Factorization of Quadratic Polynomial with Fault–Tolerance and Practice Oriented Learning Architecture

Hsiu-Ju Chang
hsiu108@ms41.hinet.net
Taipei County Shu-Lin High School, 238, ROC.

Abstract: *The main purpose of this research is to build automatic schemas for efficient and effective thinking, learning, and solving the quadratic polynomial factorization with cross-multiplication method for less able learners in junior high school. The Fault–Tolerance and Practice-Oriented (FTPO) web based learning system is based on the comprehensible and recognizable learning objects with the well concept simplifications, linkage concatenations, and structure implementations to help learners to construct their own mental images. In supporting mechanism, the adaptive presentations, linkages and structures will be the essential components for the practice-driven learning system to maintain fault-tolerance mechanisms which can build and share an interpretable knowledge framework for learners to interpret and imitate the new concepts and skills meaningfully and reasonably during learning and solving processes.*

1. Introduction

To lead and assist the less able learners with simpler, easier, and clearer learning processes for individuals to make sense in knowledge constructions and connections is the main purpose of this research. Accordingly, the visualization, recognition, and organization are the essential mechanisms of system architectures for supporting a fault-tolerance learning and solving processes. The fault-tolerance mechanisms are based on the concept simplifications, skill concatenations, and structure implementations of the learning objectives to create evident understandings, build mental images and motivate individual inspirations during learning and solving processes. Furthermore, in schema construction, the complication and automation of schema constructions (Sweeler, Merrienbore, & Paas, 1998) will be helpful to solve mathematic problems with sophisticated and proficient solving processes. The Fault–Tolerance and Practice-Oriented (FTPO) web-based learning system is based on the comprehensible and recognizable learning objects with the reasonable concept simplifications, skill concatenations, and structure implementations to help learners to construct their own mental images. In practice, we see the gaps of the less able students in perception, comprehension, interpretation, and application of mathematical learning and solving processes. Accordingly, the more essential, structural, analyzable, and interpretable knowledge framework with meaningful, connectable, and authenticable concept linkages will lead learning behaviors with enough reciprocal effects between the learners' mental states and concrete applications. However, cognitive depletion (Chang, 2010) is occurred in individual learner who has insufficiency knowledge or skill while could not be assisted any supports during teaching and learning processes. On the contrary, cognitive redemption is the application of cognitive pool (Chang, 2007) which combines, maintains and integrates the major of knowledge, misconception, solving structure, and metacognitive knowledge/strategy as the cognitive supporting factors of specific domain knowledge in order to support authentication processes and fault-tolerance mechanisms for learning and teaching transparently and interactively. Moreover, after the authentication processes, the effects will not merely maintain suitable feedbacks or helpful mechanisms for the fault-tolerance learning processes, but sustain and uphold the motivation and confidence for learners to learn more and go further confidently. Supporting fault-tolerance learning may suitably change strategies and appropriately respond requirements in mixed-initiative interactions with learners on the web-based learning system. Consequently, the interpretable and shareable knowledge framework is not only to maintain the ways to interpretation of concepts and skills, but also to support the interactive management strategies for learners, instructors, and administrators to detect, realize, and support the thinking, learning, and solving processes.

1.1. Suitable cognitive load for encouragement

In perspective of cognitive load, the different knowledge flows, structures, expressions, representations, and element interactions will be the distinctly cognitive load of individuals (Sweller, 1988). In FTPO learning architecture, using the similar illustration structure as the fundamental knowledge flows and schemas to express, guide, solve, and generate the concepts and problems. To follow the flows and schemas will benefit for manipulating, applying, and practicing the concepts and skills easily and familiarly. Repeated practice of the fundamental schemas would eventually lead to schema formation, complication and automation step by step. Gradually, the less intrinsic cognitive load, building or enhancing the individual cognitive schemas via suitable ways, can attend to the individual cognitive process with easy and familiar learning experiences. In learning situations, the different competitive motives, disturbing emotions, environmental, and social factors will impact and influence the learning processes (pintrich, 2000). Accordingly, most of the able or less able learners based on their prior experiences to think, generate, and process their learning behaviors individually. In this perspective, the basic learning characteristics of able, less able, and disable learners are different in individual knowledge, skill, motivation, and ambition. The able learners usually maintain their successful experiences and plentiful knowledge for keeping the willingness, motivation, and confidence to conquer their learning objectives. Nevertheless, the less able learners usually perform discouraged or frustrated learning experiences during their learning processes. Accordingly, the negative learning experiences may lead individual learning behaviors with reducing the courage, willingness, motivation, and confidence in attending, thinking, constructing, and working the related learning activities. In addition, the mathematic solving processes are not unique concept identification and process construction which usually combine the related concepts, aspects and resolutions for individuals to divide, conquer, and solve the problems. The FTPO architecture tried to refine and divide the learning concepts and objectives into clear subsequences and operable sub-objectives for building and constructing complication and automation schemas easily and confidently.

2. Fault–Tolerance in cognitive depletion and cognitive redemption

Cognitive depletion (Chang, 2010) is the mental state of learners who may or may not aware the insufficient knowledge, skill, or strategy for them to achieve specific objectives. In metacongition view, the awareness or unawareness refer to what individuals have known or unknown about their cognition in the same tasks/situations or the across tasks/situations. Generally, no matter what the individual learning situations are, the course usually goes on step by step. Then the cognitive depletion will be occurred in such situations which the individual learner can not be understood the insufficiency knowledge or skill and can not be assisted any supports during learning processes. However, the depletion condition is not easily knowable, detectable, and assessable in time by others. Therefore, the learning processes are not only difficult to be detected or realized the actual situations, but also hard to be assisted and enhanced cognition depletions of individuals. The cognitive pools (Chang, 2007) are the correspondence sets which maintain the most relationships of misunderstanding concepts and useful knowledge/ concept/ skill for supporting the fault-tolerance learning processes. In web-based learning, the learning objects are the essential instructional materials (Chang, 2005; Vovides & Sanchez-Alonso, 2007) for learners to learn and practice. Owing to the processes of learners' knowledge construction will affect the learners' knowledge cognition, concept application and problem resolution. As regard this perspective, Mayer (2005a, 2005b) asserts that the multimedia may facilitate learners' knowledge construction. Accordingly, the cognitive pool is a combination which maintains and integrates the major of knowledge, misconception, solving skill, concept structure, and metacognitive knowledge/strategy as the cognitive factors of specific domain knowledge in order to set the related objects as the knowledge base to detect and support the conceptions or misconception from learning or solving processes. Cognitive redemption is the fault-tolerance mechanism to redeemed leaning from cognition depletion transparently and interactively. Accordingly, the purposes of cognition redemption want to detect and support the cognition depletion of learners in order to give individuals a successful learning experience and lead learning processes more fluently for learners to learn more go further confidently.

3. Knowledge framework and concept hierarchy

A shareable knowledge-handling framework is a transparent way to communicate and balance the knowledge and information with the devised perspectives and intended objectives of users (learner, instructor, material developer, and system administrator) to enhance knowledge and information communication (Chang, 2008). And the interpretable knowledge-handling framework is the knowledge framework which maintain the meaningful, achievable, and realizable guidance concatenations for directing or redirecting the learning or solving processes in time. In schema construction and modification, one concept or skill usually need to give chances for learners to practice and apply for novel learners to be similar with specific concept or skill. Furthermore, the supporting fault-tolerance mechanisms for learning or solving processes are the completive strategies which communicate the factors between the cognitive depletion and cognitive redemption in order to make suitable linkages or skill concatenations for misunderstandings or mistakes to be corrected. Accordingly, no matter what different characteristics that learners keep, distinct aspects that learners think, and misconceptions that learners have, all solutions are the well fault-tolerance mechanisms, learning structures and access controls between learning situations, learning strategies, concepts, and skills in design time and run time. Meanwhile, the cognitive depletion and cognitive redemption are necessary to be acknowledged and maintained for fault-tolerance supports. However, how to sense the occurrences of cognitive depletion; how to support cognitive depletion for learner to learn and solve the polynomial factorization; how to get ideas, take advantages, and make senses to enhance learning performance during learning and solving processes; are the essential issues in Fault–Tolerance and Practice-Oriented (FTPO) web-based learning system. Owing to learning frustrations will reduce the learners' motivations and ambitions in learning processes, a well refinement in concept simplification, classification and skill provision of learning objects are the essential construction for cognition redemption in order to help and inspire the initiative thinking, connecting, and practicing concepts or skills during learning and solving processes. The figure 1 illustrates the concept simplification of the quadratic polynomial factorization with cross-multiplication method.

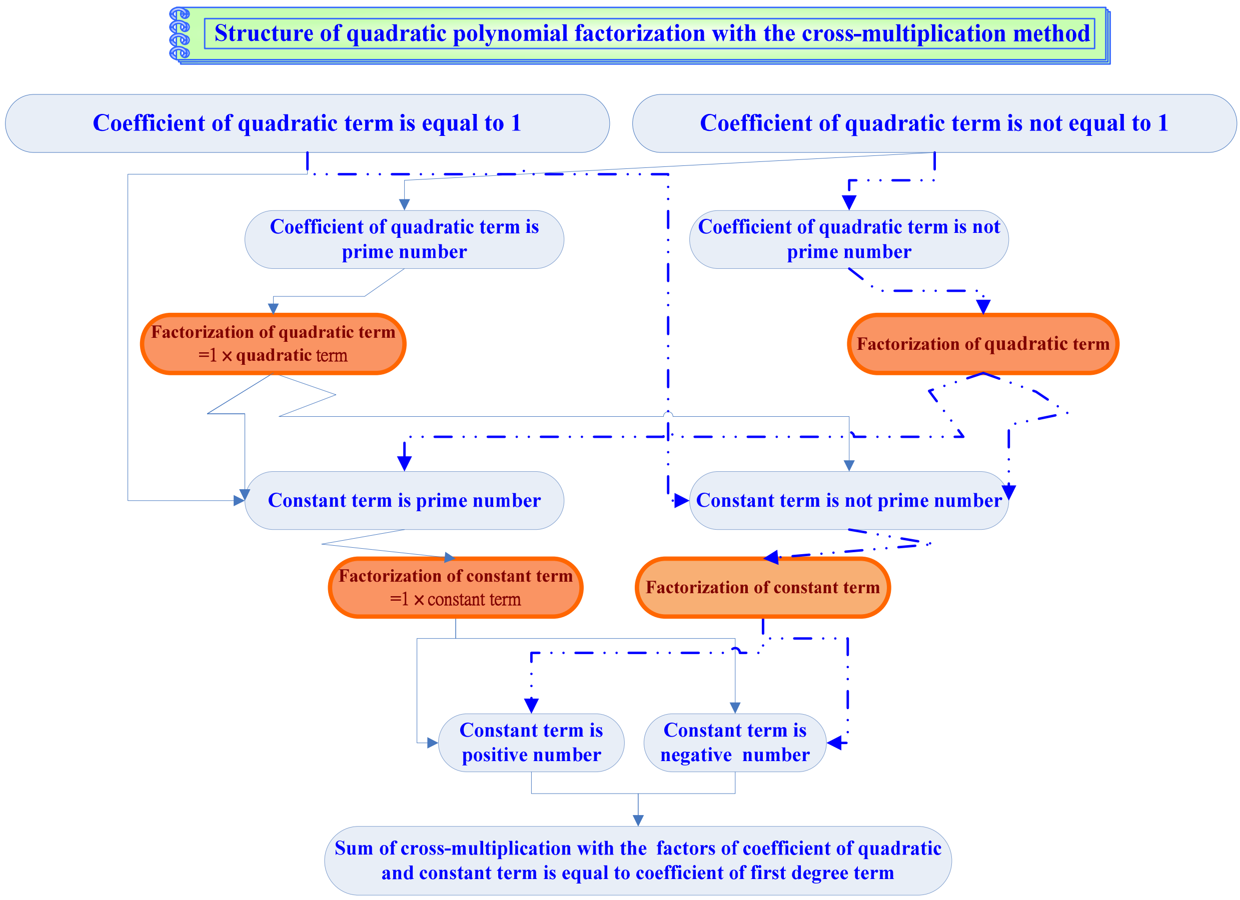

Figure 1: The simplification of concept hierarchy of polynomial factorization

4. Concept simplification, skill concatenation, cognitive classification and knowledge provision

A learner comprehends the instructions by engaging in the learning activities and interprets the concepts by their individual comprehensions and experiences. Owing to the construction of learning schemas is from the fundamental to complex learning. Meanwhile, the practice-driven learning hierarchy need to be refined and identified a well structure for learners to make senses and create their fundamental to complex schemas. Mayer (2002) mentioned that learner should learn basic problem-solving skills in isolation to build the cognition in what to do and when to do. Furthermore, each successful learning outcome in complex or automation learning behaviors always need to connect the concepts, strategies, and skills with suitable contact in order to make them familiarization for increasing the chances of interaction, comprehension and application. Consequently, the system needs to concatenate the concept with concept, concept with skill, and skill with application step by step. As a result, in cognitive views, system needs to concatenate the specific knowledge with knowledge, knowledge with comprehension, comprehension with application meaningfully and usefully. Obviously, the more adaptive concatenate and connect with the knowledge, comprehension, and application of concepts and skills, the more adaptive-in-width (AIW) and adaptive-in-depth (AID) (Chang, 2006) learning behaviors will be constructed during learning and solving processes. In fundamental to complex schema construction, the simplification of learning object and action will reduce the cognitive loading or learning frustration and will have the chances to maintain or enhance the motivations or ambitions for learners to learn more and go further confidently. The simplification stages of learning and solving the polynomial factorization with cross-multiplication are the followings; 1) setting the coefficient of quadratic term equal to 1; 2) setting the constant term into prime number with positive sign; 3) setting the constant term into prime number with negative sign; 4) setting the constant term into nonprime number with positive sign; 5) setting the constant term into nonprime number with negative sign; 6) setting the coefficient of quadratic term equal to prime number with positive sign; 7) setting the coefficient of quadratic term equal to prime number with negative sign; 8) mixing all the situations; The figure 2 is to show the reductions and simplifications of concept hierarchy of the quadratic polynomial factorization with cross-multiplication method during the coefficient of quadratic term is set to 1.

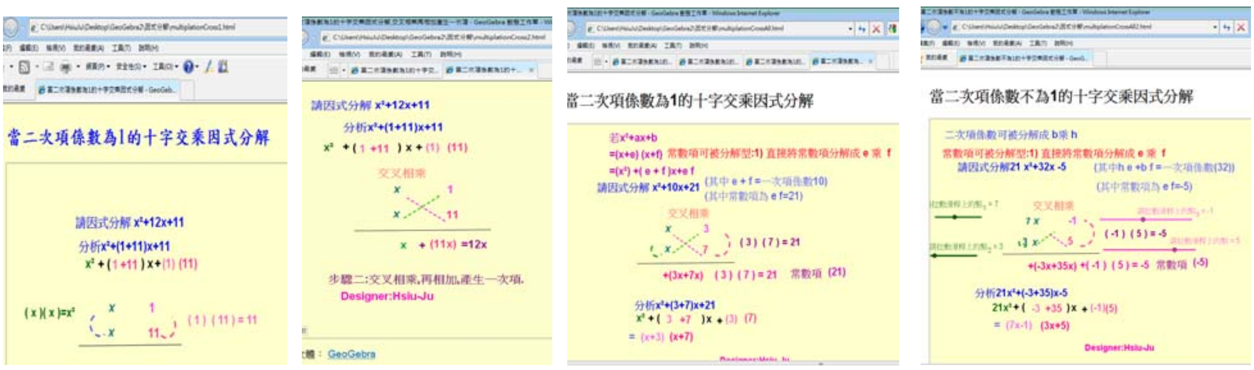

Figure 2: The concept simplifications, skill concatenations, and structure implementations of the FTPO learning objects

The figure 3 illustrates the simplification of concept hierarchy of polynomial factorization. In schema construction and automation (Sweller, Merrienbore, & Paas, 1998), the rehearsal and recognition the related concepts will benefit on the reducing the working memory and helping learners to be sophisticated problem solvers. During the practice-oriented learning system will an essential way to construct and apply their individual mental images during learning and solving processes. And the figure 3 illustrates the interactive operation of cross-product method in solving polynomial factorization. Ex: $x^2 + (a+b)x + ab = (x+a)(x+b)$

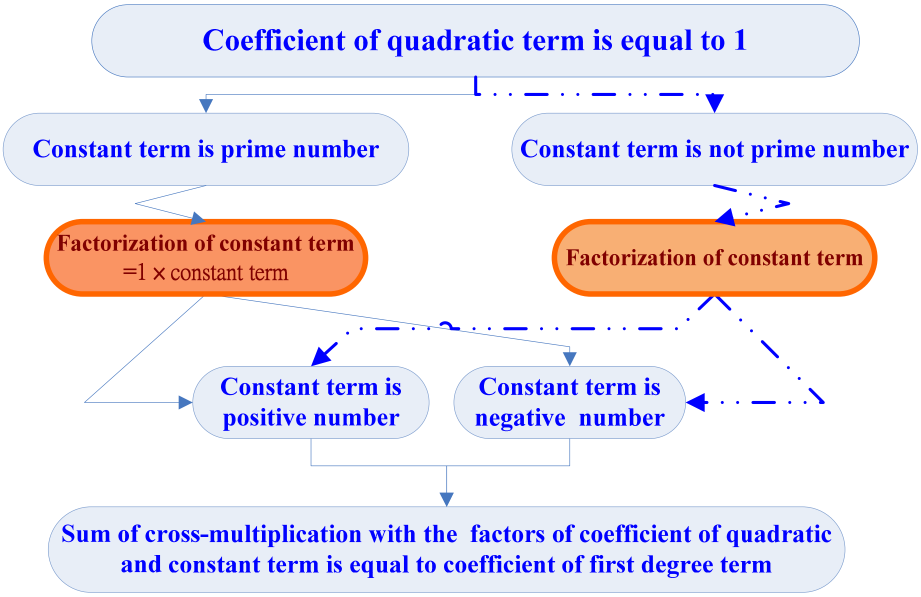

Figure 3: The simplification of concept hierarchy of polynomial factorization

The related positions in solving polynomial factorization of cross-product method are a key resolving way to clarify and link the relationships between factors and equation coefficients of equations.

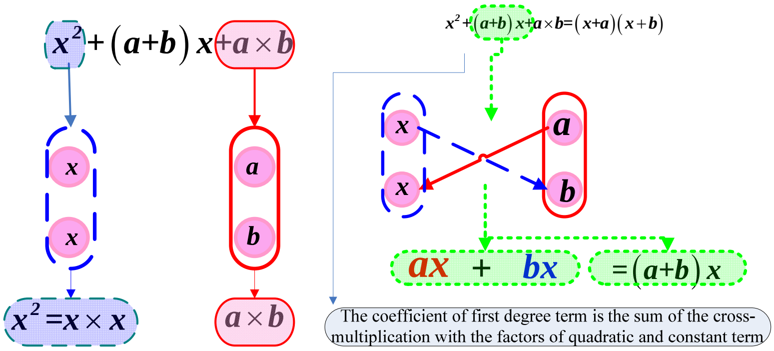

Figure 4: The interactive operation of cross-product method in solving polynomial factorization

The adaptive learning system is set to adjust the learning and teaching behaviors which are based on the acquisitions and detections of individual learning outcomes, and then support the cognitive learning objects in order to assist and enhance the learning performances. The figure 5 illustrates the interactive operations to build the fundamental schema to complex schema of cross-product method in solving polynomial factorization. As a result the student not only learns the topic and subject under the FTPO web-based learning system, but also gains a number of transferable learning and solving skills in solving polynomial factorization with cross-product method.

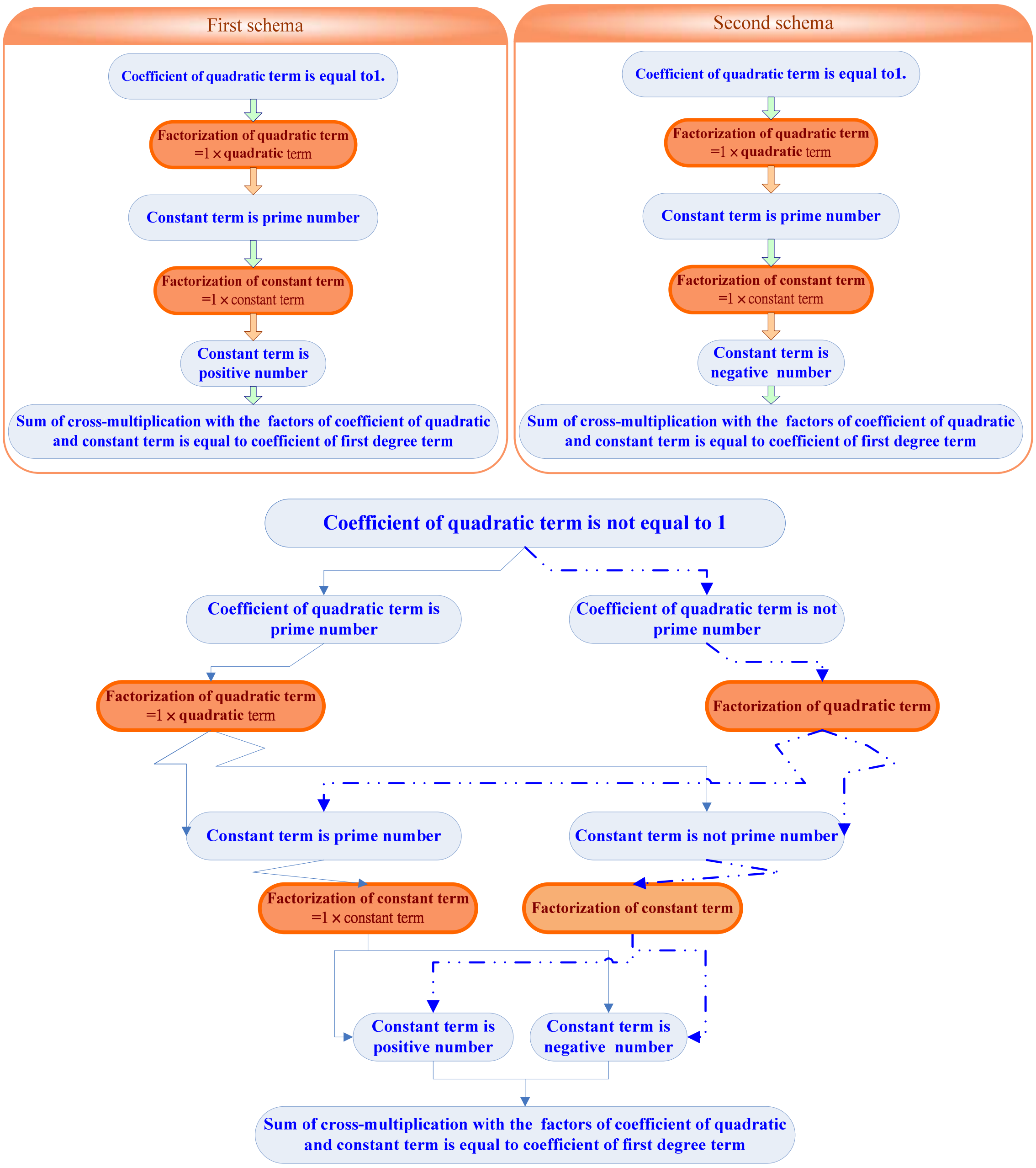

Figure 5: The illustration is to segment the main intrinsic cognitive load into some isolation elements for reducing cognitive load of novices in the interactive operations and schema constructions.

5. Conclusion

The fault–tolerance and practice-oriented (FTPO) web-based learning system led learning processes simpler, easier, and clearer to make sense in learner's knowledge constructions and connections. Otherwise, the more complex, difficult, and nonstructural learning objects will have the chances to lead them to make holes in their learning processes. Accordingly, the shareable and interpretable knowledge framework will benefit individuals' knowledge and schema construction, complication, and automation in teaching, learning, and solving processes. Participants were 35 junior high school students (grade 8, 13~14 years old, 17 males, 18 females) with low achievement and ambition of individual learning performance mostly. The correct percent of the experiences are section I: 87.14%; section II: 84.29%; section III: 71.43%; section IV: 75.71%; section V: 65.63%; and section VI: 68.57%. Owing to learning behavior is influenced by learners' viewpoints and believes which were built and constructed the knowledge, skill, and strategy from individuals' leaning experiences (Chang, 2007). Consequently, when new issues or problems need to learn or solve, then learners will interpret learning concepts and make senses by learners themselves which based on their prior learning experiences. In cognitive depletion, the limitations are usually happened in without maintaining and supporting fault-tolerance mechanisms. However, the cognition redemption needs meaningful or well-defined linkages to connect the concepts, skills, and applications between failures and assistances. Consequently, the interpretable knowledge framework is not only to maintain the ways to interpretation of concepts and skills, but also to support the interactive management strategies for learners, instructors, and administrators to detect, realize, and support to build the complex and automatic schemas in learning and solving polynomial factorization with cross-product method.

References

Chang, H. J. (2006). Adaptation in Depth: The Use of 'Cognitive Object-Oriented Teaching Model'. *ED-MEDIA 2006--World Conference on Educational Multimedia, Hypermedia & Telecommunications, Association for the Advancement of Computing in Education*, Orlando, FL, USA, 751-758.

Chang, H. J. (2007). Knowledge of Web-Based Cognitive and Interactive Metacognition Interface within Teaching Similar Triangles. *ATCM 2007--The 12th Asian Technology Conference in Mathematics*, Taipei, Taiwan.

Chang, H. J. (2008). Supporting Fault-Tolerance Learning within Cognitive, Object-Oriented Teaching Model. *ED-MEDIA 2008--World Conference on Educational Multimedia, Hypermedia & Telecommunications, Association for the Advancement of Computing in Education*, Vienna, Austria.

Chang, H. J. (2010). The Implementation and Evaluation Learning Processes within Cognitive, Interactive, and

Transparent, Teaching Interface, *2010-- Global Learn Asia Pacific 2010*, *Association for the Advancement of Computing in Education*, Penang, Malaysia.

Mayer, R. E. (2002). *Metacognition in learning and instruction theory, research, and practice* edit by Hartman, H. J.

Mayer, R. E. (2005a). *Cognitive theory of multimedia learning*. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (pp. 31e48). New York: Cambridge University, Press.

Mayer, R. E. (2005b). *Multimedia learning*. Cambridge, UK: Cambridge University Press

Pintrich, P. R. (2000). Anachievement goal theory perspective on issues in motivation terminonlogy, theory and research. *Contemporary Educational Psychology, 25,* 92-104.

Sanchez-Alonso, S., & Vovides, Y. (2007). Integration of metacognitive skills in the design of learning objects. *Computers in human behavior*, *23*, 2585-2595.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12, 257-285.

Sweller, J., van Merriënboer, J. J. G., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10*, 251–296.