Watch-Inside

—— Targeting Eighth-Grade Students in Mainland China under Gaokao-Oriented Education System

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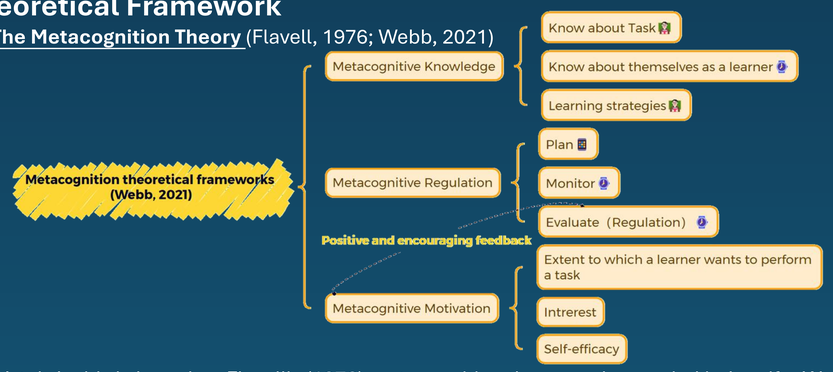
Blending AI Dialogue, Smart Wearable Devices, and Teacher Instruction to Enhancing Metacognitive Skills in Students

Introduction

"Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them." (Flavell, 1976). Enhancing students' metacognitive skills is not only a strong predictor of high academic performance but also fosters self-regulated learning, enhances problem-solving abilities, and cultivates lifelong learning skills (Tanner, 2012; He et al., 2024). However, developing metacognitive skills often requires significant student engagement and teacher guidance. In school settings, implementing metacognitive training is frequently perceived as time-consuming and competing with subject-specific learning. By integrating smart wearable devices, we can simplify and seamlessly incorporate metacognitive training into daily routines. With just five minutes per day, students can effectively acquire metacognitive knowledge and practice metacognitive strategies.

Theoretical Framework

(1) The Metacognition Theory (Flavell, 1976; Webb, 2021)



Watch-Inside is based on Flavell's (1976) metacognition theory and grounded in Jennifer Webb's (2021) The Metacognition Handbook: A Practical Guide for Teachers and School Leaders, which provides a structured framework for guiding students in developing metacognitive skills. The app is designed around 3 key components: (1) Metacognitive Knowledge, (2) Metacognitive Monitoring, and (3) Metacognitive Motivation.

(2) Wrist-Based Physiological Monitoring in Learning (Cain & Lee, 2016; Mansi et al., 2021; Shi et al., 2007; Surangsrirat et al., 2019; Zhu et al., 2023)

The physiological indices measured at the human wrist—including heart rate (HR), heart rate variability (HRV), electrodermal activity (EDA/GSR), blood oxygen saturation (SpO_2), and skin temperature—can provide real-time assessments of an individual's stress levels, fatigue, and focus during learning processes (Cain & Lee, 2016; Mansi et al., 2021; Shi et al., 2007; Surangsrirat et al., 2019; Zhu et al., 2023). Leading brands such as Apple and Huawei have already integrated multimodal physiological signal processing into their smart wearable devices, introducing functions like stress management and emotion monitoring.

Watch-Inside, drawing on psychophysiology, deep learning, and artificial intelligence, collects wrist-based physiological signals to provide real-time insights into students' learning status, including their learning styles, academic strengths, and metacognitive awareness. By integrating multimodal data, the system constructs personalized metacognitive knowledge models, tailored to each student's unique learning profile.

(3) Self Determination Theory (Deci & Ryan, 2012) & **Metacognitive Instruction Combined with Collaborative Learning** (Teng, 2016)

Cutting-edge research in metacognition suggests that metacognitive instruction combined with collaborative learning yields the most significant improvements in academic performance and metacognitive regulation skills (Teng, 2016). Moreover, relatedness is one of the three fundamental components of Self-Determination Theory (SDT,), which plays a crucial role in intrinsic motivation and sustained engagement.

To maximize the effectiveness of metacognitive training and increase user retention, *Watch-Inside* incorporates social interaction features, such as:

- Leaderboards to foster motivation through healthy competition.
- Peer evaluations and mutual supervision to encourage collaborative learning.

These features enable embedded metacognitive instruction within a socially interactive learning environment, reinforcing both self-regulation and peer-supported growth.

Intervention Program

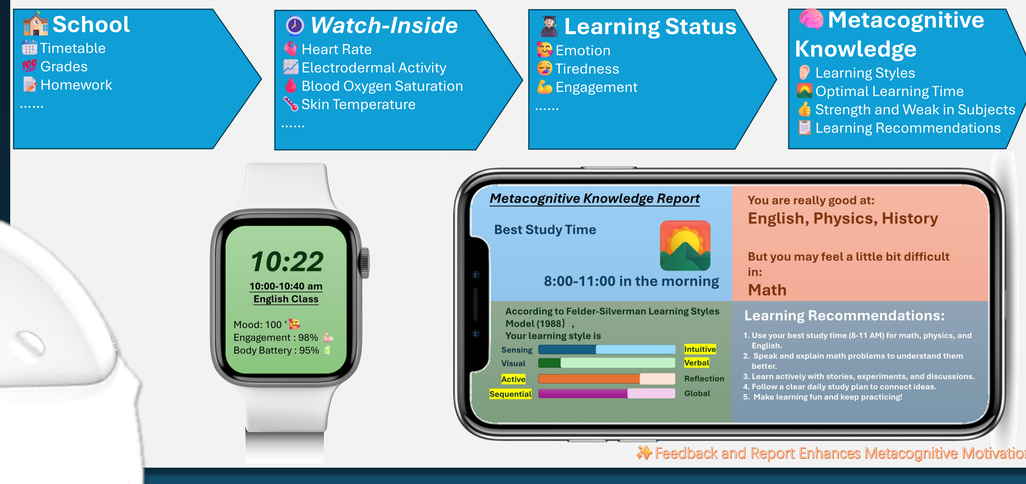
(1) Metacognition Knowledge Course

1. Explicit Strategy Instruction
2. Use of Watch-Inside System ⭐
3. Modelling of Learned Strategy
4. Guided and Practice
5. Independent Practice
6. Structured Reflection

(2) *Watch-Inside* Assisted Training

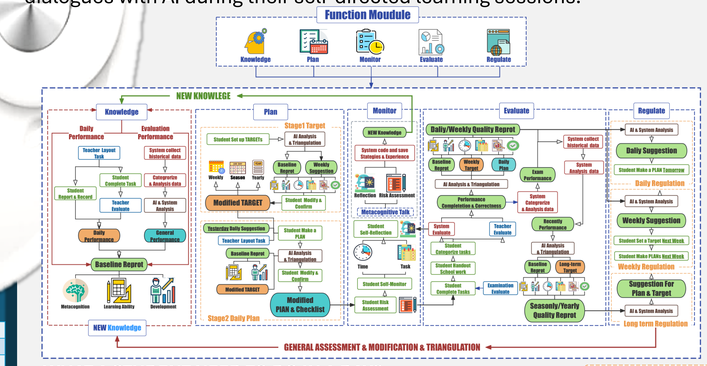
Function 1: Passive Monitoring

By simply wearing the watch, students undergo effortless, passive tracking, allowing the system to gather insights into their metacognitive knowledge without requiring any active effort.



Function 2: Active Engagement through AI-Driven Metacognitive Talk

Students actively participate in metacognitive planning, monitoring, and reflection by engaging in interactive dialogues with AI during their self-directed learning sessions.



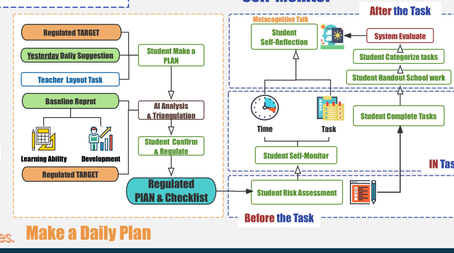
Based on metacognitive theory, we designed a training system with five modules: knowledge, plan, monitor, evaluate, and regulate. Each module includes user-friendly activities to help students practice metacognitive skills after completing metacognition courses. Noting that secondary school students in mainland China often struggle with self-regulation during their 2-hour self-study time, we developed an AI-assisted tablet system to help them manage daily tasks efficiently. The system breaks down self-study tasks into steps, aligns them with metacognitive principles, and organizes them into five phases corresponding to the modules.

WHAT A STUDENT NEED TO DO IN A DAY?

In daily training, students

(1) create and adjust plans with AI assistance,
(2) assess task risks through simple AI conversations,
(3) execute and monitor their tasks, and
(4) upload completed work.
(5) After receiving feedback, they reflect with AI to build metacognitive knowledge.
(6) The next day, they review teacher feedback and suggestions to create a new plan, fostering continuous improvement.

Enhances social interactive via leaderboards, peer evaluations, and other activities.



Assessment Scheme

	Class A (Experimental)	Class B (Control)
Intervention	Instruction + *Watch Inside Smart System*	No intervention
Time 1	a. Academic Performance: **First** monthly exam scores. b. Metacognitive Skills: Metacognitive Awareness Inventory (MAI) c. Metacognition knowledge Baseline in *Watch Inside*	a. Academic Performance: **First** monthly exam scores. b. Metacognitive Skills: Metacognitive Awareness Inventory (MAI)
	One Month Later	
Time 2	a. Academic Performance: **Second** monthly exam scores. b. Metacognitive Skills: Metacognitive Awareness Inventory (MAI) c. Metacognition knowledge Post-Test in Watch Inside d. Interview: Randomly select six students to share their experiences in the program	a. Academic Performance: **Second** monthly exam scores. b. Metacognitive Skills: Metacognitive Awareness Inventory (MAI)
Expected Outcomes	1. Compared to Class B, a one-month intervention program is expected to enhance students' scores in Academic Performance and MAI in Class A. 2. Compared with the Metacognition Knowledge Report at the beginning, students in Class A may find their report more detailed and enriched one month later. The learning ability reflected in this report has shown a significant improvement.	

Conclusion

In conclusion, the app is designed to simplify the process of acquiring metacognitive knowledge and remind students to use metacognitive skills at the right time. By enabling conversations with AI, it reduces the need for extensive teacher support, saving both time and resources. By handling the effort-intensive parts of metacognitive monitoring, the app helps students improve their metacognitive awareness in just five minutes a day. This approach can also be applied to other areas of learning, such as sports or musical instruments.

While metacognitive training can sometimes feel tedious and repetitive, we don't expect students to rely on the app all the time. Instead, our goal is to encourage them to develop the habit of actively reflecting on their learning before, during, and after study sessions. Over time, this fosters lasting metacognitive habits and skills, ultimately helping students understand themselves, monitor their learning, and adjust their study strategies—even without the app.