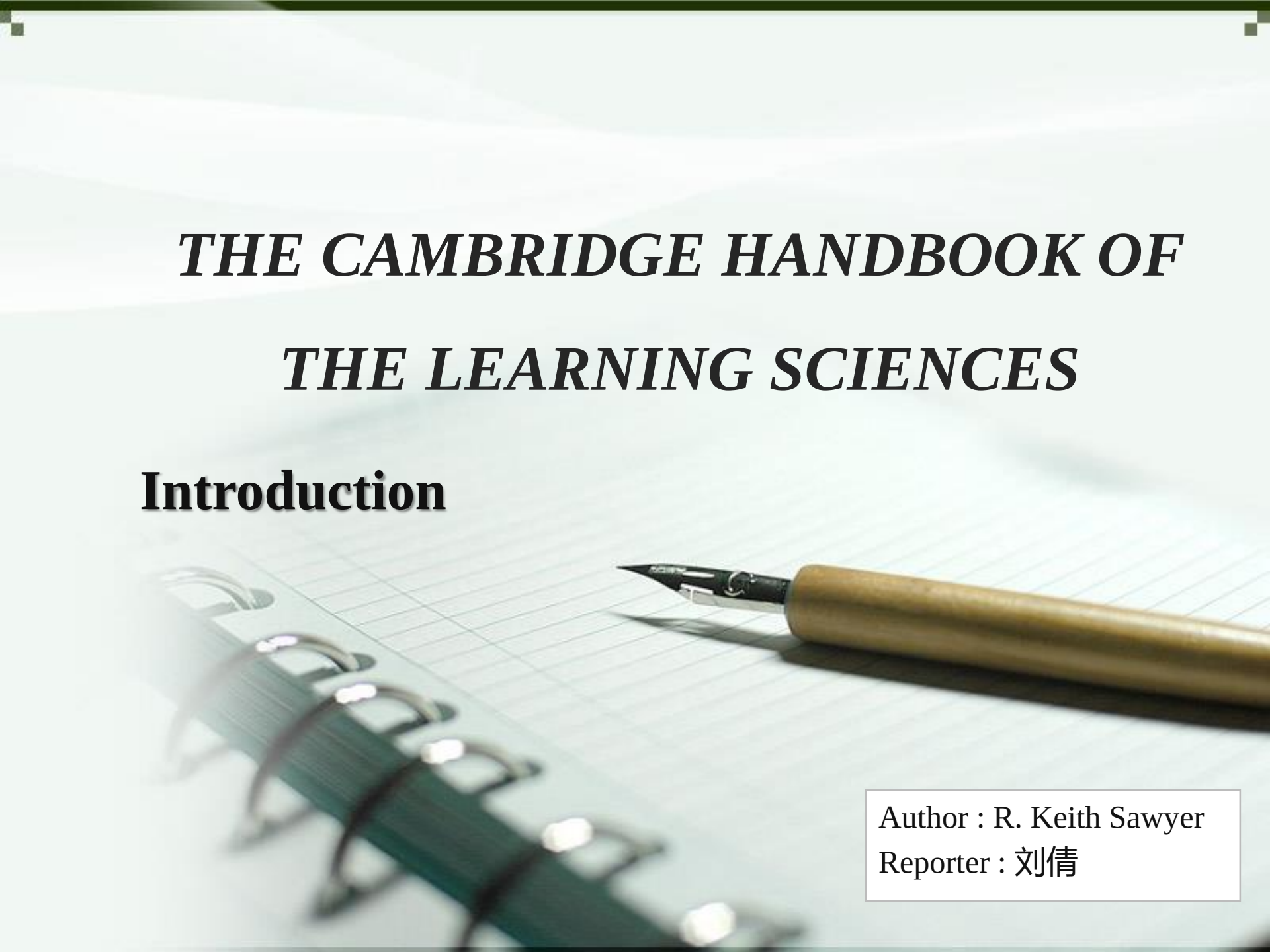
# *THE CAMBRIDGE HANDBOOK OF THE LEARNING SCIENCES*

## Introduction



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# The Learning Sciences

The learning sciences is an interdisciplinary field that *studies teaching* and *learning*.

The goal of the learning sciences is to *better understand* the cognitive and social processes that result in the *most effective learning* and to use this knowledge to redesign classrooms and other learning environments so that people *learn more deeply and more effectively.*

# The Learning Sciences

- Knowledge is a collection of *facts* and *procedures* for ***how to solve problems***.
- The goal of schooling is to get these *facts and procedures into students' heads*.
- Teachers ***know*** these facts and procedures, and their ***job is to transmit them to students***.
- Simpler facts and procedures should be *learned first*, followed by *progressively more complex* facts and procedures.
- The way to determine the ***success of schooling is*** to ***test students*** to see how many of these facts and procedures they have ***acquired.***

# The New Science of learning

In the 1970s, a new science of learning was born – based on research emerging from psychology, computer science, philosophy, sociology, and other scientific disciplines. As they closely studied children's learning, scientists discovered that instructionism was deeply flawed.

- *The importance of deeper conceptual understanding.*
- *Focusing on learning in addition to teaching.*
- *Creating learning environments.*
- *The importance of building on a learner's prior knowledge.*
- *The importance of reflection.*

# The New Science of learning

This handbook is an introduction to this new science of learning and to ***how researchers are using this science*** to lay the groundwork for the schools of the future.

This new science is called the ***learning sciences*** because it is an interdisciplinary science: it brings together researchers in psychology, education, computer science, and anthropology, among others, and the collaboration among these disciplines has resulted in new ideas, new methodologies, and ***new ways of thinking about learning.***

# The Goals of Education

| **Learning knowledge deeply (findings from cognitive science)** | **Traditional classroom practices (instructionism)** |
|---|---|
| Deep learning requires that learners relate new ideas and concepts to previous knowledge and experience. | Learners treat course material as unrelated to what they already know. |
| Deep learning requires that learners integrate their knowledge into interrelated conceptual systems. | Learners treat course material as disconnected bits of knowledge. |
| Deep learning requires that learners look for patterns and underlying principles. | Learners memorize facts and carry out procedures without understanding how or why. |
| Deep learning requires that learners evaluate new ideas and relate them to conclusions. | Learners have difficulty making sense of new ideas that are different from what they encountered in the textbook. |

# The Goals of Education

One of the most important goals of learning sciences research is to identify exactly *what practices* are *appropriate* for students to engage in and learn and *how to design age appropriate* learning environments without *losing the authenticity* of professional practice.

# The Nature of Expert Knowledge

Should we reduce auto emissions because of global warming?

Should we avoid growing and eating genetically modified organisms (GMOs)?

Should we allow stem cell research to proceed?

Are market-based mechanisms capable of helping to address pressing social problems?

# The Nature of Expert Knowledge

By the early 1900s, major industrial countries had realized the ***important role*** that science and engineering played in their ***rapid growth***, and many scholars began to analyze the nature of scientific knowledge.

In the first half of the 20th century, philosophers came to a consensus on the nature of scientific knowledge: scientific knowledge consisted of statements about the world and of logical operations that could be applied to those statements. This consensus was known as ***logical empiricism*** (see McGuire, 1992; Suppe, 1974).

# The Nature of Expert Knowledge

In this new view, scientific knowledge is situated, practiced, and collaboratively generated.

This new view of expert knowledge has extended beyond science to other forms of knowledge work.

# Processes Involved in Learning

The learning sciences are centrally concerned with exactly *what is going on in a learning environment* and exactly *how it is contributing* to improved student performance.

The learning *environment includes* the people in the environment (teachers, learners, and others), the computers in the environment and the roles they play, the architecture and layout of the room and the physical objects in it, and the social and cultural environment.

***How much support for the student should come from the teacher, the computer software, or from other students?***

# How Does Learning Happen?: The Transition from Novice to Expert Performance

- **How do experts acquire their expertise?**

*Cognitive development* has been an important *foundation* for the learning science.

Because learning scientists focus on the *expert knowledge* underlying knowledge work, they study how novices think and what misconceptions they have; then, they design curricula that leverage those misconceptions appropriately so that learners end up at the expert conception in the *most efficient way*.

# How Does Learning Happen?: Using Prior Knowledge

One of the most important discoveries guiding learning sciences research is that ***learning*** always takes place against a ***backdrop of existing knowledge***.

The basic knowledge about cognitive development that has resulted from this research is absolutely critical to ***reforming*** schooling so that it is ***based on the basic sciences of learning.***

# Promoting Better Learning: Scaffolding

The learning sciences are ***based on a foundation*** of constructivism.

To describe the support that promotes deep learning, learning scientists use the term ***scaffolding***. ***Scaffolding*** is the help given to a learner that is tailored to that learner's needs in achieving his or her goals of the moment. The best scaffolding provides this help in a way that contributes to learning.

(see Part I. Foundations, 3. Scaffolding)

# Promoting Better Learning: Externalization and Articulation

The learning sciences have discovered that when learners externalize and articulate their developing knowledge, they learn more effectively.

Articulating and learning go hand in hand, in a mutually reinforcing feedback loop.

The learning sciences have discovered that articulation is ***more effective*** if it is scaffolded – channeled so that certain kinds of knowledge are articulated, and in a certain form that is most likely to result in useful reflection. (see the chapters in part 4 )

# Promoting Better Learning: Reflection

Learning scientists have repeatedly demonstrated the importance of reflection in learning for deeper understanding.

Many learning sciences classrooms are designed to ***foster reflection***, and most of them foster reflection by providing students with tools that make it easier for them to articulate their developing understandings.

One of the most central topics in learning sciences research is ***how to support*** students in educationally ***beneficial reflection***.

# Promoting Better Learning: Building from Concrete to Abstract Knowledge

The learning sciences have taken Piaget's original insight and have developed computer software to visually represent a wide range of types of knowledge. Even very abstract disciplinary practices have been represented visually in the computer; the structure of scientific argument can be represented (see Andriessen & Baker, Chapter 22, this volume), and the step-by-step process of scientific inquiry can be represented.

# Educational Technology

Computers only benefit learning when they are designed to take into account what we know about how children learn and are closely integrated with teacher and student interactions in the classroom.

By the 1990s, a strong ***consensus*** had formed in many countries, among politicians, parents, and the business community, that it was essential to get ***computers into schools*** (Cuban, 2001) .

# Educational Technology

- Computers can represent abstract knowledge in concrete form.
- Computer tools allow learners to articulate their developing knowledge in a visual and verbal way.
- Computers allow learners to manipulate and revise their developing knowledge via the user interface in a complex process of design that supports simultaneous articulation, reflection, and learning.
- Computers support reflection in a combination of visual and verbal modes.
- Internet-based networks of learners can share and combine their developing understandings and benefit from the power of collaborative learning.

# A Design Science

The gold standard of scientific methodology is the experimental design, in which students are randomly assigned to different learning environments. Many education studies are also quasi-experimental – rather than randomly assigning students to environments, they identify two existing classrooms that seem identical in every way, and use one teaching method in one classroom and a different teaching method in the other classroom, and analyze which students learn more and better.

# A Design Science

Learning scientists have discovered that deep learning is more likely to occur in complex social and technological environments.

# Conclusion

Since the beginning of the modern institution of schools, there has been debate about whether education is a science or an art. The language of science makes some educators nervous. ***Everyone can remember the artistry of a great teacher – a teacher*** who somehow against all odds got every student to perform better than they thought they could. ***Teachers themselves know how complex their job is – every minute of every hour,*** a thousand different things are going on, and it can seem so unlikely that the cutting-and-slicing reductionist approach of science could ever help us understand what's happening. ***The history of scientific approaches to education is not promising; in the past,*** scientists studied learning in a university laboratory and then delivered pronouncements from the Ivory Tower that teachers were expected to adopt unquestioningly (Cremin, 1961)

# Conclusion

Unlike these ***previous generations*** of educational research, learning scientists ***spend a lot of time*** in schools – many of us were full-time teachers before we ***became researchers.*** And learning scientists are committed to improving classroom teaching and learning – many are in schools every week, working directly with teachers and districts. Some even take time off from university duties and return to the classroom, teaching alongside teachers and learning ***how to make theories work in the real world***. This is a new kind of science, with the goal of providing a sound scientific foundation for educational innovations.

# Thank you!