ISSN: 2710-0170

An Adaptive Approach for Knowledge Acquisition in the Age of AI

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Abstract

The exponential growth of big data and artificial intelligence has fundamentally transformed how learners acquire knowledge. They frequently navigate through the internet and artificial intelligence application to gather necessary materials to fulfill their learning needs. In these cases, they often find themselves overwhelmed by the sheer volume and complexity of the available information. The challenge of learning becomes to acquiring meaning and gaining understanding through artificial intelligence generated materials. This study focuses on the core challenges of knowledge acquisition faced by the learners in the context of artificial intelligence generated information overload. By integrating the understandings of information search process with constructivism, this research proposes an adaptive framework comprising knowledge gap bridging component and personalization component. The framework can balance the cognitive load and facilitating knowledge construction. By matching the difficulty level of learning content to learner' abilities, the study promote the gradual deepening of cognitive development.

Keywords

Knowledge acquisition, Adaptive learning, Knowledge gap, Personalization.

1. Introduction

Human society is undergoing an unprecedented digital transformation with the rapid development of the big data and artificial intelligence. The technology has fundamentally reshaped the production, dissemination, and acquisition of knowledge. The huge amount of information generated in the digital ages urge a strong demand for knowledge acquisition among learners. However, the demand also exposes a severe reality that we are currently in an era characterized by the coexistence of information overload and knowledge fragmentation. Learners construct fresh scientific understanding from their prior concepts and everyday experiences. They are also noticeably shaped by earlier misunderstandings. The learning theory posits that learning constitutes an active process wherein individuals build meaningful knowledge, rather than merely absorbing transmitted information. In this process, learners' prior knowledge can either facilitate the formation of new understandings or obstruct the development of new scientific conceptions.

Facing the increasing amount of information available for learners generated in digital age, traditional teacher centered teaching is shifting toward a learner centered learning paradigm. In this transition, learners are no longer passive containers receiving information. They are expected to be active meaning constructors. However, this transformation brings new challenges. When confronted with the vast ocean of online learning resources and AI generated materials, they often fall into the predicament of being lost in hyperspace. They may spend excessive time browsing through the resources and struggle to form an effective knowledge structure. This pressing situation demands that we re-examine the design of learning process and explore how to support learners in achieving efficient knowledge acquisition.

Based on this recognition, the paper presents a study to implement an adaptive knowledge acquisition framework. It draws upon learners' prior knowledge and misconceptions. The

ISSN: 2710-0170

framework centers on learners' capacity to articulate learning objectives and appraise their current knowledge levels. It pinpoints what new knowledge they must pursue. The framework tries to address a fundamental difficulty within the information search process: The learners require new information to bridge knowledge gaps but they lack adequate knowledge to clearly express what information they actually need. The framework aims to build an adaptive knowledge acquisition tailored for intentional learning. It addresses practical difficulties in information searching and knowledge integration through theoretical analysis and technical design. It deeply analyzes the internal logic of constructionist and intentional learning, diagnosing the cognitive and emotional characteristics of learners at various stages of information search. It proposes multidimensional scaffolding mechanism, including scope control, gap bridging, visualization of knowledge structures, expansion of cognitive horizons.

2. Theoretical Foundations

2.1. Constructivism

Constructivism has been the most influential in the learning sciences since the 1980s. Its core premise posits that knowledge is not transmitted by teachers. Instead, learners acquire it through meaning construction within specific contexts, utilizing necessary learning materials and assistance from others[1].

In this study, the theory provides support for adaptive knowledge acquisition across three stages. Firstly, learners are the subjects of information processing and active constructors of knowledge meaning. This implies that technological tools such as Artificial Intelligence Application should not merely serve as information sources but must act as cognitive scaffolds. Secondly, the construction of new knowledge must be rooted in the learner's existing experiences. The most important single factor influencing learning is what the learner already knows[2]. Thus, adaptive approach must be implemented upon accurate diagnostics of the learner's prior knowledge. Thirdly, knowledge acquisition is closely tied to the context in which it occurs. Abstract knowledge devoid of context is difficult to transfer and apply. This requires the study to emphasize the embedding of authentic cases and scenario simulations.

2.2. Information Search Process

To gain a deeper understanding of learners' behavioral characteristics during knowledge construction, this study incorporates information search process model. This model divides inquiry-based learning into six stages: initiation, selection, exploration, formulation, collection, and presentation[3]. Among these, the exploration and formulation stages are critical turning points in knowledge acquisition and represent periods of maximum uncertainty for learners. The model provides a temporal analytical framework for this study. It suggests that a framework of scaffolding components must be timely providing the most appropriate support when learners need it most.

3. Conceptual Approach

From the perspective of constructivism learning theory, knowledge is not an objectively existing entity. It is the product of active construction by learners through their interactions with the environment. It is based on their existing knowledge and experiences. This active construction does not always occur smoothly because they frequently encounter multiple obstacles stemming from their cognitive structures, emotional states, and behavioral patterns.

According to constructionist, learners do not come to the classroom with empty heads. Prior knowledge serves as the cornerstone for constructing new knowledge. It is simultaneously the root cause of cognitive bias. In the process of knowledge acquisition, prior knowledge exhibits a two opposite effects. When learners are exposed to new information, they first attempt to

ISSN: 2710-0170

incorporate it into their existing cognitive structures. Under ideal conditions, rich prior knowledge can provide anchorage points for incoming new information which is known as assimilation. Compared to assimilation, the process of accommodation presents greater challenges. When new information drastically conflicts with a learner's existing cognitive structure and cannot be assimilated, cognitive disequilibrium occurs. At this point, lacking meta cognitive monitoring capabilities, learners often fail to revise their original knowledge structure and fall into the trap of alternative conceptions. Alternative conceptions refer to naive theories formed through long-term life experiences or informal learning that contradict scientific concepts.

In the age of Artificial Intelligence, the information encountered by the learners can be overwhelmingly voluminous which obscures valuable insights and imposes a significant extraneous cognitive load on the learner's processing capacity. On the early stages of knowledge acquisition, learners explore various information sources on a broad topic to extend beyond their existing understanding. When learners engage in these stages, the encountered information seldom aligns neatly with their prior knowledge. From the learner's perspective, information originating from different sources may even appear inconsistent or incompatible. Under such conditions, learners can easily become discouraged and frustrated. Since learners often struggle to articulate precisely what information would fulfill their learning needs, obtaining support from teachers and digital world becomes more difficult.

Based on the analysis above, the paper proposes a conceptual approach to scaffold learners in their knowledge acquisition in the age of Artificial Intelligence. The core approach lies in three folds. First, it help the learners to be aware of what activities constitute a scientific investigation. Second, it helps the learners to know which activities to perform at different phases of an investigation. Third, it provides the learners with the background information that experts habitually use when conducting investigations. Thus, when learners are to engage in scientific exploration, the conceptual approach can provide significant support to help them mindfully do the cognitive science tasks that are just out of their reach. Quintana have suggested that to support learners, technology can embed scaffolding features that render complex practices accessible and mindfully executable by students[4].

In summary, the conceptual approach of the adaptive knowledge acquisition is not a linear accumulation process, but a complex nonlinear system fraught with cognitive conflicts. Alternative conceptions in cognition and inefficient cycles in behavior hindering learners' deep learning. Addressing these core issues through multidimensional scaffolding components and intelligent service design constitutes the primary objective of this approach.

4. Framework of Adaptive Knowledge Acquisition

The framework of Adaptive Knowledge Acquisition serves as the foundational architecture that supports learners in dynamically and intelligently acquiring new knowledge based on their current cognitive states. This framework is designed to address a fundamental challenge in intentional learning. It systematically guides learners from what they already know toward what they need to learn, while adapting to their individual differences. To achieve this goal, the framework comprises two interconnected components: the Knowledge Gap Bridge Component and the Personalization Component.

4.1. The Knowledge Gap Bridge Component

The Knowledge Gap Bridge component seeks to help learners expand outward from existing knowledge into unfamiliar knowledge domains. It directly corresponds to the learner's earlier stages of the information search when the learners are investigating diverse information sources to extend prior understanding. A dynamic task decomposition help learners to break

ISSN: 2710-0170

down complex topics into specific sub-problems. Before the information search commences, it is crucial to assist learners in clarifying what they already know, identifying knowledge gaps, and setting personalized learning goals.

The learning theory stresses that learning should be built upon existing experience, and activating prior knowledge is an essential first step toward effective learning. This can be accomplished through pee-tests, self-assessments, and similar methods. The component is aimed to identify discrepancies between learners' existing concepts and target concepts, providing cognitive bridges to help learners traverse understanding gaps. Research shows that learners' misconceptions can affect scientific understanding formation, thus calling for targeted conceptual change support[5]. The essence of bridging concepts is to help learners perceive continuity and connections between old and new knowledge. This can alleviate anxiety arising from cognitive conflict. In the process of expanding cognitive horizons, the component propose to analyze the intrinsic connections among related concepts and set up the foundation for building knowledge bridges. Through in-depth mining of knowledge structures of the learners, the component reveals the logical relationships and hierarchical structures among concepts, thereby providing learners with a clear knowledge navigation. Such concept-association analysis not only helps learners grasp the meaning of individual concepts but also enables them to understand the overall knowledge framework. The knowledge-transfer mechanism in multi-task collaborative optimization offers important insights for concept-association analysis.

To help learners better understand and construct the new knowledge structure, the component proposes several bridging methods, including analogies, examples, and visualization. These methods aim at reducing learners' cognitive load and promoting deep comprehension. Analogies are a commonly used bridging method, particularly effective in teaching abstract concepts[6]. In addition, providing some concrete examples is also an effective bridging strategy. It is especially useful when the examples are representative and closely related to learners' everyday experiences. It can significantly enhance their learning outcomes.

Visualization technology plays a crucial role in knowledge bridging[7]. The component presents complex conceptual relationships in a graphical format. It helps learners quickly develop intuitive understanding. The component integrates the bridging methods and dynamically adjusts their presentation formats according to learners' cognitive levels. This integration can achieve efficient knowledge transfer and internalization.

4.2. The Personalization Component

According to the zone of proximal development theory, the difficulty of learning tasks should be set slightly above the learner's current level of competence in order to stimulate their latent learning potential[8]. The personalization component adopts an adaptive challenge path design that dynamically adjusts knowledge acquisition difficulty based on the learner's study performance. The component helps cognitive development through challenges at an appropriate level of difficulty. The personalization component proposes to incorporate machine learning model to estimate the learner's competency level in real time. Based on these results, it recommends learning resources with an appropriately moderate level of difficulty. This dynamic difficulty adjustment mechanism can effectively prevents learners from experiencing frustration and sparks their interest in exploring unknown areas.

The component also positions abstract knowledge content within concrete, authentic situations, helping learners understand the application scenarios and practical relevance of knowledge. It thus foster deep understanding and knowledge transfer. It promotes to tailor the presentation format of learning content and inquiry paths according to learners' personal backgrounds, interests, life experiences, and learning objectives.

Personalization stands as a central goal of this component. The personalized context association makes each learner's path unique. It enhance the sense of meaning and personal

ISSN: 2710-0170

relevance in learning. By presenting how the same concept manifests across different situations, the component helps learners recognize both the general principles and the contextual dependencies of knowledge. It promotes flexible knowledge transfer and the cultivation of abstract generalization abilities. By comparing how a concept behaves differently across contexts, learners can develop richer and adaptable conceptual understanding.

5. Conclusion

This study aims to enhance the effectiveness of knowledge acquisition in Artificial Intelligence age by employing an adaptive framework. The approach includes cognitive horizon expansion, knowledge gaps bridging and knowledge integration. By using a dynamic task decomposition, learners can break down complex topics into specific sub-problems, thereby reducing cognitive load and improving learning efficiency. The introduction of progress aware mechanisms effectively alleviates learners' anxiety during the information search phases. The proposed multi-dimensional information quality evaluation can help the learners to foster their critical thinking skills. In order to bridge knowledge gaps for the learners in the information search phrases, this study has designed an adaptive diagnostic assessment model for prior knowledge. It helps learners quickly identify their own knowledge blind spots and effectively build cognitive bridges. This help to resolve conflicts learners encounter in conceptual understanding. The approach also ensures that the difficulty level of learning content is appropriately matched to learners' current abilities, thereby promoting the gradual deepening of cognitive development.

Although this study has achieved certain results in enhancing the knowledge acquisition in Artificial Intelligence age, there are still some shortcomings that require further improvement. In terms of knowledge gap bridge component, this study has primarily focused on knowledge linked with the learner's prior knowledge. Thus, it is efficient only within specific domain and has not yet fully validated its applicability in interdisciplinary or multi-domain learning contexts. Future research could attempt to extend the component to a broader range of learning scenarios and explore optimization directions for the component across different fields. The approach proposed in this study are expected to find broader applications. By deeply integrating with other technologies, it can offer learners a more personalized and efficient knowledge construction experience. It thereby can accelerate the advancement of intelligent education.

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ISSN: 2710-0170

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