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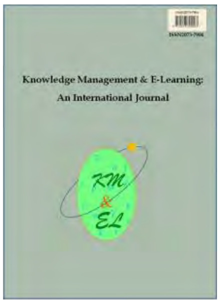

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Rethinking how people learn: A holistic framework for effective learning design

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Abstract: Learning is an integral part of being human. How people learn has long been discussed, revealed in many learning theories, investigated in numerous studies, and demonstrated in extensive practices. The goal of this article is to rethink how people learn from four fundamental perspectives, that is, learning by interaction with content (C), learning by interaction with other people (O), learning by interaction with self (S), and learning by interaction with tasks or practices (T), so-called COST model. This framework offers a high-level view of human learning and the role of technology in human learning. Moreover, it serves as a guide for effective design of learning experiences, learning environments, and learning approaches, where technology has become a crucial component.

Keywords: Rethinking; How people learn; Framework; Learning design

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1. Introduction

Learning is an integral part of being human. How people learn has long been discussed, revealed in many learning theories, investigated in numerous studies, and demonstrated in extensive practices. Young educational researchers and practitioners may get lost in the face of the vast number of issues discussed and studied in this field. The goal of this article is to rethink how people learn from four fundamental perspectives. The framework offers a high-level view of human learning and the role of technology in human learning.

Moreover, it can inform effective design of learning experiences, learning environments, and learning approaches, where technology has become a crucial component.

2. Rethinking how people learn

How people learn has been widely discussed in the literature (e.g., Bransford et al., 2012). People have been trying to understand human learning for over 2000 years. Although there is a variety of viewpoints, it is generally agreed that people learn by interactions with **C**ontent (e.g., learning materials), **O**ther people (e.g., teachers, peers, parents), **S**elf (e.g., self-reflection, self-regulation), and **T**ask or practices (e.g. problem-solving tasks), so-called the **COST** model (Wang, 2018). The four perspectives are outlined in Fig. 1 and illustrated as follows.

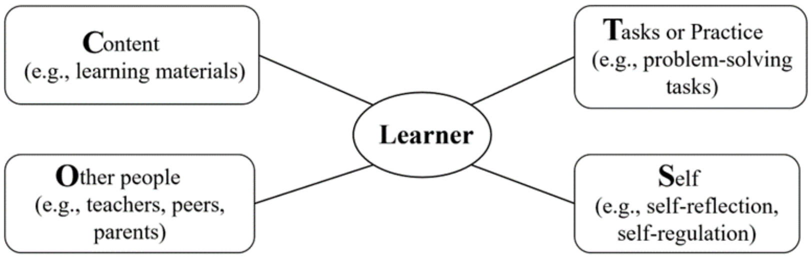

Fig. 1. How people learn: The COST model

2.1. Learning by interaction with content

Interaction with learning content is one of the most important aspects of the learning process. Learning by interaction with content starts with the access to learning materials (e.g., text, graphics, multimedia, online resources). With an increased promotion of online learning and digital learning resources, learners are offered extensive exposure to a wide range of learning resources. While enjoying the benefits of flexible access to massive learning resources, many learners face the challenges of information overload and disorientation when navigating a variety of learning materials. The challenges become even greater when learning content is scattered across disparate topics and complex structures.

Researchers have highlighted the importance of effective presentation of learning content to reduce learners' cognitive load caused by processing poorly presented information (Mayer, 2009). More importantly, researchers emphasized that it's crucial to help learners make meaning from the content. The main approach is to help learners see a big picture of knowledge by building connections between knowledge and combining discrete pieces of knowledge into a coherent whole. In this way, learners can anchor new understandings and integrate them with prior knowledge in a coherent structure for meaningful learning (Ausubel, 1963). To this end, concept maps and related cognitive tools have been widely promoted in educational practice to foster in-depth thinking and flexible understanding of subject matter (Jonassen, 2000; Novak, 2010).

2.2. Learning by interaction with others

Living in social environments, people learn from others, such as teachers, parents, peers, and experts. Learning by interaction with more knowledgeable others is fundamental to an individual's cognitive development in social contexts (Vygotsky, 1978). Among them, student-teacher interaction is the basis of school education. Teachers not only deliver knowledge, correct misconceptions, evaluate student performance, and provide feedback, but also inspire students and help them develop motivation and confidence. In the learning process, students are encouraged to play an active role, while teachers are expected to be facilitators to foster learner autonomy and independence.

Learning by interaction with peers (e.g., collaborative learning, group-based learning) is an important component of educational practice. In collaborative learning contexts, students often work together to share information, discuss or debate different viewpoints, co-construct understanding, and engage in peer feedback and peer coaching. Meaningful collaboration is more likely to occur when students work together on real-world problems or authentic tasks or discuss meaningful topics. Guiding or scaffolding group interaction also plays an important role in improving the quality of collaborative learning. Moreover, use of appropriate language that fosters effective thinking is crucial to learning through communication with others, such as teacher-student dialogue and peer dialogue (Mercer et al., 1999). In recent years, visual representations or cognitive maps have been used as a kind of special language for communication of complex issues to facilitate group thinking and interaction (Sun et al., 2022).

2.3. Learning by interaction with tasks or practices

Knowledge is assumed to be better constructed through interaction with real-world practice, where knowledge is created and applied. Accordingly, experiential learning or learning by doing has long be advocated, which encourages students to learn by engaging in and making meaning from practical experience (Dewey, 1938). One of the best ways to encourage experiential learning is to engage students in problem-solving practice or authentic whole tasks or projects (Jonassen, 1997; van Merriënboer & Kirschner, 2013). Such kind of learning is often implemented as problem-based learning and project-based learning, where students are required to investigate real-world problems and/or create solutions to solve real-world problems. Through such learning experiences, students are expected to develop critical thinking, creative thinking, and problem-solving skills; moreover, they are expected to consolidate learned knowledge and construct new understanding. Given the constraints of classroom settings, technology-mediated learning environments (e.g., computer simulations, immersive virtual environments, educational games) have been increasingly explored to expand the opportunities for learning in authentic situations.

It should be noted that effective learning through practice with real-world problem or authentic tasks is difficult to achieve either in the classroom or technology-mediated environments. Solving a real-world problem often involves a sophisticated process of understanding the problem, linking abstract knowledge to problem information, and applying relevant methods to solve the problem. Such a complex process can impose a heavy cognitive load on learners (Hmelo-Silver et al., 2007; Kirschner et al., 2006). Without necessary help, many learners tend to engage in surface rather than deep learning experience that enables them to achieve desired learning outcomes (Wang et al., 2017). Moreover, students may experience negative emotions (e.g., boredom, anxiety, frustration) when performing complicated tasks without necessary help, which will influence their thinking process and learning outcomes. Recent research has highlighted the importance of making complex thinking visible or scaffolding student thinking with the support of cognitive tools when students perform complex problem-solving tasks (Chen et al., 2018; Peng et al., 2019; Wang et al., 2018a). This is aligned with cognitive apprenticeship theory, which claims that carrying out a complex task involves complex, implicit processes; it is crucial to visualize such processes so that they can be observed and learned by novices with necessary help (Collins et al., 1991).

2.4. Learning by interaction with self

Students are encouraged to play an active role in the learning process, while teachers are expected to be facilitators to foster learner autonomy and independence. During the learning process, students are expected to constantly interact with themselves by reflecting on their learning experience. Reflection on learning experience will help students identify gaps in their learning and areas for improvement. Reflection is a kind of manifestation of deep learning and may lead to the development of critical thinking skills and personal growth in multiple aspects such as knowledge, skills, attitudes, and beliefs.

In addition to reflecting on learning experience, students are expected to manage their learning experience, which is related to self-directed or self-regulated learning. Prior studies emphasize self-regulation and metacognitive processes, which may involve defining learning goals, setting up learning plans, implementing planned learning, monitoring learning processes, and making adjustments during the process. To do so, students need to develop relevant knowledge and skills to manage their learning experience. The management of learning experience involves not only learning behavior and cognitive process, but also affective experience. Students need to regulate their emotions, in particular alleviate negative emotions and develop motivation and confidence for effective learning performance.

Before managing their learning, students should learn how to implement their learning by applying general learning strategies (e.g., information seeking, synthesizing or organizing information, help seeking, time management, group work skills) and specific problem-solving methods (e.g., scientific reasoning, systematic design). Such kind of knowledge and skills can be referred to as learning how to learn, which are often missing in most school curricula (White & Frederiksen, 1998), but are crucial to student learning. Visual representations or cognitive maps can be used to externalize complex thinking or cognitive processes. They can serve as scaffolding to help students articulate and reflect on their thinking and reasoning processes. Moreover, they can help students identify gaps by comparing their thinking and reasoning processes with those of experts in solving complex problems (Wang et al., 2018b).

3. Technology-supported learning: A holistic view

In recent decades, technology, in particular computers and information and communication technology (ICT) and artificial intelligence (AI) technology, has been extensively employed to support human learning and instruction. Technology has significantly changed student interactions with learning content, teachers and peers (Moore, 1998), supporting human learning and instruction in a variety of aspects.

The COST model offers a high-level view of human learning. Moreover, it can be used to build a big picture of how technology is integrated into different aspects of human learning or educational practice. For example, Zhu et al. (2023) applied the COST model to explore how ChatGPT can impact education through enabling student interaction with AI-generated learning materials, AI tutors, AI learning buddies, AI-generated guidance on solving complex problems or tasks, and AI-generated answers that stimulate reflection and critical thinking. Table 1 presents typical examples of technology integration in educational practice, which are organized based on the COST model.

Table 1
Technology integration in educational practice

Four dimensions	Technology integration
Learning by interaction with content	• Multimedia learning content. • Online learning resources. • Personalized learning content recommended by AI systems. • Interactive white boards for interactive presentation of content. • Computer-based cognitive tools (e.g., concept map) for in-depth understanding of learning content. • AI-generated learning content.
Learning by interaction with others	• Online forums. • Video conferencing systems. • Groupware and communication applications. • Visual representations tools for visualizing shared understanding. • Virtual learning communities. • Social media platforms. • Collaborative learning in virtual environments or games. • Interaction with AI virtual teacher or tutor. • Interaction with AI virtual learning buddy. • Interaction with AI chatbot.
Learning by interaction with tasks or practices	• Virtual environments simulating real-world problems or authentic tasks. • Mixed reality. • Educational games. • Computer simulations. • Cognitive tools for scaffolding complex problem-solving process. • Virtual patient in medical education. • AI-generated expert guidance or feedback to task performance. • AI-generated tasks. • AI-generated solutions.
Learning by interaction with self	• Digital learning portfolio. • Digital storytelling. • Visualizing individual learning trajectories. • Interactive quizzes and assessments. • Visualizing individual performance and gaps. • Visual representation of individual understanding or thoughts • Reflective learning with AI-generated answers • AI-generated support for self-direction.

4. Effective learning design

The COST model offers a high-level view of human learning and the role of technology in human learning. Moreover, it serves as a guide for effective design of learning experiences, learning environments, and learning approaches, where technology has become a crucial component. The key issues on effective learning design informed by the COST model are presented in Table 2.

Table 2
Effective learning design

Four dimensions	Key issues
Learning by interaction with content	• Making learning resource easy to access. • Effective presentation of multimedia learning content. • Minimizing the cognitive load caused by poorly presented learning content. • Organizing learning content in a coherent structure. • Helping learners to connect new understanding with prior knowledge. • Externalizing the connections between knowledge to foster meaningful learning. • Visualizing knowledge structure or showing a big picture of knowledge to foster flexible understanding and in-depth thinking.
Learning by interaction with others	• Teachers deliver knowledge, correct misconceptions, evaluate learner performance, provide feedback, and inspire students to develop motivation and confidence. • Students play an active role in the learning process. • Encouraging meaningful collaboration via working on real-world problems, authentic tasks, and meaningful discussion topics. • Guiding or scaffolding group interaction. • Using appropriate language for dialogue with others.
Learning by interaction with tasks or practices	• Encouraging students to engage in and make meaning from practical experience. • Encouraging students to apply and consolidate knowledge as well as create new understanding from practice. • Engaging students in realistic problem-solving practice or authentic tasks or projects. • Encouraging students to investigate real-world problems and/or create solutions to solve real-world problems. • Supporting students to develop critical thinking, creative thinking, and problem-solving skills. • Pay attention to complex, implicit processes of problem-solving tasks. • Making complex thinking visible or scaffold student thinking when they perform complex problem-solving tasks.
Learning by interaction with self	• Enabling students to reflect on learning experience. • Supporting self-directed or self-regulated learning. • Teaching students to regulate learning behavior and cognitive process. • Helping students acquire knowledge and skills for self-regulation and self-direction. • Promoting learning how to learn. • Paying attention to affective experience, such as motivation, confidence, and negative emotions.

Moreover, effective learning design should consider two basic principles. *First*, effective learning design requires a holistic view of human learning (Perkins, 2010). The four types of interaction outlined in the framework are interconnected rather than separated. They should be integrated into the design of learning experience, learning environments, and learning approaches. *Second*, effective learning design requires a clear understanding of the role of technology. Technology has shown promising impacts on supporting and transforming human learning in multiple aspects. With technology, learners have greater opportunities and more facilities to access and process learning resources, practice with problem-solving tasks, communicate with other people, and reflect on learning experience. Nevertheless, technology cannot solve all problems. While learners are enabled to effectively engage in learning with the support of technology, they are not always directly afforded to engage in effective thinking or developing meaningful understanding from technology-supported learning. It is important to provide learners with necessary support when needed, and the support that can help student learn how to learn will be more helpful. To this end, fostering higher-order thinking is key to effective learning design (see Fig. 2). It is important to externalize complex thinking as well as scaffold student thinking in complex situations, such as making meaning from learning content, solving complex problems, communicating complex issues to others, and learning how to learn.

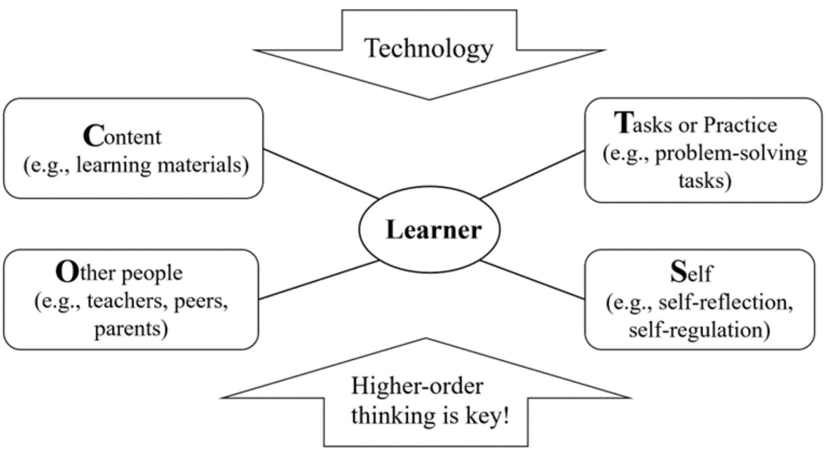

Fig. 2. Effective learning design informed by the COST model

5. Conclusion

Human learning is the process by which people make persistent changes in their knowledge, skills, abilities, attitudes, and beliefs. There are a vast number of issues discussed and studied on human learning from different perspectives. This paper presents a holistic framework of how people learn from four fundamental and interrelated perspectives, that is, learning by interaction with content (C), learning by interaction with other people (O), learning by interaction with self (S), and learning by interaction with tasks or practices (T), called the COST model.

The framework offers a high-level view of human learning and the role of technology in human learning, which can inform effective learning design. Hopefully, the framework will enrich the understanding of human learning, how people learn with technology, and how to design effective learning experiences, learning environments, and learning approaches with the support of technology.

Effective learning design should enable learners to effectively interact with learning content (C), other people (O), self (S), and tasks or practices (T). Higher-order thinking is key to effective interaction in such learning contexts. It is important to externalize complex thinking as well as scaffold student thinking in complex situations, such as making meaning from learning content, solving complex problems, communicating complex issues to others, and learning how to learn.

Author Statement

The author declares that there is no conflict of interest.

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