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論文の内容の要旨

To make learners become self-regulated learners is a heart of education, because, after graduating from school or college, learners are expected to be able to learn many crucial skills informally for living their life by their own. To become self-regulated learners, learners must have motivation for maintaining their emotion to perform metacognitive skills to accomplish their tasks. However, learning or training metacognition is not a simple task due to the implicitness of metacognition and the complication of its training process. To avoid cognitive load and frustration which is a cause of demotivation in novices learners in training metacognition, there should be an implicit meta-level thinking skill which could be alike an assisting ladder to support them to step up to the stage of self-regulated learners. I would name that implicit skill as *Seed skill to become a self-regulated learner* (S2SRL). That is, S2SRL here refers to a skill in which learners are curious on their own understanding and awareness of self-improvement in their learning before learners can perform metacognitive questions by themselves to reflect their own cognition for planning, monitoring, and doing self-evaluation.

The goal of training metacognitive skills is to help learners to be comfortable with applying meta-level thinking on their cognitive process and become self-regulated learners who can automatically monitor and regulate their learning processes and be aware of their difficulties to achieve their tasks. However, it is also a difficult task for novices to think about metacognitive questions by themselves. Therefore, in this dissertation, before encouraging novice learners to use metacognitive skills, I proposed to provide them some examples of metacognitive questionings and examples of a situation to use those metacognitive

questions to engage and encourage them to gain S2SRL. To promote metacognitive questionings corresponding to learners' learning process by using an adaptive method, computer technology is considered.

Moreover, to encourage learners to be curious on their own understanding and awareness of self-improvement in their learning or to gain S2SRL, it is necessary to motivate and facilitate them to have clear process of a given task in their mind. Later, they can use those in their mind as their cognitive target to perform meta-level thinking. From my past experience and evidence in standards test (e.g., PISA, TIMSS), most students have difficulties in solving MWP, due to they rarely take the time to monitor and regulate the use of cognitive strategies. This shows that solving MWP having a room to applied metacognitive skills. This is considered as an advantageous feature of MWP which could be employed as a medium to train metacognition.

To achieve my desire to design an environment for encouraging learners to use intrinsic comprehension of metacognitive questioning to acquire S2SRL in MWP learning, instead of just proposing a specific environment, there is more impact to create a framework for designing a required environment. Thus, CREMA has been developed to be a framework for designing an environment to encouraging learners to use intrinsic comprehension of metacognitive questioning to acquire S2SRL in MWP learning. This raised the research problems that "can the proposed framework really support learner to gain S2SRL?" And "how does it work in a practical environment?" In order to answer the research questions, the investigation to evaluate the effectiveness of and investigate the implementation of CREMA was performed by comparing three classes of low-performance students of grade-9 were assigned into three different learning groups: (i) a group of students who learnt MWP with our proposed method by implementing CREMA, (ii) a group of students who learnt MWP in traditional method combining MetaQ MetaQ—metacognitive questions and motivative statements, and (iii) a group of students who learnt MWP in traditional method.

The result from our investigation showed that MetaQ played an important role in CREMA while integrating computer and technology enhanced students' learning sense and empowered methodology to facilitate learning objects in the implementation of CREMA to effectively support students to gain S2SRL in MWP learning.

Keywords: Mathematical word problem; metacognition; metacognitive questioning; motivation; seed skills to become a self-regulated learner; self-regulated learners.

論文審査の結果の要旨

本論文は、算数の文章題の学習を通じた自己調整学習スキルの形成を促すリフレクティブ学習モデルと、その学習を支える学習環境の実装、評価について論じたものである。自己調整学習ス

キルは、自己の学習を自分で評価し、それを自分で適切な方向に導くスキルであり、あらゆる学習に共通する転移性のある汎用スキルとして習得・定着が望まれる。自己調整スキルの習得は、特定の科目の具体的な学習過程を内省し、汎化することによってのみ可能であるため、自分の思考過程をメタレベルで内省することができない学習者には習得に困難が伴なう。本研究では、中等教育の学生が算数文章題を学ぶ過程を対象として、その過程のメタレベルでの内省を支援し、転移性のある自己調整学習スキルの習得を促すことを目指している。算数文章題の学習は、日常概念を数学の基礎となる概念に対応づける過程で、問題解決の素朴概念と数学的な形式的概念に対応付けて考える能力を形成することができるため、思考を内省する対象として初学者にとって取り組みやすく、かつ理論的な科目の学習への手がかりが得やすい。本研究では、メタレベルで思考を内省するスキルの初期段階のスキルをシードスキルとよび、シードスキルの習得を促す学習モデルを提案し、さらに、それに基づいて学習者にメタレベルの内省を促す質問を適応的に提示する機能(MetaQ)と、思考プロセスをグラフ化して可視化する機能（InDi）を備えた学習環境 CREMA を開発している。本論文では、メタ認知・自己調整学習に関する教育学・学習科学の理論に基づいて、学習モデルの構成原理を論じ、その実装としての学習環境 CREMA の機能と全体の構成を説明したうえで、支援の効果を評価する目的でタイ人の中学生約 100 人を対象として行われた実証実験について論じている。実験結果は、統制群と実験群の比較により、CREMA を用いた学習により自己調整学習のシードスキルが形成され、自己調整学習スキルの習得の動機付けが促されていることが確認されている。

以上、本論文は、転移性のある汎化スキルとしての自己調整スキルの学習を促進する手法を提案し、その有効性を実験的に示しており、学習科学・知識科学の新規性の高い知見示した点において学術的に貢献するところが大きい。よって博士（知識科学）の学位論文として十分価値あるものと認めた。