



# Learning Styles for K-12 Mathematics e-Learning

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## INTRODUCTION

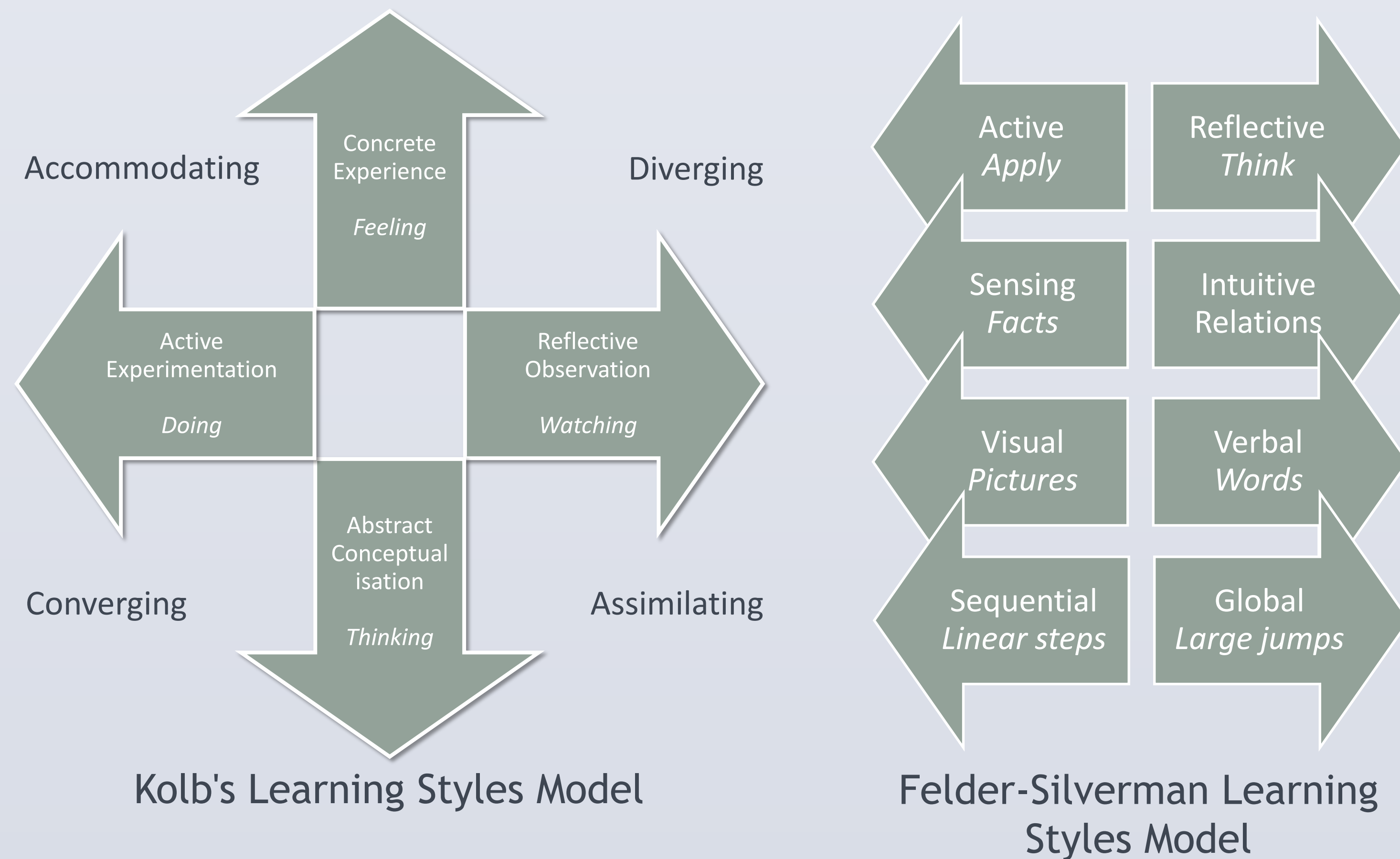
Computer supported education environments offer a significant alternative to traditional learning methods. Among other benefits, they also allow specializing or adapting according to learners' needs. Herein, designing an e-Learning application that is capable of detecting user's learning style and teaching a subject by accommodating itself to that style is an interesting research area. However, it is necessary to investigate the impact of learning styles on e-Learning environments before launching out such a research.

## OBJECTIVES

This study aims to review the existing literature for teaching mathematics to K-12 students in an e-Learning environment according to students' learning styles. Reviewed papers were selected according to their significance and relevance. Significance is measured by the quantity and quality of citations while relevance is decided according to the applicability of the study to K-12 mathematics e-Learning. Although we tried to cover as many papers as possible, we are aware that we may have left out some significant and relevant papers.

## LEARNING STYLE MODELS

Learning style or cognitive style is the preferences or methods of a learner in his/her learning activities. Different people have different methods to understand a subject better. Some individuals may prefer visual learning while others may find auditory or verbal approaches more useful. Yet, some may succeed by only studying the theory while experimenting may be essential for others. Learning style models aim to specify and designate general preference categories similar to these examples. They also classify learners according to their approaches in learning and understanding subjects by means of various measures.



## LEARNING STYLE DETECTION

Before trying to teach a subject using a method that matches the learning style, challenge of determining the learning style stands. There are both traditional and computerized approaches trying to solve that challenge.

Questionnaires designed for some models provide valid and reliable classifications in ideal situations; however, there are problems with the questionnaire approach, because; it is not realistic to assume that learners are aware of their learning style and motivated to answer the questionnaire properly. This awareness and motivation problem is especially evident in the case of younger children in K-12 level and it puts the validity and reliability of the questionnaires in question.

Although automatically detecting learning style according to user behavior offers a more natural and unnoticeable solution to the detection problem, there is not as much research as questionnaires demonstrating its validity and reliability. Moreover, logging detailed user behavior and deducing a meaningful model from the data to guess a learning style is not an easy task. There are enormously many user actions and it is required to decide which action contributes to which learning style and in what level. Automatic detection functionality is also hard to implement afterwards, unless the e-learning system is natively developed with logging capabilities.

## LEARNING STYLES AND PERFORMANCE

When developing an application that considers learning styles, it is important to understand whether designing different learning processes for different learning styles actually affect learning performance positively. Intensive research has been devoted on the impact of learning style models for both traditional learning and e-Learning environments.

We draw two conclusions from the studies on both traditional teaching methods and on e-Learning: (i) When the same teaching method is applied to all learners, there is a correlation between learning performance and learning style. Learners of certain styles perform better while some others fail to improve. Although, this outcome is suggested as a drawback of e-Learning in some studies, it can be considered primarily as a drawback of just the methods where the same content and methods are applied to all learners regardless of their learning styles. (ii) When a learning method which is compatible with the learner's learning style is used, learning achievement significantly increases. Both conclusions support the claim that: in an ideal learning environment each learner should be treated differently depending on his/her learning style.

## LEARNING STYLES IN K-12 MATHEMATICS TEACHING

Here, we cover the details on the learning performance effects of learning styles and adapting teaching style according to learning styles. We focus only on mathematics teaching for K-12 students and examine the effects in two cases: traditional (face-to-face) learning and e-Learning, respectively.

In the case of K-12 mathematics education there is not an adequate number of studies on either traditional learning or e-Learning to enable reliable deductions. However, the small number of studies considered in our study create an impression that similar positive outcomes in other age groups and other subjects can also be obtained for K-12 mathematics. More research should be devoted especially on adaptive teaching methods based on learning style to understand its impact on K-12 mathematics performance.

## CONCLUSION AND FUTURE WORK

Our literature review shows that the research in learning style models and their application to e-learning environments is quite adequate both theoretically and empirically. There is a potent and detailed background for learning style models despite of some minor differences among them. Moreover, there are many publications suggesting that, considering learning styles appropriately enhances the learning experience. On the other hand, amount of studies on the effects of learning styles in younger learners (K-12 in our case) and in specific school subjects (Mathematics in our case) are not proportionally intensive, although a few available studies are encouraging. Besides, almost all of the learning style detection/determination methods are either questionnaires or automated systems that track user behavior in an e-Learning environment. Those are not quite suitable for K-12 students due to lack of learner self-awareness and motivation in the case of questionnaires and due to highly sophisticated infrastructure and decision algorithm requirements and lack of reliability/validity experiments in the latter case.

Our aim is to develop an educational game which detects learning style of a K-12 student (especially 3 to 5 graders), then tries to teach a simple mathematics subject in accordance with his/her learning style and finally measures the level of cognition. We would like to give an example for how learning style differences could be used for easier multiplication table learning. This subject is chosen due to the difficulty that students have in learning it as well as its applicability to multiple teaching styles on a computer. For instance, multiplication table can be taught through a game with numbers, spoken explanations and applying speech recognition to learner responses for verbal learners or using symbols, animations or images of real-life objects such as fruits for visual learners. User interaction can be emphasized by allowing dragging and dropping symbols or numbers to the multiplication equations in order to support kinesthetic learners who prefer to learn by getting involved and carrying out a physical activity.

We expect to observe that, games which are natural ways of learning for students of these ages, can accurately detect learning style and increase learning performance when suitable teaching methods for learning style are employed.