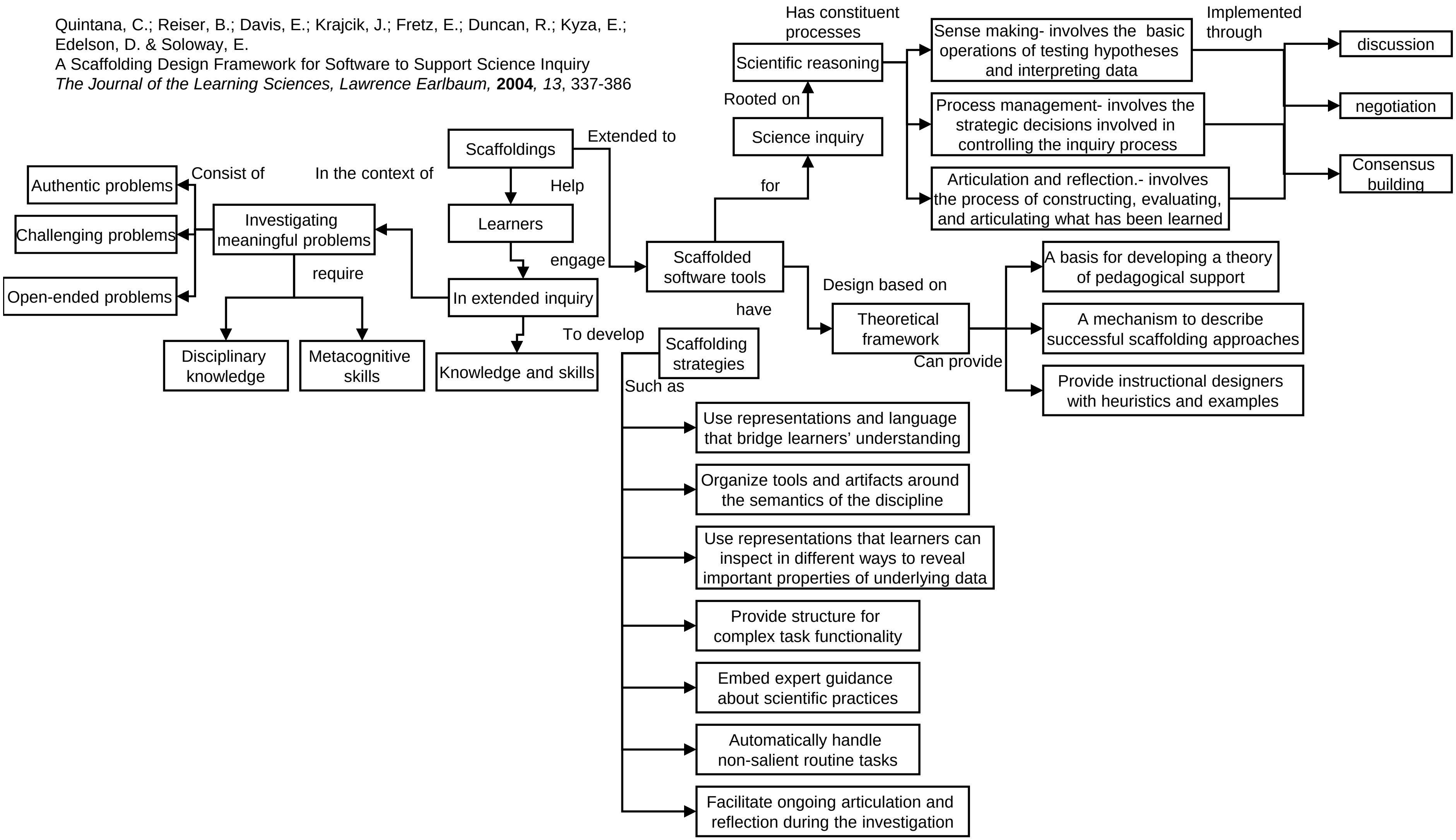
Quintana, C.; Reiser, B.; Davis, E.; Krajcik, J.; Fretz, E.; Duncan, R.; Kyza, E.; Edelson, D. & Soloway, E.
A Scaffolding Design Framework for Software to Support Science Inquiry
The Journal of the Learning Sciences, Lawrence Earlbaum, **2004**, *13*, 337-386



Authors	Software scaffolds proposed
Guzidal (1994)	Suggested three roles of software scaffoldings: a) communicating processes to learners, b coaching learners with hints and reminders about their work, and c) eliciting articulation from learners to encourage reflection.
Soloway, Guzidal,and Hay (1994)	Introduced the idea of "learner-centered design", focused on providing ad-hoc scaffolds according to learners' needs. Scaffolds not only for the learning task, but also for the tolls and interfaces learners use.
Linn, Davis, and Eylon (2004) Lyn and His (2000)	Suggested the integration of scientific understanding with prior accurate knowledge
Scardamalia and Bereiter (1991)	Encouraged learners to articulate their understandings through structured discourse

Principles	
Authors	Theory
Linn, Davis, and Eylon (2004) Lyn and His (2000)	Proposed the scaffolded knowledge integration framework
Quintana, Soloway, & Krajcik (2003)	Proposed the principle of learner-centered design
Kolonder et al. (2003)	Proposed the principle of problem-based inquiry
Bruner (1996) Collins, Brow, & Newman (1989b)	Cognitive apprenticeship .- proposes that students become increasingly accomplished problem-solvers given guidance from mentors through coaching, task structuring and hints. Provides a model of how performance of complex tasks can be distributed, with other helping to minimize obstacles and compensate for limitations by providing assistance and opportune moments.
Anderson (1983) VanLehn (1989)	Cognitive models of learning by doing to explore the nature of expertise in a discipline and the difficulties learners face in working on rich open-ended problems
Lave & Wegner (1991) Vygotsky (1978)	Perspectives of social constructivism and situated cognition which provide an account of socially situated tasks and describe how learning a discipline involves social interaction and discourse dimensions E.g. Vygotsky's zone of proximal development which refers to providing the assistance learners need to accomplish tasks more complex than theory could do alone in a way such that they can still learn from that experience.

Problem: Sense Making	Solution
Klahr (2000) Schauble, Glaser, Raghavan, & Reiner (1991) Learners face difficulty in keeping track of plans and monitoring progress Lin & Slotta, (2000) Quintana, Eng, Carra, Wu, & Soloway (1990) Software with features designed to support learners by providing ways to help them keep track of where they were in an overall plan. Learners must learn how to represent what is known or understood about a situation by making diagrams and symbolic notations. As learners reason about a situation, they must modify representations to encode new inferences. Learners can further progress toward constructing empirical tests, which can require encoding numerical data (p.346). Greeno (1989) Leher & Schauble (2002) Argued that scientific reasoning requires coordinating these representations and fluidly mapping between them to develop empirical tests and draw inferences.	
Chase & Simon (1974) Chi, Feltovich & Glaser (1981) Larkin, Mcdermott, Simon & Simon (1980) VanLehn (1989) Argued that meaningful patterns in problem-solving situation may not be apparent to novices. This, in consequence distracts the novices by similarities that are only superficial. Reif & Larkin 1991 Sherin 2001 There is a gap between the way learners intuitively think about a phenomenon and the formalism used to represent in expert practice. Eldeson, Gordin, & Pea (1999) Learners need support to map from their understanding to disciplinary formalisms. Collins & Brown (1988) Collins, Brown & Newman (1989) Merrill, Reiser, Ranney, T Trafton (1992) Learners lack substantial conceptual domain-specific knowledge that is required to notice important features about scientific situations. In addition, the expert strategies needed to guide sense making ma not be made explicit in traditional instruction.	Guideline 1: Use representations and Language that bridge learners' understanding Clement, (1993) It is necessary that new expert practices are connected with learners' prior conceptions and with their was of thinking about ideas in the discipline. Norman (1991) Tools can support learners by using representations that connect with learner's intuitions and also map onto expert practice. The representations employed in a tool can shape how people conceive a task. The authors identified three strategies for implementing this guideline: 1. Provide visual conceptual organizers to give access to functionality 2. Use descriptions of complex concepts that build on learners' intuitive ideas 3. Embed expert guidance to help learners use and apply science content Guideline 2: Organize tools and artifacts around semantics of the discipline 1. Make disciplinary strategies explicit in learners' interactions with the tool 2. Make disciplinary strategies explicit in the artifacts learners create Guideline 3: Use representations that learners can inspect in different ways to reveal important properties of underlying data 1. Provide representations that can be inspected to reveal underlying properties of data 2. Enable learners to inspect multiple views of the same object or data 3. Give learners "malleable representations" that allow them to directly manipulate representations

<table>
<tr><td>Problem: Process management</td><td>Solution</td></tr>
<tr><td colspan="2">Anderson (1983)
Classic models of problem solving contain both basic operations and a set of control processes.
Davis, Hawley, McMullan, & Spilka (1997): Newell & Simon (1972); Simon (1973)
Process management is particularly critical given the ill-structured nature of inquiry. A science investigation is ill-structured because it lacks a definitively prescribed manner for how the problem should be tacked and because one cannot always define in advance the exact process to find a solution (p.358).
Krajcik et al, (1998); National Research Council (1996); Quintana et al. (1999); Reiser et al. (2001)
There is a large range of activities to perform in an investigation, and one must constantly take stock of previous work to select and perform activities that may take the investigation a step closer to completion.</td></tr>
<tr><td>Anderson (1983)
Bransfor et al. (2000)
Springmeyer, Blattner, & Max (1992)
Found that learners lack the knowledge experts have about the activities that constitute inquiry and the procedures for performing those activities, so they may not know what actions are most relevant.
Bransfor et al. (2000)
Learners lack the strategic knowledge needed to select activities and coordinate the inquiry.
Anderson (1983)
Newell & Simon (1972)
In complex domains, the strategic knowledge managing the basic operations of the discipline constitute the core of what is learned typically through decades of experience. Without such expertise learners can be overwhelmed by the complexity of options available, making it difficult to direct their investigations, see what steps are relevant and productive and make effective activity decisions (p. 359).
Knapp (1994)
Learners can be distracted thy the less important managerial chores that need to be performed through an investigation. Management task can require a significant amount of time and effort. Therefore, learners need support to help them automatically handle routine tasks that are not as salient to the learning goals themselves.</td><td>Science inquiry component: Process management
Guideline 4: Provide structure for complex tasks and functionality
1. Restrict a complex task by setting useful boundaries for learners
2. Describe complex tasks by using ordered and unordered task decompositions
3. Constrain the space of activities by using functional modes
Guideline 5: Embed expert guidance about scientific practices
1. Embed expert guidance to clarify characteristics of scientific practices
2. Embed expert guidance to indicate the rationales for scientific practices
Guideline 6: Automatically handle nonsalient, routine tasks
1. Automate nonsalient portions of tasks to reduce cognitive demands
2. Facilitate the organization of work products
3. Facilitate navigation among tools and activities</td></tr>
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<tr><td>Problem: Articulation and Reflection</td><td>Solution</td></tr>
<tr><td colspan="2">Collins & Brown (1988); Davis (2004); Davis & Linn (2000); Loh et al. (2001)
A critical aspect of inquiry involves constructing and articulating an argument; this in turn involves reviewing, reflecting on, and evaluating results; synthesizing explanations; and deciding where the weaknesses and strengths are in one's thinking.
Linn (1995); Linn, Davis et al. (2004); Linn & Hsi (2000)
Highlighted the importance of making thinking visible and promoting autonomous lifelong learning, and reflections.
White & Frederiksen (1998)
Engaging in reflective self-assessment can help student improve their understanding of content and inquiry
Schoenfeld (1987)
Reflective processes help learners proceed with an investigation process, detect when past decisions should be reconsidered, identify dead ends, and remember to address goals.
Scardamalia & Bereiter (1991)
Reflecting and articulating intentionally and publicly can promote knowledge building at the individual and community level.</td></tr>
<tr><td>(p. 370)
Linn & Songer (1991)
Loh et al. (2001)
Scardamalia & Bereiter (1991)
Van Zee & Minstrell (1997)
Learners often do not realize that they should articulate their ideas
Davis & Linn (2000)
Schauble, Glasser, Duschl, Schulze, & John (1995)
Learners sometimes interpret opportunities for articulation and reflection as merely being blanks to fill.
Schauble, Kolpfer, & Rghavan (1991)
Learners may focus on achieving quick outcomes. Learners also have difficulty in planning and monitoring their investigations. They forge ahead without considering alternatives or ramifications of their decisions, get bogged down in logistical details of their work.
Collins & Ferguson (1993)
Students have problems in articulating and reflecting due to the fact that the form of the articulated epistemic products of science is critical.</td><td>Guideline 7: Facilitate ongoing articulation and reflection during the investigation
1. Provide reminders and guidance to facilitate productive planning
2. Provide reminders and guidance to facilitate productive monitoring
3. Provide reminders and guidance to facilitate articulation during sense-making
4. Highlight epistemic features of scientific practices and products</td></tr>
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