THE EFFECTIVENESS OF SELF-DIRECTED LEARNING VS. TEACHER-LED LEARNING OF ADVANCED SUBJECT MATTER ON GIFTED AND TALENTED STUDENTS

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ABSTRACT

The rapid expansion of online resources and the emergence of self-directed learning (SDL) opportunities have transformed traditional education methods. 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 gifted and talented (GT) students learned basic computer programming equally well on their own or when taught by a human teacher while non-GT students learned better when taught by a human teacher than on their own. This raises the question of how well students can continue to learn on their own as the subject matter becomes more advanced. Nittala et al. (2022) found an interaction effect when students were learning advanced material, specifically GT students did better on their own than with a teacher while non-GT students still learned better with a teacher. The present study investigates whether GT students can reach a "breaking point" when trying to learn very advanced material on their own compared to learning with a teacher. 24 GT middle and high school students learned a very advanced topic in biology, taught either by a teacher or by reading a scientific publication (self-directed learning-SDL). The results showed that GT students performed significantly better when learning on their own than when learning with a teacher. Future research should focus on what knowledge-building mechanisms are mediating this trend in which the more difficult the subject matter, the better GT students learn on their own than with a teacher.

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 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 been 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, so we wanted to expand the work done on children, especially since many of them are supplementing their education with resources from the Internet and are even learning topics that are not offered to them 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 previous study (Leddo et al., 2017), we tested whether there is a difference in performance in GT and non-GT students when taught by human 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 where 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 introductory computer programming is a relatively simple topic, the question becomes, "How far can students learn on their own?" Can GT students continue to learn advanced material on their own as well as they can with a teacher? This question was subsequently tested by Nittala, Leddo and Nittala (2022). In that study, GT and non-GT students learned an advanced topic in biology, cellular senescence and its relationship to aging, either on their own or by being taught by a teacher. This time, results showed an interaction effect whereby non-GT students learned better with a teacher as before, whereas GT students learned better on their own.

Given that the Nittala, Leddo and Nittala (2022) study did not demonstrate a "breaking point" where GT students no longer learned better on their own than with a teacher, the present study decided to push the envelope more by giving students an even more advanced topic to learn. Since the pattern held in our previous two studies that non-GT students learn better with teachers

than on their own, the present study did not investigate the learning of non-GT students on this very advanced material.

Method

Participants

There were 24 high school and middle school students from Fairfax County and Loudoun County in Virginia who participated. These students were all a part of a medical machine learning class. Every student was a part of a GT program. Students were not paid to participate in the experiment.

Instructional materials

The self-directed group was taught with one scientific publication. The publication is a peer-reviewed, published paper about cellular senescence and its effects on aging (Grimes and Chandra, 2009). The paper provides an in-depth discussion of the different alleles and genes that affect cellular senescence. The paper also discusses how cellular senescence can be used to help with cancer therapies.

The materials used in the teacher-led group was a teaching script created from information from the published paper. The teaching script represented a comprehensive summary of the article.

The other materials were a two-question pretest to make sure that Participants did not already know the material covered in the journal article and a 20 question post-test that covered the topics in the post-test. The questions were open-ended, so that students would have to generate their own answers to questions.

Procedure

The total session lasted two hours. During the two-hour session, students first took a timed pre-test for fifteen minutes to verify that the students did not already know the material to be taught. Then, students were randomly assigned to a learning condition. There were 14 assigned to the teacher group and 10 assigned to the self-directed learning group.

After they were split into their groups, they learned about cellular senescence and possible anti-aging techniques. Students in the teacher-led group were taught as a group by a medical doctor, who routinely tutors biology to high school students, and who was blind to the fact that her students were part of an experiment on learning. The medical doctor used the instructional materials–both the publication and the teaching script-- provided. Students in the self-directed learning condition learned at their own pace by reading the provided publication. Finally, all

students took a 20-question, timed post-test for twenty minutes to test how much each student learned.

Results

The results on the pre-test and the post-test were scored. No students had prior knowledge of the topic and therefore scored 0 on the pre-test.

Accordingly, Table 1 presents the mean post-test scores, broken out by instructional method (self-taught or teacher taught).

Table 1: Mean Post-test Scores by Instructional Method (out of 20)

	Self-Taught	Teacher Taught
Gifted and Talented	11.9	6.71

A t-test was performed on the data. The t-test showed that GT students learned significantly better (almost twice as well) when learning on their own than when taught by a teacher, t = 3.58, df = 22, p < . 002. These results were consistent with the Nittala, Leddo and Nittala (2022) findings that GT students learn very advanced material better on their own than when taught by a teacher.

Discussion

The present results show that, for very advanced subject matter, GT students learned considerably better when engaged in self-directed learning than they did when engaged in teacher-led learning. In fact, if we look at the three studies in our series: Leddo et al. (2017), which looked at learning basic computer programming; Nittala, Leddo and Nittala (2022), which looked at learning an advanced topic in biology; and the present study, which looked at learning a very advanced topic in biology, we see a pattern in which the more difficult the material becomes, the better GT students do on their own compared to being taught by a teacher.

On the one hand, the present results do not directly answer the question of whether there is a breaking point where GT students can no longer teach themselves as well or better than teachers can. On the other hand, the fact that GT students scored higher on their own than when taught by a teacher is not the complete story here. GT students still scored, on average, below 60% on the post-test. Therefore, GT students by no means mastered the subject matter they were learning.

This is understandable since GT students did not have sufficient foundation for the new material, as evidenced by the fact that each student scored 0 on the pre-test. Nevertheless, these results do suggest that GT students were reaching a breaking point in what they could learn on their own as their performance on the very advanced subject matter post-test was low.

However, since teacher-led students performed even worse than the self-directed learning students did, we cannot attribute the low post-test scores to the lack of a teacher. Rather, the logical explanation is that self-directed learning performance dropped due to lack of a foundation in the subject matter. In order to truly test whether GT students can continue learning increasingly advanced material without the aid of a teacher, we need to conduct a study in which GT students engage in self-directed learning of progressively advanced material that builds on the previously learned material.

The above discussion notwithstanding, there still remains the trend that the more advanced the subject matter, the better GT students are doing by learning on their own than with a teacher. This raises the fundamental question of what is transpiring when GT students learn on their own compared to when they learn from a teacher? What do they get from themselves that they do not get from a teacher? This seems reminiscent of the findings described in Leddo et al. (1990) in which experts were studied to determine what knowledge they had that differentiated them from non-experts. Leddo et al. (1990) found two things that may be useful here. First, Leddo et al. (1990) found that experts tended to have greater knowledge of cause and effect principles–the why things worked the way they did–than did non-experts. Second, the authors also found that experts reported that their expertise did not come from what they learned in the classroom, i.e., was not imparted to them by teachers, but was acquired from experience, i.e., they learned on their own.

If the results of Leddo et al. (1990) are applied to the present study, they create a hypothesis about what may be happening with the GT students. It may be the case that when the teacher is reviewing the concepts in the publication, she may be presenting them more factually. When GT students are learning on their own, they may be emulating the experts in the Leddo et al. (1990) study and developing a deeper, more cause and effect-based understanding of the subject matter. This deeper understanding may allow GT students to derive correct answers from general principles rather than having to memorize them as they may be doing when learning on their own.

One way to test if this is the case is to assess the type of students' knowledge as well as students' accuracy in answering questions. The assessment would seek to determine whether self-taught GT students develop more causal knowledge than do teacher-taught students and whether student performance on a post-test correlates with the amount of causal knowledge the student develops.

To accomplish this, we can use the Cognitive Structure Analysis (CSA) assessment technique (Leddo et al., 2022; Ahmad and Leddo, 2023), which is a question and answer technique that assesses how much factual, procedural, problem solving strategy and rationale (causal) knowledge that people have about a subject matter. Assessments produced by CSA have been shown to identify what types of knowledge are most important for problem solving in different subject areas and could be useful in a similar capacity here.

References

Ahmad, M. & Leddo, J. (2023). The Effectiveness of Cognitive Structure Analysis in Assessing Students' Knowledge of the Scientific Method. International Journal of Social Science and Economic Research, 8(8), 2397-2410.

Dagal AB. & Bayindir D. (2016). The Investigation of the Relationship between the Level of Metacognitive Awareness, Self-directed Learning Readiness and Academic Achievement of Preschool Teacher Candidates. Universal Journal of Educational Research. 4(11):2533-2540.

Firat M., Sakar A.N., & Yurdakal IK. (2016). Web Interface Design Principles for Adults' Self-Directed Learning. Turkish Online Journal of Distance Education. 17(4):2

Grimes, A., & Chandra, S. B. C. (2009). Significance of cellular senescence inaging and cancer. Cancer Research and Treatment : Official Journal of Korean Cancer Association. https://synapse.koreamed.org/articles/1152877

Leddo J., Boddu B., Krishnamurthy S., Yuan K., & Chippala S. (2017). The effectiveness of self-directed learning and teacher-led learning on gifted and talented vs. non-gifted and talented students. International Journal of Advanced Educational Research, 2(6):18-21.

Leddo, J., Cohen, M.S., O'Connor, M.F., Bresnick, T.A., & Marvin, F.F. (1990). Integrated knowledge elicitation and representation framework (Technical Report 90-3). Reston, VA: Decision Science Consortium, Inc.

Leddo, J., Li, S. & Zhang, Y. (2022). Cognitive Structure Analysis: A technique for assessing what students know, not just how they perform. International Journal of Social Science and Economic Research, 7(11), 3716-3726.

Lee, K., & Kang, S. (2018). Exploratory Research for Development of SDLT(Self-directed Learning Test) for Young Children. The Educational Review, USA. 2(3), 199-208. http://dx.doi.org/10.26855/er.2018.03.001

Morris, T.H. (2019). Self-directed learning: A fundamental competence in a rapidly changing world. Int Rev Educ 65, 633–653. https://doi.org/10.1007/s11159-019-09793-2

Nittala, T., Leddo, J. & Nittala, H. (2022). The Effectiveness of Self-directed Learning Vs. Teacher-led Learning of Advanced Subject Matter on Gifted and Talented Vs. Non-gifted and Talented Students. International Journal of Social Science and Economic Research, 7(8), 2619-2627.

Oladoke AO. (2017). Measurement of self-directed learning in online learners. Ph.D. thesis, Capella University. Retrieved from https://www.learntechlib.org/p/118702/.

Pai K. M., Rao KR., Punja D., & Kamath A. (2014). The effectiveness of self-directed learning (SDL) for teaching physiology to first-year medical students. Australasian Medical Journal. 7(11):448-453.

Pintrich PR. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. Educational Psychology Review, 16:385-407.

Saeid N., Eslaminejad (2017). T. Relationship between Student's Self-Directed-Learning Readiness and Academic Self-Efficacy and Achievement Motivation in Students. International Education Studies,10(1):225-232.

Schunk DH.(2008). Metacognition, self-regulation, and self-regulated learning: Research recommendations. Educational Psychology Review. 20(4):463-467

Song D., & Bonk CJ. (2016). Motivational factors in self-directed informal learning from online learning resources. Cogent Education,3(1):1205838.

Sumantri MS., & Satriani R. (2016), The Effect of Formative Testing and Self Directed Learning on Mathematics Learning Outcomes. International Electronic Journal of Elementary Education, 8(3):507-524