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THE EFFECTIVENESS OF SELF-DIRECTED LEARNING VS. TEACHER-LED LEARNING ON GIFTED AND TALENTED VS. NON-GIFTED AND TALENTED ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

In the age of the Internet, where information is readily accessible, many people are expanding their knowledge through self-directed learning without being in a traditional classroom setting. This raises the question of how well people can learn on their own without the aid of a human teacher. In our previous work (Leddo et al., 2017), we found that middle and high school gifted and talented (GT) students learned basic computer programming equally well on their own as when taught by a human teacher while non-GT students learned better when taught by a human teacher than on their own. Nittala, Leddo and Nittala (2022) replicated these findings with high school students learning advanced biology material and found that while non-GT students learned better with a teacher than on their own, GT students actually learned better on their own than with a teacher. The present study investigates whether these previous findings hold up with younger, elementary school students. 80 GT and 80 non-GT students were randomly assigned to teacher-led or self-directed-learning conditions where they learned the Pythagorean Theorem. Results showed that both groups learned better with teachers than on their own, and that this increase in performance of teacher-led vs. self-directed learning was greater for GT students than for non-GT students. This result runs counter to our previous findings and suggests that younger students may not yet be ready to learn well on their own but that having a teacher may actually help younger GT students develop the knowledge that they later will use to learn well on their own.

Introduction

The advent of the Internet has changed the way people learn. While people still go to school and learn the basic curriculum through the traditional classroom setting, they are now supplementing

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their learning with online resources. There are even online courses on platforms such as Coursera, EdX, Udemy, etc. where people can earn certifications. Even less structured ways of learning are from YouTube videos and reading online articles. Self-directed learning (SDL) research has focused on characteristics of SDL programs that increase its effectiveness (cf., Firat, Sakar, and Yurdakal, 2016; Sumantri and Satriani, 2016), student interest and motivation (cf., Oladoke, 2006; Pintrich, 2004; Song and Bonk, 2016), and student self-efficacy/metacognitive strategies (cf., Dagal and Bayindir, 2016; Saeid, and Eslaminejad, 2017; Schunk, 2008).

Much of SDL research has been conducted on adult populations. In this study, children are included, especially since many of them are supplementing education with resources from the Internet and are even learning topics that are not offered in school. More research with children would also show the factors that impact their learning without the guidance of an adult. One of these factors could be student aptitude.

Many school districts test for student aptitude and place the more advanced students in gifted and talented (GT) programs where they learn curriculum above their grade level. However, these students are still taught by teachers, so it is interesting to see how they will perform if they are left to learn on their own. In our first study (Leddo et al., 2017), we tested whether there is a difference in performance in GT and non-GT middle and high school students when taught by teachers or learn in an SDL environment. The study involved the teaching of introductory computer programming to two groups: a teacher-led one and a self-directed one in which students learned from videos. Students in both groups had no prior computer programming experience. Students in both groups individually made a website as their post-test, and these were scored by experienced web designers. The scores showed that GT kids learned the same, regardless of whether they were self-directed learners or taught by a teacher, while non-GT kids learned better with a teacher.

Given that the Leddo et al.(2017) study showed that GT students learned introductory material equally well regardless of whether taught by a teacher or engaged in SDL, the next step was to see if that finding would continue when students learned more advanced material. Nittala, Leddo and Nittala (2022) replicated the Leddo et al. (2017) study, this time using an advanced topic in biology and a pool of high school students, all of whom had completed high school biology. Again, both GT and non-GT students were included in the study. Once again, the results showed an interaction effect between learning format and whether students were GT or non-GT. As with the Leddo et al. (2017) study, non-GT students learned better with a teacher than on their own. However, this time, GT students actually learned better on their own than with a teacher.

The Leddo et al. (2017) and Nittala, Leddo and Nittala(2022) studies both showed that GT students learn as well as or even better on their own than with a teacher. Both studies were done

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with older students. The present study investigates whether these findings apply to younger students. Accordingly, the present study replicates the previous two studies using both GT and non-GT elementary school students. The subject matter taught is the Pythagorean Theorem.

Methods

Participants

Participants were 160 students recruited from 5th and 6th grades in Montgomery County in Maryland. Of these, 80 were enrolled in gifted and talented (GT) classes and 80 were not (non-GT). Students were all familiar with square roots and exponent operations. To qualify for advanced (GT) math, students must maintain top grades and be recommended by their teachers.

Materials

There were four videos used for self teaching. The videos were (in the order they were viewed by participants):

1. https://youtu.be/AA6RfgP-AHU- Pythagorean Theorem Intro

2. https://www.khanacademy.org/math/cc-eighth-grade-math/cc-8th-geometry/cc-8th-pythagorean-theorem/e/pythagorean_theorem_1_Using the Pythagorean Theorem

3. https://youtu.be/O64YFlX1_aI- Pythagorean Theorem 2

4. https://youtu.be/TjOlZr_2uW4 - Pythagorean Theorem for Right Triangles

Procedure

The 80 GT and 80 non-GT students were randomly assigned to either the teacher-taught or self-directed learning conditions. Each was given a pre-test to ensure that s/he did not already know how to solve problems using the Pythagorean Theorem. None of the Participants were able to solve the pre-test problems.

Participants were then taught how to use the Pythagorean Theorem to find legs and the hypotenuse of a right triangle. The teacher was provided a script to teach in order to ensure consistency in the teaching format for students in the teacher-led condition. Participants in the SDL condition watched the instructional videos in the order presented above. After the instruction, Participants received a post-test with 10 questions on finding the hypotenuse length and 10 questions on finding the length of one of the legs of a right triangle.

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Results

The results of the pretest showed that none of the Participants already knew how to solve problems using the Pythagorean Theorem. Therefore, the post-test data from all Participants were used in the analysis. The post-test results were scored by calculating the total number of correct answers out of 20 questions each Participant gave. The mean number of correct answers, broken down by condition, is shown in Table 1.

Table 1: Mean number of correctly answered questions by condition

	Self-directed learning	Teacher-directed learning
Gifted & Talented	7.18	11.7
Non-Gifted & Talented	4.05	5.75

An analysis of variance was performed on the data. The analysis showed a main effect for the type of student, $F(1,156) = 63.93$, $p < .001$, such that Gifted and Talented students generally outperformed non-Gifted & Talented students. There was also a main effect for this type of learning, $F(1,156)=30.08$, $p < .001$, such that students taught by teachers generally outperformed those engaged in self-directed learning. Finally, there was a type of student by type of learning interaction, $F(1, 156) = 6.20$, $p = .01$, indicating that Gifted & Talented students' scores improved more as a result of being taught by a teacher than did non-Gifted and Talented students' scores.

Discussion

The present results show that both GT and non-GT elementary school students learn better with teachers than on their own. This departs from our previous findings (Leddo et al., 2017; Nittala, Leddo and Nittala, 2022) that showed that for middle and high school GT students, being taught by teachers did not improve learning performance compared to self-directed learning. Moreover, the interaction effect in the present study actually went in the opposite direction from that in the Nittala, Leddo and Nittala (2022) study. In that study, having a teacher decreased learning performance for GT students compared to non-GT students. In the present study, having a teacher led to an even greater increase in student performance for GT students compared to non-GT students.

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We attribute this difference to the notion that older GT students may be better at assimilating new information on their own than younger students. Therefore, when learning on their own, older GT students may be able to comprehend the material they are learning without the aid of a teacher. However, younger students may lack this ability and therefore, learn better with a teacher. However, GT students may have the advantage of being able to process explanations better than non-GT students and therefore benefit even more from the teacher's instructions.

The explanation that the ability to process a teacher's instruction is age dependent is further strengthened by taking into account the Leddo et al. (2017) results. While elementary school GT students outperformed non-GT students when given teacher-led instruction in the present study, middle school non-GT students performed identically to GT students in the teacher-led and self-directed instruction conditions in the Leddo et al. (2017) study.

This raises the question as to what is going on in the GT student's knowledge base that allows him/her to perform better while learning from teachers at a younger age and learn equally well on his/her own as with a teacher at an older age? One hypothesis can be derived from research on expert knowledge. Leddo et al. (1990) studied the different types of knowledge that experts have. The researchers found that experts not only learn facts and procedures as postulated by Anderson's ACT* framework (1982) but also use generalized strategies and causal principles/rationales in reasoning.

Leddo et al. (1990) describes a progression of knowledge development that extends the ACT* framework. In ACT*, people first learn basic facts (semantic knowledge) that later gets proceduralized into problem solving processes (production rules). In the Leddo et al. extension, people abstract procedures into generalized problem solving processes and the causal principles behind why they work.

Generalizing problem solving processes and understanding why they work are useful in helping people learn new concepts. For example, in algebra, students learn how to solve a variety of equations. However, the method for solving these equations often follow a general strategy. Typically, a student is given an equation. Then, a step-by-step process is followed, often including reverse order of operations and concrete procedures like using additive or multiplicative inverses and properties of equality. Finally, the last step is often of the form "x =" and then answer.

Students who understand this generalized strategy should find it much easier to learn new topics in algebra than those who see each new topic as a unique set of procedures to memorize. In fact, Leddo and Liang (2021) were able to create a software program that used such generalized problem solving knowledge to read websites and teach itself math without human intervention.

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This may explain the Leddo et al. (2017) self-directed learning results as well as those in the present study. It may be the case that older GT students may possess these generalized problem solving strategies and causal principles that allow them to learn new topics without the intervention of a teacher, but that non-GT students lack these types of knowledge and need a teacher to explicitly teach the concepts. Younger students may lack these types of knowledge and, therefore, learn better across the board with a teacher than on their own. However, younger GT students still benefited from teachers more than non-GT students did.

This latter finding raises the interesting question of whether younger GT students simply learned more than non-GT students did or if the nature of their learning was somehow different. If the latter is the case (and both can be true), then GT students may be developing the seeds of expert knowledge as teachers explain concepts to them. Such seeds may be in the form of greater development of generalized problem solving strategies and causal rationales. If this is occurring, it may explain why GT students perform better than non-GT students when they are younger and as well on their own as when taught by a teacher when they are older. The generalized strategies they are beginning to develop when they are younger may help them solve a wider range of problems than can be solved by non-GT students who lack these strategies. Moreover, as students continue to develop these strategies and principles/rationales, they may reach the point when such strategies and principles/rationales allow them to make sense of new topics on their own, without the intervention of teachers.

One way to test this hypothesis is to replicate the above study (potentially with different subject matter) and assess not only how well teacher-taught GT vs non-GT students solve problems but also whether GT students are internally representing the concepts they are being taught more as experts do than do non-GT students. Fortunately, an assessment methodology called Cognitive Structure Analysis (CSA) developed by Leddo and his colleagues (cf., Leddo, Li and Zhang, 2022) assesses the types of knowledge people have. It is modeled after the previously described work on expert problem solving and assesses a person's facts, strategies, procedures and causal principles/rationales. Leddo, Li and Zhang (2022) found that the CSA assessments correlate .966 with how well students can correctly solve problems. In the proposed case, younger GT and non-GT students would be taught new topics and then assessed using CSA. Of interest would be whether GT students show greater development of strategies and causal principles/rationales than do non-GT students and whether this greater development is linked to superior problem-solving performance.

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