**Linear vs. Non-Linear Puzzle-Solving Structures**

In educational design, puzzle-solving is a powerful method to foster critical thinking, problem-solving, and learner engagement. The structure of these puzzles—whether linear or non-linear—plays a crucial role in shaping the learning experience. On one hand, the **Linear Puzzle-Solving Structure** follows a fixed, sequential path where learners must complete one step before progressing to the next. This model is typically centrally controlled, with a single correct pathway from start to finish. It is commonly used in traditional curricula, standardized testing, and procedural learning environments, particularly in well-structured domains such as mathematics and science, where knowledge builds cumulatively and predictably [1]. On the other hand, the **Non-Linear Puzzle-Solving Structure** allows learners to explore multiple paths, revisit previous steps, or even begin from different entry points. These structures are open-ended, learner-driven, and adaptable to individual interests and needs. They are often employed in project-based learning, game-based learning, and exploratory digital environments, especially in less structured domains such as the arts and humanities [1].

There are several scenarios where a linear structure is particularly effective. First, it supports **skill-building in sequence**, making it ideal for subjects where foundational knowledge must be acquired step-by-step, such as programming syntax or grammar rules [1]. Second, it aligns well with **standardised learning goals**, offering consistency and clarity in environments with fixed outcomes, such as national exams or certification programs [1]. Third, it benefits **beginner learners** by providing clear guidance and reducing cognitive load, which is essential for those unfamiliar with the subject matter [2]. According to **Cognitive Load Theory**, linear instructional designs are particularly effective for novice learners because they reduce cognitive demands and provide structured guidance. This is especially important when learners are unfamiliar with the content and need step-by-step support to build foundational knowledge [3].However, linear structures also have limitations. They often suffer from a **lack of flexibility**, which can disengage students who learn at different speeds or bring varying levels of prior knowledge [4]. They may also hinder **curiosity-driven learners**, who prefer to explore topics based on personal interest rather than a prescribed sequence[5]. Furthermore, **neurodiverse learners**, such as those with ADHD or autism, may find rigid sequences challenging. These students often benefit more from environments that offer autonomy and adaptability [6][7].

There are several educational contexts in which linear learning structures may prove inadequate. First, **rigid progression can limit exploration**; linear pathways often suppress learners’ curiosity by preventing them from delving deeper into topics that spark their interest. Second, the **one-size-fits-all approach** inherent in linear models assumes uniformity in learners’ prior knowledge and pace, which can lead to frustration among both advanced and struggling students. Third, **limited real-world applicability** is a concern, as real-life problem-solving is rarely linear; over-reliance on such models may inadequately prepare students for complex, dynamic environments. Fourth, **reduced learner engagement** may occur when students are required to follow a fixed sequence that does not align with their interests or perceived relevance. Finally, **inflexibility in assessment and feedback** is a notable drawback—linear systems often delay feedback until the end of a unit, whereas non-linear approaches can provide immediate, contextualised feedback that supports ongoing learning

Non-linear learning structures are particularly effective in educational contexts that emphasise flexibility, autonomy, and learner engagement. They promote exploratory and creative learning, encouraging students to follow their curiosity, make interdisciplinary connections, and engage in deeper inquiry [8]. These structures also support personalised learning paths, allowing learners to progress at their own pace and in their preferred sequence, which has been shown to enhance motivation and academic performance [4]. Additionally, non-linear structures are effective in **collaborative and real-world problem-solving**, as they mirror the complexity and unpredictability of authentic tasks [9]. In open learning environments such as Massive Open Online Courses (MOOCs), where learners often come from diverse backgrounds and possess varying levels of prior knowledge, non-linear pathways enable them to bypass familiar content and focus on areas of need or interest [4]. Furthermore, project-based and inquiry-based learning approaches thrive in non-linear settings, as they empower students to formulate their own questions and determine their own paths to solutions, fostering deeper engagement and critical thinking [10][11][12]. For neurodiverse learners, including those with ADHD or autism, non-linear structures provide greater autonomy and help reduce cognitive overload by allowing flexible navigation through content[13].Finally, collaborative and peer-led learning is well supported in non-linear environments, where students can engage with different components of a task simultaneously, share insights, and co-construct knowledge in dynamic and interactive ways [14].

Despite their advantages, non-linear structures are not universally appropriate. One key limitation is the potential lack of structure for beginners, who may become overwhelmed without clear guidance or a defined progression [4]. These learners often require more scaffolding to navigate content effectively. Additionally, non-linear learning environments pose assessment challenges, as the diversity of learning paths complicates the standardisation and comparability of outcomes [15]. This can make it difficult for educators to evaluate student performance consistently. Lastly, time management issues may arise, particularly in self-paced or asynchronous settings, where students without strong self-regulation skills may struggle to stay on track or complete tasks efficiently [4].

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