TECHNOLOGY-SUPPORTED INQUIRY-BASED LEARNING: AN ANNOTATED BIBLIOGRAPHY
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Introduction

The purpose of this annotated bibliography is to provide a very brief overview of Inquiry-Based Learning (IBL) and how technology can support learners and instructors in successfully implementing IBL in the learning environment. The bibliography begins with a very brief discussion of the origins of IBL, followed by an overview of four major models of IBL—Problem-Based Learning, Case-Based Learning, Learning by Design/Project-Based Learning, and I-Search. Once the stage is set for building background in IBL, the bibliography offers an article discussing how technology can answer several major criticisms, or failures, of IBL as an instructional approach. The remaining entries provide progressive examples of technology use in supporting IBL, with the final article discussing the use of mobile devices and augmented reality; cutting edge technology and practices and how they can be combined to deliver powerful IBL-inspired learning activities.

Entries


As with most theories and models of education, Inquiry-Based Learning (IBL) has been around in one form or another as long as learners have been around. The idea of learning through inquiry was supported by Socrates, one of the great thinkers and teachers of early recorded history. At the same time, as a modern component of learning, IBL looks to Dewey as an early advocate. Dewey suggested that *inquiry* was an important goal for all learners. In this way, Dewey set the wheels in motion for later work toward instructional models based on IBL, some of which will be described below. I realize that Dewey’s work noted here was not technically peer reviewed, but his role in modern educational theory and thought cannot be discounted in general, and for promoting inquiry learning specifically.


One the major models of instruction built on IBL is known as Problem-Based Learning (PBL). Howard Barrows from McMaster University of Canada is recognized as its originator, this article by Savery and Duffy present a general history of how the model of instruction expanded from the basic foundation of IBL to evolve into an instructional model that was school ready. Savery and Duffy describe an approach to instruction founded in constructivist thought, making learning student centered, and reserving a basic facilitator role for teachers. PBL is on a completely different end of the instructional spectrum from the Direct Instruction of Engelmann, et al, and almost as far removed from the traditional lecture classroom present for much of educational history. Behaviorist pedagogy has no place in PBL. Savery and Duffy support the construction of student-centered classrooms with learning built through hands-on, reflective learning activities relying on ill-structured problems. While students are encouraged to collaborate, inquire through research, and build habits of mind that result in creative thinking and problem-solving skills, how they get there is largely up to them. The teacher takes on a very passive role in the classroom, and the problem itself offers very little guidance to the student. Students would be assessed based on their presentations and defense of their thinking and solutions, not necessarily on the “correctness” of their solutions. The models for Case-Based Learning, Learning by
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Design/Project-Based Learning, and I-Search discussed next all have more structure and more
involvement from the teacher.

D. H. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning

Case-Based Learning (CBL) is most definitely a student-centered, inquiry-focused learning
model, although one with a clear structure to inquiry. In actuality, CBL is a systems approach to
inquiry, with a strong technology focus from its initial development. The idea is to build large,
organized, searchable indices of cases to give learners access to a history of experience and the
processing tools to access the indices to complete focused learning tasks. Over time, students
build the strategies and the knowledge base to efficiently and effectively use past experience and
existing knowledge to suggest solutions for current problems or questions. CBL requires a strong
reflective learning component for evaluating and expanding case knowledge. Those who believe
in Problem-Based Learning (PBL) would take issue with the strong structure and repetitive
nature of CBL. For the proponent of PBL, the focus is on unstructured inquiry, while CBL
attempts to build up a reusable strategy and approach to solving problems. At its heart, CBL is
best delivered through computers with their large, fast, and structured database and processing
units.

Han, S., and Bhattacharya, K. (2001). Constructionism, learning by design, and project
based learning. In M. Orey (Ed.), *Emerging perspectives on learning, teaching,

Constructionism, learning by design, and project-based learning are often tied together
throughout the different literature discussing aspects of IBL. Where project-based learning really
differentiates itself from other IBL models is through its sustained, cooperative investigation, but
done through a structured project approach that requires multiple learning sessions to complete.
By offering structure to students with multiple questions, activities, and product deliverables,
project-based learning encourages students to be engaged in productive, guided inquiry learning
over a period of time. While students have some meaningful choice and are expected to complete
investigative research, they are completing guided activities that will build some habits of mind,
but do not offer the case history of case-based learning or the introspective responses required in
I-Search. More often than not, this is the form of IBL that is most present with younger learners
due to its structure and the increased role of the teacher in the learning process.


I-Search, developed by Ken Macrorie in the late 1980’s, is another form of IBL. While it is
definitely inquiry based and student centered, I-Search provides more background and support
than many of the other IBL models presented in this bibliography. Case-based learning, Learning
by Design/Project-Based Learning, and Problem-Based Learning all provide students with a
relatively narrow direction for their inquiry. True I-Search projects, as described by Zorfass and
Copel, puts even greater choice of topic in the hands of students, but, at the same time, offers a
more structured process than at least Problem-Based Learning. I-Search still asks teachers to take
on the role of a coach or facilitator for much of the research time, but does require the teacher to
provide a solid, motivating central theme for students to base their research on. The structure and
the individualized nature of the I-Search approach lends itself to younger student populations and for shorter-term activities than some of the other IBL approaches.


Cronjé acts as a check against assuming that one has to choose a one end of the continuum of instruction or the other. This bibliography focuses on following the development of inquiry-based learning; however, Cronjé argues that you can in fact develop objectivist and constructivist lessons together. His premise is that one is a theory of instruction and the other is focused on learning design. Building strong, clear, concise objectives, but allowing open-ended inquiry are not in fact incompatible. This makes great sense in terms of Learning or Understanding by Design. But it also applies to other inquiry-based activities. Without a specific objective in mind, teachers will fail to challenge students without confusing or overwhelming them.


De Jong goes even further than Cronjé in discussing some of the inherent instructional challenges presented by IBL. For de Jong, research into IBL indicates students struggle for a variety of reasons, mainly based on the fact that they struggle to understand and master the inquiry process. Instead of understanding that research has a pattern and that results should challenge hypotheses, students often come up with an answer to a problem and then build an experiment to specifically prove their beliefs. While this challenge gives pause to the use of IBL in the classroom, de Jong suggests that technology itself can provide the supports students need in order to master the inquiry process. With this in mind, it is clear that de Jong would not support true, open-ended problem-based learning, but would lean toward experiments and cases with strong structure and clear inquiry paths for students. This does rob students of a little freedom, but does respond to some of the criticisms leveled at IBL. De Jong suggests the use of well-defined simulations as the approach that makes the most sense technologically for IBL activities.


The authors of this article delineate six key elements of technology that support inquiry-based learning as envisioned in a motivating, project-based learning environment. All six elements are valid for more than just IBL developed around project-based learning, although the structured process and support components do not fit well with problem-based learning. In Problem-Based Learning (PBL), as described previously, there is very little in the way of structure and prepared support; that is more a facet of the project-based learning and case-based learning approach to IBL. In general, the ability to structure an inquiry project delivered electronically, with the ability to reflect, revise, and repeat the inquiry process to experience the best of IBL. The challenge is identifying the appropriate technology tools for the inquiry target at hand. While this article suggests reasons to support technology use in IBL settings, it does not specify which
technologies are most appropriate for which setting. The suggestion is that the specific technology leveraged in learning should logically support the inquiry task at hand.


While Edelson, Gordin, and Pea focused mainly on incorporating technology-supported inquiry learning (TSIL) in the area of science education, their premise really applies to all areas. Research prior to this study focused on inquiry as research and modeling of experiments, as opposed to thoughtful student engagement in inquiry-based activities. This is an advancement actually pre-dates the work of Bruce and Bishop discussed previously; however, this can be a major challenge for younger learners that has to be taken into consideration when planning on using IBL in the classroom.


Bruce and Bishop put together an early attempt to bring inquiry-based learning to the Web. Their basic premise focused on developing a sequence of inquiry steps and an online community of teachers who shared inquiry-based learning units with each other to be used in the classroom, revised, and improved online. This approach does not take inquiry-based learning using technology directly to the learner him or herself, which is the main thrust of Edelson and Gordin’s approach to technology-supported inquiry learning (TSIL), as described in a later entry in this annotated bibliography. At the same time this approach to IBL has great merit for the K-5 classroom, where students are using basic technology to complete tasks, but are focused more directly on developing habits of mind that will make them better long-term learners through active inquiry, reflection, and repeated practice. Bruce and Bishop build on the case for technology offered by Blumenfeld by adding the concepts of managing extended activities and keeping in mind the practical context for learning as keys to successful technology integration into the learning activities.


The authors present an a approach to IBL that is focused on using the latest mobile technologies and the burgeoning research supporting augmented reality (Eric Klopfer/Scot Osterweil from MIT Education Arcade) to create a motivating, embodied learning experience for social sciences. Augmented reality activities tied to mobile devices (smart phones, touch devices, GPS tools, and so on) have the feel of the future of education, especially in the areas of social studies and science learning. This situated learning expands the classroom beyond the traditional school or home setting and into the real world. In some ways, this becomes the ultimate in problem-based or case-based learning, as it uses truly real-world experiences as the center of the instruction. At the same time, this type of instructional experience has its limitations in what is available near by to the learner. For instance, if I do not have oceans near my classroom, an augmented reality lesson does me little good; a virtual field trip, video, or illustrated book all offer more possibilities for building knowledge around oceans. At the same time, the freedom offered by
mobile devices can release the learner from the restraints of the classroom and take their learning with them wherever they go. Mobile learning requires strong support from teachers and community members, as well as access to the right tools, but the payback has tremendous potential. This may not be where inquiry learning ends, but it will be part of the near-term future as mobile devices proliferate in schools and the general population.