# Literature Review of SE/CS Concepts

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## CONTRIBUTION

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- Scope and Objectives
- Synthesis of Theories for History Quest

## I. SCOPE AND OBJECTIVES

This literature review examines the application of the following education theories: behaviourism, constructivism, cognitivism, connectivism, and experientialism, within the context of Software Engineering (SE) and Computer Science (CS) tools for history education. This review informs the design and development of History Quest, an interactive application designed to teach Modern History to Year 9-11 students.

Modern History, spanning from the late 18th century to the present, encompasses transformative events such as the Industrial Revolution, World Wars, and Digital Revolution. This period was selected for its global significance, engaging narratives, and alignment with secondary education history curricula [1].

The review focuses on educational tools that are at the intersection of educational theory, SE/CS applications, and social sciences learning. By refining the target audience to Year 9-11 students, the review aligns with curriculum requirements, prioritising engagement and accessibility for this age group. The key objectives are to analyse how the following educational theories can inform SE/CS-based learning tools, identify relevant applications in social science education, and synthesise insights that will guide History Quest's interactive features, such as timelines, maps, and quizzes, to foster effective learning outcomes for young learners.

## II. EDUCATIONAL THEORIES

### *A. Behaviorism*

*1)* ***Concept Overview****:* Behaviourism is a foundational learning theory that explains learning as a result of observable interactions between an individual and their environment. It operates on principles of stimulus-response mechanisms and reinforcement, where behaviours are shaped by rewards or punishments.

This theory was pioneered by Ivan Pavlov through classical conditioning, and further developed by B.F. Skinner, through operant conditioning, emphasised the role of positive reinforcement (such as rewards) and negative reinforcement (removal of undesirable stimuli) in influencing behaviour [2] [3]. Behaviourist approaches promote directed instruction and focus on repetition and reinforcement to form desired learning habits. In educational settings, particularly those involving structured knowledge such as history, behaviourism supports the memorisation of factual content and procedures through continual practice and feedback. According to Papert, behaviourist strategies are often employed in a teacher-led manner, where a skill is explained, demonstrated, and then reinforced through feedback and repetition [4].

By presenting material in a controlled, stimulus-rich environment and reinforcing desired outcomes, behaviourism aims to instil measurable and lasting learning outcomes, which makes it highly suitable for subjects that rely on factual recall and concept reinforcement.

*2)* ***Applications in SE/CS and History****:* In the domain of Software Engineering and Computer Science education, behaviourist principles are widely employed in the development of interactive learning platforms that promote engagement through extrinsic motivation. Applications such as Duolingo, Kahoot, and CodeCombat leverage behaviourism by rewarding users with points, levels, and badges when they demonstrate correct understanding [5] [6]. These platforms create learning environments where reinforcement and repetition are central to student progress. In history education, similar mechanisms have been integrated into quiz-based learning tools that test students on key dates, events, and cause-and-effect relationships. For example, Duolingo's gamified structure has inspired many educational tools that use short, repeatable drills and immediate feedback to improve factual recall.

Codecademy can be analysed from a structured reinforcement point of view. The application utilises step-by-step tutorials and coding exercises, such as quizzes. This allows students to receive instant feedback after an activity and rewards users for correct responses by advancing to the next module or achievement. From a behavioural perspective, it aligns with the view that knowledge is objective and by producing the correct response to a given stimulus, reinforces such knowledge.

Behaviourism has also been validated at the tertiary level, with research such as that by Ross and Neuringer demonstrating that students exposed to reinforcement-driven learning tasks exhibited greater variability and responsiveness, confirming the enduring relevance of behaviourist methods even in advanced educational contexts [7]. In addition, education platforms stated before employ gamification techniques such as points to further serve as motivators. These visual and reward cues encourage students to continue and complete modules. Such strategies not only keep the learner engaged but also measure the learner's progress to provide feedback.

*3) **Synthesis for History Quest:*** The educational software History Quest applies behaviourist principles by embedding gamified quizzes that reinforce key facts about Modern History for students in Years 9-11. The app is designed to trigger engagement through stimulus-response cycles, where students respond to structured prompts and receive immediate feedback on their answers. Correct answers are reinforced with points and visual rewards, encouraging students to repeat interactions and retain knowledge through repetition.

By aligning its structure with behaviourist theory, History Quest ensures that students are continuously motivated to engage with content while reinforcing desired learning behaviours such as memorisation and recall of historical facts. From a software engineering perspective, the app embodies core behaviourist design strategies such as guided learning paths, reinforcement loops, and feedback systems. These features ensure that learning is not only structured and goal-oriented but also engaging and adaptive to the learner's pace, making History Quest an effective educational tool grounded in a well-established theoretical framework.

### B. Cognitivism

*1) **Concept Overview:*** Where behaviourism emphasises observable actions shaped by external reinforcement, cognitivism highlights the internal mental processes involved in learning. Cognitivism views learning as the active processing of information, focusing on how knowledge is received, organised, stored, and retrieved [8]. Central contributors to this theory include Jean Piaget, who proposed developmental stages of cognitive growth, and Robert Gagné, who outlined a sequence of internal events essential for effective learning.

Information Processing Theory [9] conceptualises the mind as processing input through stages: sensory input, attention, short-term memory, long-term memory, and retrieval. According to this theory, practical learning occurs by guiding attention, organising information clearly, and supporting memory encoding and retrieval through techniques like chunking, rehearsal, and repeated practice [10] [11].

Cognitive Load Theory [12] further develops this model by recognising the limitations of working memory during learning. It identifies three cognitive loads: intrinsic (complexity of content), extraneous (unnecessary mental effort due to poor presentation), and germane (productive effort building understanding). Instructional design guided by Cognitive Load Theory aims to minimise extraneous load and manage intrinsic load, thus allowing learners to dedicate mental resources to schema formation [13].

These theories underpin effective learning strategies in education by emphasising active mental engagement, structured content delivery, and strategic repetition, thereby enhancing long-term retention.

*2) **Applications in SE/CS and History:*** Cognitivist theories are particularly relevant in Computer Science and History education, where learners engage with complex concepts and interconnected information. In Computer Science, learners grapple with logic, syntax, and problem-solving; in History, they must navigate timelines, cause-and-effect relationships, and thematic connections. Without a structured presentation, the cognitive load may become overwhelming [12]. Khan Academy's World History course exemplifies cognitivism through concise videos and review questions. Lessons on topics like the Cold War use timelines and maps to direct attention, aiding memory encoding and retrieval [10]. To be specific, a lesson on World War I begins with a simple timeline and key events, then progresses to a deeper analysis of cause-and-effect relationships. Key terms introduced early, such as "containment" or "proxy war," reappear in subsequent modules, reinforcing retrieval practice and deepening complexity over time.

Similarly, the Mimo app exemplifies cognitivism in a Computer Science educational context by structuring coding lessons into bite-sized and specific tasks. This approach limits extraneous and intrinsic cognitive load by restricting information presented simultaneously, all while boosting germane load. For instance, Mimo introduces basic syntax through simple tasks, gradually integrating these into more complex problems such as debugging nested loops.

These examples showcase how History Quest can effectively apply cognitive theories by maintaining student attention through structured content, fostering meaningful practice with retrieval activities, and incrementally building deeper understanding, thus addressing the cognitive demands of complex historical content.

*3) **Synthesis for History Quest:*** Cognitivism as a theory is a large inspiration for History Quest's educational design, ensuring content is delivered effectively for Year 9-11 students. History Quest manages intrinsic cognitive load by segmenting timelines and clearly structuring historical events, helping students process and retain complex historical information. Consistent repetition and retrieval activities reinforce memory encoding and long-term recall, aligning with IPT. Furthermore, History Quest incorporates minimalist interface designs common in computer science education platforms, reducing extraneous cognitive load and allowing students to focus entirely on the educational content. Together, these cognitivist principles ensure History Quest provides an engaging, manageable, and meaningful learning experience tailored to its target audience.

### *C. Constructivism*

*1)* ***Concept Overview:*** Constructivism can be summarised as a learner-centred philosophy of education in which individuals actively build understanding through experience, interaction and reflection. In practice, this translates into exploratory activities that allow learners to navigate, question and construct their own narratives.

Jean Piaget, a renowned psychologist, is a key figure in constructivism, and his early work laid the foundation of cognitive constructivism [14]. He argued that learners develop mental frameworks through processes of familiarisation and adaptation, continuously refining their understanding of the world. The key takeaway from his work being that knowledge is not transmitted from teacher to student but instead emerges from the learner's active engagement.

Jerome Bruner extended Piaget's insights with "discovery learning theory", stating that students learn most effectively when they discover underlying principles for themselves rather than receiving explicit instruction [15]. Bruner believed that this approach fostered deeper conceptual retention and helped develop essential skills for lifelong learning.

Lev Vygotsky, another foundational name in the building of constructivism, introduced the Zone of Proximal Development (ZPD) to describe the gap between what learners can achieve independently and what they can accomplish with appropriate support [16].

A major practice within constructivism is scaffolding, first described by Wood, Bruner, and Ross. It is the process of providing targeted support (prompts, hints, worked examples) that align with the learners' ZPD and gradually withdraw as learners gain independence [17]. This practice helps manage cognitive load by breaking complex tasks into manageable steps and promotes self-regulated learning as students internalise the knowledge.

In summary, constructivism positions learners as active agents who form knowledge through iterative experiences. Guided by the early work of theorists Piaget, Bruner, and Vygotsky, its core practices, such as discovery learning and scaffolding, ensure that education adapts to each learner's developmental stage, fostering deeper understanding and self-autonomy.

*2)* ***Applications in SE/CS and History:*** Constructivism is an extremely influential theory in many areas; CS/SE in particular has been largely impacted. Programming tasks, by their very nature, require the learner to hypothesise, test, debug, and revise, making them particularly well suited to constructivist based methodology. Two of the most prominent examples of constructivist educational tools are Scratch and Minecraft: Education Edition, both of which utilise this theory's principles in distinctive ways.

Scratch was developed at the MIT Media Lab under the leadership of Mitchel Resnick. Its drag-and-drop, block-based interface eliminates syntax barriers so that novices can focus on the logic of programming and immediate feedback loops. A systematic review found that Scratch supports the acquisition of core computational thinking practices, such as abstraction, algorithmic design, and debugging across diverse K–12 contexts [18]. Another study found that scratch projects promote learner agency and creativity, enabling students to iterate on designs in a social online community [19]. Due to the creative nature of this platform, scratch games can be used to develop a game/tool that teaches any topic, there are a large number of games that help teach different aspects of history. This makes Scratch an extremely good example of applied constructivism in the CS/SE field; the creator is taught programming concepts while simultaneously building a tool that will help teach others a completely different topic.

Minecraft: Education Edition (M:EE) extends constructionist principles into a three-dimensional, collaborative world-building. Players manipulate blocks to create environments, which can help students build their own understanding of abstract concepts. A Springer study on M:EE in science classes demonstrated that its open-ended exploration, real-time feedback, and embodied interaction substantially increased engagement and conceptual understanding of atomic structure, illustrating how sandbox learning can bridge concrete and abstract domains [20]. In relation to history, a study found that primary-school students collaborating to rebuild UNESCO heritage sites reported deeper historical empathy and contextual understanding [21]. This interactive hands-on experience is the core of constructivism itself, and M:EE is a great example of how a SE/CS tool can be leveraged to teach almost any subject.

*3)* ***Synthesis for History Quest:*** With all this in mind, there are a large number of different principles and design elements that the application could take from constructivism and incorporate into History Quest. A few areas this project will focus on include:

Scaffolding: Implementing scaffolding through an interactive guided pathway through the different historical events. The tool could offer embedded hints and contextual prompts that are slowly removed as the user learns more about the topic.

ZPD: The platform could integrate with AI, providing an AI assistant that the user could ask questions and learn from. The assistant would be programmed to never give answers and instead give hints that are slightly outside the user's current ability, which aligns with Vygotsky's zone of proximal development theory.

Collaborative Knowledge Building: Enable users to work on shared timelines or maps of historical events. Participants contribute observations and debate interpretations, leveraging social constructivist principles to deepen understanding.

This interactive approach will help transform passive historical learning into an active construction process where users become historians themselves, investigating, connecting events, and developing their own narratives about the past.

### D. Connectivism

*1) **Concept Overview**:* A paper from 2020 looks into Connectivism. Connectivism is a learning theory that emphasises the role of social and cultural contexts in learning, particularly in the digital age [22]. It suggests that learning occurs through the formation of connections between individuals and information sources, facilitated by technology. Connectivism posits that knowledge is distributed across networks, and learning involves navigating these networks to access and utilise information effectively. In the context of SE/CS education, Connectivism can be applied through online collaborative platforms, social learning networks, and the use of AI as a knowledge base.

A paper in 2016 by John Goldie frames connectivism as a knowledge theory that combines "technology and socialisation". They make allegories to the structure of the human mind, with neurons that connect to disparate sections. Thus, knowledge is formed through the presence of these connections and not the sources themselves. There is increasing complexity when navigating the many knowledge bases available online, so connectivism serves to provide a context for understanding these systems by finding meaningful connections.

*2) **Applications in SE/CS and History**:* In Software Engineering (SE) and Computer Science (CS) education, connectivist principles are applied through the use of online collaborative platforms, social learning networks, and tools that facilitate peer-to-peer interactions. These technologies enable learners to access and contribute to a collective pool of knowledge, reflecting the core idea of connectivism that learning occurs across networks [23].

For instance, platforms like GitHub and Stack Overflow exemplify connectivist environments where learners and professionals collaborate, share knowledge, and solve problems collectively. In history or social sciences education, similar applications are seen in the use of online forums, wikis, and collaborative projects that allow students to co-construct knowledge and engage with historical content interactively.

The Flat Classroom Project is an example of a global collaborative initiative that leverages Web 2.0 tools to foster communication and interaction among students and teachers worldwide, embodying connectivist principles in practice [24].

*3) **Synthesis for History Quest**:* In designing History Quest, integrating connectivist principles can enhance the learning experience by fostering networked learning and collaboration among Year 9-11 students studying Modern History. By incorporating features such as discussion forums, collaborative timelines, and shared digital archives, the platform can facilitate connections between learners, educators, and diverse information sources.

These features align with SE/CS principles by utilising networked systems and AI-driven knowledge bases to provide personalised learning pathways and adaptive content recommendations. For example, incorporating AI algorithms can help identify students' learning preferences and suggest relevant resources or peer collaborations, thereby supporting the connectivist emphasis on personalised, networked learning experiences.

By embracing connectivism, History Quest can move beyond traditional rote memorisation, encouraging students to actively engage with historical content, collaborate with peers, and develop critical thinking skills through diverse, technology-mediated learning networks.

### E. Experientialism

*1) **Concept Overview**:* Experientialism, often associated with the work of educational theorists such as John Dewey and David Kolb, emphasises learning through direct experience. At its core, this theory asserts that knowledge is created through experience transformation, meaning students learn best when actively involved in a process that includes reflection, conceptualisation, and experimentation. Kolb's Experiential Learning Cycle outlines this process in four stages: concrete experience, reflective observation, abstract conceptualisation, and active experimentation.

In the context of Computer Science (CS) and Software Engineering (SE) education, experiential learning is particularly valuable due to the inherently practical and iterative nature of programming and software development. Hackathons, software development projects, and lab-based assignments exemplify experiential learning, allowing students to apply theoretical knowledge in real-world or simulated scenarios [25]. This approach deepens understanding and fosters the development of soft skills like teamwork, adaptability, and problem-solving.

Another paper from 2018 [26] explores experientialism by investigating whether the students prefer working on real projects and whether this can build the students' depth of knowledge regarding the topics that are explored when developing a real project. The study spanned over 8 years, involving 737 students from 30 universities and followed their progress whilst working on an Undergraduate Capstone Open Source Projects (UCOSP) project. They found that students value learning from performing real processes and helps them understand the complexity of their tasks. The study followed only software engineering projects and found that students learn more from experimentation and "encourage fellow educators" to implement this educational theory in their own programs.

*2) **Applications in SE/CS and History**:* In Software Engineering (SE) and Computer Science (CS) education, experiential learning manifests through practical, hands-on activities such as hackathons, lab-based assignments, and real-world projects. These experiences enable students to apply theoretical knowledge, collaborate with peers, and develop problem-solving skills in authentic contexts. Research indicates that hackathons serve as effective platforms for cultivating both technical competencies and soft skills among engineering students [27].

Similarly, in history and social sciences education, experiential learning is employed through simulations and interactive tools that allow students to explore historical scenarios actively. For instance, virtual reality (VR) applications have been developed to immerse students in historical environments, enhancing engagement and retention. A study involving 11- to 12-year-old students demonstrated that immersive VR experiences could effectively teach prehistoric cultural heritage by enabling learners to navigate and interact with virtual reconstructions of historical sites [28].

*3) **Synthesis for History Quest**:* In designing History Quest, the contribution of experientialist principles is relatively limited, as the platform does not support full project-based learning or rich simulation environments. While experiential learning traditionally involves hands-on, open-ended tasks that promote reflection and adaptation, History Quest instead focuses on guided, module-based progression through historical content. The interactive elements, such as map-based 2D scenarios, allow students to explore events and outcomes in a structured way, but these do not constitute immersive experiences or in-depth simulations like how VR simulations do.

Because of this, experientialism doesn't contribute significantly to the core design, it's somewhat out of scope. The system is not designed to facilitate project ownership, experimentation, or deep exploration, which are typical markers of experiential learning environments. However, some minimal experiential influence remains through structured user interaction and simple decision-making elements that allow for limited reflection. While these features support engagement, they don't fully realise the experientialist vision of learning through doing.

From a Software Engineering perspective, History Quest aligns more with principles of modularity and UI-driven navigation than with simulation or experiential design patterns. Thus, although experientialism offers a valuable lens for educational software design, in this context, its role is peripheral rather than foundational.

## III. Synthesis of Theories for History Quest

### A. Commonalities Across Theories

Behaviourism, constructivism, cognitivism and connectivism share strengths that directly inform the pedagogical design of History Quest. Despite their differing theoretical basis, all four frameworks emphasise interactivity as central to effective learning, a key requirement for engaging Year 9-11 students in modern history. Interactivity promotes active learning, critical thinking, and the ability to engage meaningfully with historical content. These theories also support scaffolding, guiding students through complex material in manageable chunks.

In practice, these shared strengths are embedded in History Quest's design. Behaviourism and cognitivism inform the use of structured quizzes and chronological timelines to reinforce factual knowledge and schema development. Constructivist principles guide the inclusion of exploratory tools such as interactive maps, allowing users to construct historical narratives through spatial and temporal engagement. Connectivism is reflected in features such as leaderboards and source-sharing, which support distributed learning and peer interaction.

These pedagogical features combine to create a personalised and interactive learning environment. Features such as event-based timelines, map navigation, and gamified quizzes with real-time feedback are designed to improve retention, foster inquiry, and promote collaboration, all essential for meeting curricula standards in studying history.

### B. Differences and Tensions

The theories differ in their approaches, creating tensions that History Quest must balance to ensure accessibility, depth and collaboration for Year 9-11 students. One of the most significant tensions lies in the contrast between structured and exploratory learning. Behaviourism and cognitivism rely on clearly defined outcomes and guided pathways, favouring predictability and skill acquisition. In contrast, constructivism values learner autonomy and discovery, which can be more open-ended and less predictable. This creates a design challenge: providing sufficient structure for students who need guidance, without undermining opportunities for self-directed learning.

A second tension emerges between individual and networked learning. Cognitivist and behaviourist approaches often prioritise internal, individual knowledge acquisition processes, whereas connectivism emphasises socially constructed knowledge and the importance of networks. If not carefully integrated, this can lead to fragmentation or inconsistency in the learning experience.

There is also a pedagogical divergence between skill-based and conceptual learning. Behaviourism tends to focus on procedural mastery through repetition and reinforcement, while constructivism and connectivism are more concerned with understanding complex ideas and generating meaning. Balancing these priorities requires thoughtful implementation.

History Quest addresses these tensions through a hybrid design. Quizzes are scaffolded to move beyond rote memorisation, instead encouraging application of knowledge. Using timelines and concise event summaries aligns with cognitivist strategies to reduce cognitive load while maintaining conceptual depth. Interactive maps and flexible navigation allow for student-driven exploration, supporting constructivist engagement. Meanwhile, the user account and leaderboard features incorporate social elements that maintain individual accountability while promoting peer connection. This synthesis ensures that the app remains accessible, curriculum-aligned, while supporting diverse learning needs.

### C. Lessons from SE/CS Tools

Modern SE/CS tools such as Kahoot, Duolingo, Scratch, Khan Academy and GitHub offer practical insights into how theoretical principles can be effectively applied to engage young learners. These platforms demonstrate how behaviourist, cognitivist, constructivist and connectivist principles can be embedded into the user experience to be intuitive and educationally effective.

For instance, Kahoot and Duolingo, grounded in behaviourist learning theory, employ gamified quiz mechanics, point scoring and immediate feedback to reinforce factual recall and motivate user engagement. These elements inform the design of History Quest's quiz and leaderboard features. Drawing from cognitivist principles, Khan Academy organises its content into modular, sequential lessons with integrated scaffolding. This model guides History Quest's use of separate, chronological event modules with structured timelines and event summaries that support cognitive organisation and understanding.

Scratch is a powerful example of constructivist design by encouraging learners to create and explore through project-based learning. History Quest applies a similar approach through its interactive timeline and maps, which allow students to explore history spatially and temporally, fostering narrative construction. GitHub exemplifies connectivist learning through its collaborative infrastructure and shared resource development, which inspire History Quest's source-sharing features and leaderboard-based peer interaction.

These tools reflect a shared reliance on core SE/CS principles, such as real-time feedback, user-driven interfaces, and networked systems, that History Quest adapts for a secondary history teaching context. They provide concrete models for balancing structure and freedom, individual and collaborative engagement, and skill development with conceptual understanding.

### D. *Implications for History Quest's Design*

Integrating the above theories into History Quest reflects a deliberate effort to build a curriculum-aligned, engaging application tailored for students studying Modern History. Each theoretical approach informs specific features within the application, collectively supporting a comprehensive learning experience.

History Quest's quiz and leaderboard functionalities, inspired by Kahoot and Duolingo, apply behaviourist principles by offering scored assessments and real-time feedback to reinforce knowledge retention. Cognivist strategies, drawn from platforms like Khan Academy, guide the use of concise event summaries and chronological timelines, which minimise cognitive load and foster schema development. Constructivist principles underpin interactive tools such as maps and timeline navigation, allowing students to explore historical events and construct their own narratives. Finally, the use of shared source materials and learning paths reflects connectivist ideals, encouraging networked learning and collaborative inquiry.

These features are designed according to key SE/CS principles, including intuitive user interfaces, iterative design processes, and real-time feedback and social engagement mechanisms. By integrating structured progression and exploratory elements, History Quest accommodates different learning styles and supports factual recall and deeper conceptual understanding.

Ultimately, carefully integrating these theories allows History Quest to transform passive engagement with historical content into active inquiry and collaborative learning. The application provides a balanced, responsive educational environment that aligns with secondary curriculum goals while embracing the affordances of digital technology.

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