs and decision-making.

Defining Puzzle-based Inquiry (PBI)

Puzzle-based Inquiry (PBI) is a group-based active learning activity where students collaboratively assemble conceptual "puzzle pieces" or "cards" (e.g., research design elements) into multiple plausible configurations. The process stimulates critical reflection, negotiation, and inquiry, rather than focusing on a single correct solution or categorizing concepts into pre-defined categories or sequences. PBI is similar to card-sorting tasks (Spencer, 2009), in which participants either organize cards into groups and label them (open card sort) or place them into predefined categories (closed card sort). However, a key difference is that in PBI categorization is not the primary goal. Instead, students are asked to evaluate the advantages and disadvantages of different constellations of cards within a given template. The purpose is therefore less about arriving at a single correct answer and more about fostering discussion and critical reflection on the choices made.

Example from teaching quantitative methods

In a Puzzle-based Inquiry (PBI) exercise, groups of students might be asked to construct a quantitative research design for a specific research question. They are given a set of cards, each representing a different aspect of the design (e.g., sample size, sampling method, research design type, statistical analysis). Students are then asked to combine these cards into the most reasonable configuration (See Figure 1). To push students to think critically and make trade-offs, the instructor can also provide them with a limited number of "points." Each card requires a certain number of points to include in the design, which means students must decide how to allocate their resources strategically. The goal is not only to assemble a coherent design, but also to reflect on what constitutes the most appropriate and feasible design under resource constraints.

For instance, students might be asked to address the research question: *"Does implementing a universal school breakfast program improve academic performance among primary school children?"* Each group begins with 15 points and must select one card from each category (see Table 1) to construct the most appropriate research design. To introduce an element of gamification, the activity can be timed (e.g., 20 minutes), after which groups present their designs and reflect on the trade-offs involved. The instructor—or an external evaluator not directly involved in the course—can then assess the designs and provide feedback. As shown in Table 2, multiple configurations are possible, each illustrating different priorities and compromises in the research design process.

Table 1. Example of categories, options and associated points for a BPI task.

Category	Option	Points
Research Design	Cross-sectional survey (one-time questionnaire about breakfast & grades)	2
	Quasi-experimental (compare schools before vs. after breakfast program)	4
	Randomized controlled trial (assign some schools breakfast, others not)	8
Sampling Method	Convenience sampling (schools that volunteer to participate)	2
	Random sample of schools in one city	5
	Stratified random sample (urban/rural, SES, ethnic mix)	6
Sample Size	Small: 200 pupils from 2–3 schools	2
	Medium: 1,000 pupils from 10–15 schools	5
	Large: 5,000 pupils from 50+ schools	8
Measurements	Teacher-reported academic performance	2
	Standardized test scores (math & reading)	5
	Mixed data (tests + teacher reports + nutrition logs + attendance)	7
Statistical Analysis	Descriptive averages (mean differences only)	2
	Regression (adjust for SES, gender, prior grades)	5
	Multilevel modeling (pupils nested in classes/schools, control covariates)	7

Note.

Figure 1. Illustration of how cards can be placed into predefined placeholders corresponding to key components of a research design.

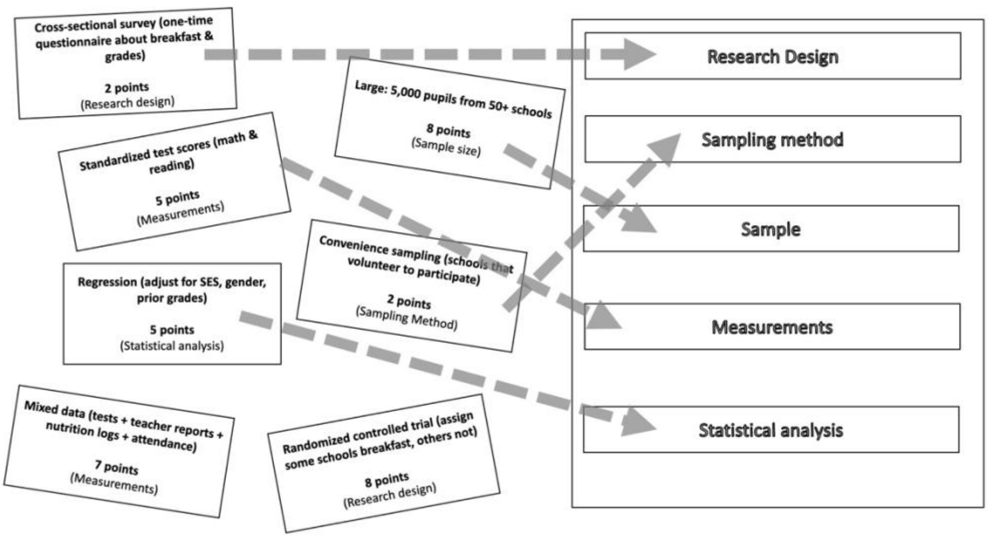

Table 2. Example of research designs configurations based on the students' suggestions

Student Group	Design	Sampling	Sample Size	Measurements	Analysis	Total Points	Within Budget?	Trade-off / Lesson
1	RCT (8)	Random (5)	Small (2)	Teacher reports (2)	Multilevel modeling (7)	24	No	Strong internal validity and advanced analysis, but over budget. Requires cuts to analysis or cheaper data/sampling.
2	Quasi-experimental (4)	Stratified random (6)	Large (8)	Teacher reports (2)	Descriptive (2)	22	Yes	Strong representativeness but limited analytical depth. Shows breadth vs. depth trade-off.
3	Cross-sectional (2)	Convenience (2)	Medium (5)	Mixed data (7)	Regression (5)	21	Yes	Rich, multi-source data but weaker design/sampling. Highlights internal validity concerns.
4	Quasi-experimental (4)	Random (5)	Medium (5)	Standardized tests (5)	Multilevel modeling (7)	26	No	Ambitious analysis and strong data, but too costly. Must scale back analysis or sample size.
5	Cross-sectional (2)	Random (5)	Medium (5)	Standardized tests (5)	Regression (5)	22	Yes	Balanced and defensible design. Reasonable rigor with manageable resources.

The advantages of BPI

PBI is a flexible framework that can be adapted to diverse course contents and disciplines. Educators can adjust both the quantity of materials (e.g., number of cards, point allocations) and their quality (e.g., cards presented as images, diagrams, or verbal labels) to align the difficulty level with students' prior knowledge and skills. For instance, students with advanced preparation may be given smaller sets of cards that require more stringent reasoning and allow fewer plausible configurations. Furthermore, PBI offers opportunities to highlight coherence across subjects, themes, and course content. In the example above, cards could extend beyond methodological elements to include philosophy of science (e.g., ontology, epistemology, paradigm) as well as relevant theoretical frameworks (e.g., population-based strategies, high-risk strategies). This integration encourages students to connect assumptions, theories, and methodological choices into a more complete study design.

In this way, the exercise not only highlights practical trade-offs in research design but also encourages students to recognize the connections between underlying assumptions, theoretical perspectives, and methodological choices. A key advantage of PBI is its potential for curricular integration—that is, linking subjects and disciplines to create a more holistic learning experience (Tegzes et al., 2023). Moreover, PBI is not restricted to a single discipline but can be applied across courses and subject areas. Such cross-disciplinary use facilitates interleaving, the practice of mixing and switching between concepts, ideas, and disciplines during learning, which has been shown to improve the transfer of knowledge and skills to new problems and contexts (Schorn & Knowlton, 2021; Steiner, 2001).

Moreover, to facilitate active recall (Roediger Iii & Karpicke, 2006) and thereby strengthen long-term retention, PBI can be adapted so that the cards are initially blank. Students must then recall and record relevant concepts from memory before engaging in the group activity. This can be organized as a two-step exercise, with card creation taking place in the first part of class and the PBI task in the second.

Finally, PBI also exemplifies how gamification can be incorporated into teaching to enhance student engagement and motivation (Dicheva et al., 2015; Zeybek & Saygı, 2024). Unlike many contemporary approaches that rely heavily on digital technologies, PBI provides a tactile, hands-on mode of interaction through the use of physical cards. This tangible quality has been reported by students to increase immersion and foster a more engaging learning experience (Smith & Conway, 2025).

The potential drawbacks of BPI

First and foremost, PBI is best regarded as a supplementary activity and should be carefully aligned with the overall course design—particularly with respect to constructive alignment, that is, the correspondence between intended learning outcomes (ILOs), teaching activities, and assessment methods (Biggs, 1996). For example, courses in subjects such as statistics, mathematics, and physics often place a strong emphasis on practical problem solving. In such cases, practice testing is a particularly effective instructional approach as compared to PBI, especially when the final examination closely aligns with this method (Dunlosky et al., 2013).

Secondly, a more general critique has been raised against minimally guided instructional approaches, including PBI and other inquiry-based formats. Kirschner et al. (2006) argue that extensive evidence supports the superiority of guided instruction over minimal guidance for promoting student learning. However, when students possess an adequate level of prior knowledge, less guided approaches such as PBI may yield comparable outcomes. A pragmatic response, therefore, is to use inquiry-based methods like PBI as a strategic supplement—positioned after direct instruction has established a solid foundation—so that students can engage meaningfully in more self-directed tasks.

About the Author

Magnus Jørgensen (PhD) is an Associate Professor of Health Sciences at the University of Stavanger. His teaching spans a wide range of subjects, including statistics, philosophy of science, health psychology, public health, and health promotion and prevention.

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