

Impact of Using NewPath's Science Multimedia Lessons on Student Learning

This study is supported by a grant from
The National Institutes of Health
Grant Number: 5R44OD016681-03



800-507-0966
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Study Research Team

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- **Guillermo Montes, Ph.D.** – Statistical Analysis

Impact of Using NewPath's Multimedia Lessons on Student Learning

EXECUTIVE SUMMARY

NewPath Learning worked in conjunction with Dr. Guillermo Montes, an expert in student outcomes measurements, to develop, implement and analyze data from validated pre- and post-assessments to determine the impact that NewPath's Online Multimedia Lessons have upon student learning. Field testing provided research-based evidence which demonstrated that the use of the Online Multimedia Lessons by middle and junior high students generates substantial and significant increase in the comprehension of the science concepts presented. Therefore, for administrators and teachers interested in ensuring the science readiness of their students, NewPath's multimedia lessons offer a proven method for success.

To make comparability to the literature and to other multimedia lessons easier, scale change scores for each lesson were transformed into a Cohen's *d* effect size, a widely used metric of effect size.

The *Defense Systems Multimedia Lesson* had an effect size ***d*=1.32**, meaning that on average students improved 1.32 standard deviations from pre- to post-testing.

The *Nervous System Multimedia Lesson* had an effect size ***d*=1.61**, meaning that on average students improved 1.61 standard deviations from pre- to post-testing.

The *Blood and Blood Typing Multimedia Lesson* had an effect size ***d*=0.98**, meaning that on average students improved 0.98 standard deviations from pre- to post-testing.

Cohen's *d* effect sizes greater than or equal to **0.80** are considered to be large intervention effects.

INTRODUCTION

Schools are placing increased emphasis on evaluating the impact of instructional materials on student learning, but few, if any, publishers provide evidence that use of their products results in increased learning of science concepts and processes. The purpose of this study was to develop and use reliable and valid pre- and post-assessments to determine whether the use of the Multimedia Lessons promotes students' science knowledge acquisition and application of that knowledge.

DESCRIPTION OF NEWPATH'S MULTIMEDIA LESSONS

NewPath Learning's Multimedia Lessons are complete, ready-to-use, interactive lessons for middle and junior high school students covering key life science topics. Each Multimedia Lesson provides engaging tutorial presentations, inquiry-based interactive activities, vocabulary review activities, and virtual investigations and assessments that are critical to the mastery of the often complex concepts pertaining to current, standards-based science requirements.

The Multimedia Lessons tested in this study were developed under the Phase I SBIR project and focused on the human body. Subsequently, NewPath Learning expanded the Multimedia Lesson product line to provide a more comprehensive coverage of core life, earth and physical science topics for the middle and junior high school grades. While initially planned specifically for whole-class use on the Interactive Whiteboard (IWB), the current versions of these Multimedia Lessons delivered online are also highly effective for use by individual students for self-paced instruction and review.

The Multimedia Lessons are delivered entirely online and accessible by teachers and students wherever Internet access is available via a standard browser. The online platform is completely hosted by NewPath Learning, thereby eliminating the need for schools or end-users to install and run any special hardware or software other than the typical plugins which are already available on most standard computers. In addition to the Multimedia Lessons, the online platform also includes a comprehensive learning management system to make assignments and track and analyze student performance.

Each Multimedia Lesson field tested included the following sections in the order outlined:

- **Pre-Test – “Check What You Know”**
Consists of lesson-specific multiple choice questions based upon Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis and evaluation) to determine students' existing understanding of the lesson content prior to its use.
- **Lesson Presentation**
Consists of a series of narrated, visual presentations, each featuring detailed graphics and animations to build student comprehension of the concept presented.
- **Interactive Activities**
Includes a variety of activities, such as drag-and-drop, matching, etc. that allow students to practice and apply the knowledge presented in the Lesson Presentation section.
- **Virtual Lab Investigation**
Includes a fully interactive virtual lab investigation, along with a study guide. The investigation allows students to practically apply the knowledge gained in the other sections of the lesson.
- **Post-Test – “Check What You Learned”**
Consists of lesson-specific multiple choice questions based upon Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis and evaluation) and directly related to the learning objectives of that module to determine students' comprehension after completing the lesson.

DEVELOPMENT OF OUTCOME MEASURE

For each of the 3 Multimedia Lessons tested, we created a reliable, valid, and unidimensional pre/post-test for its respective learning objectives. The pre- and post-assessments for the *Defense Systems* and *Blood and Blood Typing Multimedia Lessons* consisted of 20 lesson-specific multiple choice questions each, while the *Nervous System Multimedia Lesson* included 10 questions. The assessment was again based upon Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis and evaluation) and directly related to the learning objectives of that module.

The pre- and post-assessments were developed using an iterative refinement process based on modern item response theory (IRT) (Baker, 2001). In Round 1, the assessments for each of the 3 Multimedia Lessons were piloted sequentially in classrooms of 3 different teachers – one each from schools comprised of urban, rural and suburban demographics. This testing was conducted in December 2013.

Pilot test teachers were provided with a unique username and password for each student to login online. Teachers instructed their students to login to their individual online accounts to complete the pre- and post-assessments immediately before and after using the lesson.

After the first round of pilot testing, the pre- and post-assessments were rigorously analyzed using the Rasch model (Bond, 2007). Items (test questions) with low overall reliability that were (a) redundant based on item difficulty, (b) had negative or low item-test correlation ($<.15$), (c) had distractors no one chooses, or (d) were not unidimensional were either discarded or modified as necessary before we proceeded with the second round of pilot testing.

Based upon the first round results the research team decided that the tests for two of the three Multimedia Lessons could be substantially improved - *Blood and Blood Typing* and the *Nervous System Multimedia Lessons*. The tests for both lessons were substantially modified by deleting questions which were deemed through the analysis to be easy for students on the pretest, substituting questions with an anticipated higher difficulty level, and modifying distractors/answers. A second pilot round was then conducted in February 2014 for these two Multimedia Lessons after new and/or restructured assessment questions were added.

After the second round of pilot testing was conducted with this new set of teachers and students, the pre/post assessments were again analyzed using the Rasch model and we were able to identify validated pre/post assessment questions for each multimedia lesson that were unidimensional, with acceptable reliability and validity, adequately fit with the Rasch model, and demonstrated sensitivity to pre- to post-test change.

MEASURE DEVELOPMENT RESULTS - Pilot Testing

Analysis of Round 1 data of the 3 multimedia lessons occurred in December 2013.

Based upon the analysis of the tests completed by 122 students, the overall test reliability of the 20 item test for *Defense Systems Multimedia Lesson* was .83. The reliability of the questions (whether one can expect that the questions will retain their position by ability of student) was very high at .94. Infit and outfit values, item-test correlations, item difficulty, unidimensionality, behavior of the distractors and fit with the Rasch model were analyzed.

The research team decided that the test for the *Defense Systems Multimedia Lesson* was unidimensional, had adequate fit with the Rasch model, had demonstrated sensitivity to pre-post change, and was reliable enough for group assessment. Post norms were constructed. These are scaled normally distributed scores from 160 to 684, with a mean roughly at 500.

Analysis of Round 2 data of the 2 multimedia lessons occurred in February 2014.

Based upon the analysis of the tests completed by 103 students, the overall test reliability of the 20 item test for *Blood and Blood Typing Multimedia Lesson* was .70. The reliability of the questions (whether one can expect that the questions will retain their position by ability of student) was very high at .91. Infit and outfit values, item-test correlations, item difficulty, unidimensionality, behavior of the distractors and fit with the Rasch model were analyzed.

Based upon the analysis of the tests completed by 57 students, the overall test reliability of the 10 item test for the *Nervous System Multimedia Lesson* was .72. The reliability of the questions (whether one can expect that the questions will retain their position by ability of student) was very high at .91. Infit and outfit values, item-test correlations, item difficulty, unidimensionality, behavior of the distractors and fit with the Rasch model were analyzed.

After two rounds of pilot testing, and achieving high reliability with the assessment questions for all three Multimedia Lessons, field testing was scheduled for May 2014.

FIELD TESTING PROCEDURE

Field Test teachers were recruited through a database of approximately 100,000 teachers collected and maintained by NewPath Learning. Teachers applied by completing an online application via SurveyMonkey. More than 300 teachers applied to be involved in the NewPath Learning field testing of the three Multimedia Lessons. In the survey application, teachers indicated which lesson they were interested in field testing. They also provided information on their school and the type of classes they would involve in that testing.

A total of fifteen field test teachers and 1,233 students participated in the study as detailed in the data table below. Field test teachers were selected if they indicated that they would use the Multimedia Lessons with middle and junior high school Life Science/Biology classes with a mix of below average, average, or mixed ability students. No data was collected regarding gender, race, or ethnic background of students.

LESSON	TEACHER	LOCATION	SCHOOL TYPE	# of STUDENTS
Blood and Blood Typing	Buckley	Honeoye Falls, NY	Suburban	90
Blood and Blood Typing	Dehnel	San Angelo, TX	Urban	106
Blood and Blood Typing	Hunter	Fillmore, NY	Rural	62
Blood and Blood Typing	Lochmueller	Evansville, IN	Suburban	97
BLOOD LESSON TOTAL				355
Disease Defense Systems	Hart	Mammoth Lakes, CA	Rural	72
Disease Defense Systems	Matthews	Brandywine, MD	Suburban	131
Disease Defense Systems	Pangrazio	Retsof, NY	Rural	78
Disease Defense Systems	Power	La Canada, CA	Suburban	86
Disease Defense Systems	Stanton	Richmond, VA	Urban	83
DISEASE LESSON TOTAL				450
Nervous System	Cornette	Greenville, KY	Rural	76
Nervous System	McCain	Austin, TX	Suburban	72
Nervous System	Ostrander	Mesa, AZ	Suburban	125
Nervous System	Palmiotto	Union Springs, NY	Rural	97
Nervous System	Tibbs	Omaha, NE	Urban	58
NERVOUS SYSTEM LESSON TOTAL				428

Teachers were given adequate time to assign the lesson to their students when appropriate in relationship to their curriculum. Field test teachers were provided with unique username and password codes to distribute to each of the students. The lessons were assigned and completed online. Students were forced to complete the lesson in the order of the sections provided and could not jump to the next section until the section prior was fully completed. Individual student data was captured in NewPath’s learning management system and downloaded after students had completed the lesson in its entirety. Teachers allowed students with up to 90 minutes of time to complete the lesson. No prior instruction on the lesson topic was required. The investigators did not participate in the observation of the students. A stipend of \$200 was paid to each teacher whose students fully completed the lesson.

FIELD TEST STATISTICAL ANALYSIS

Field test data was downloaded from NewPath’s learning management system for each student in an Excel spreadsheet format. Students who had not completed the lesson in its entirety, had not answered all of the questions or for which any of the answers were not properly captured by the learning management system were omitted and not analyzed. A total of 1211 records with complete pre- and post-test data were analyzed.

Student’s overall results at both pre and post-test were calculated using Round 1 (Dec. 2013) for the *Defense System Multimedia Lesson* and Round 2 (Feb. 2014) for the *Nervous System* and *Blood and Blood Typing Multimedia Lesson* post norms, resulting in scale scores for each student at pre- and post-test, as well as an individual change scale score. Dependent samples’ t-test was estimated to determine if pre- to post-test change was statistically significant at the conventional $p < .05$ level.

FIELD TEST RESULTS

Defense Systems Multimedia Lesson

Students improved **66.56 points in the scale score**. The pre- to post-test improvement was statistically significant ($t=17.84$, $p<0.001$). To make comparability to the literature and to other lessons easier, these scale change scores were transformed into a Cohen's d effect size, a widely used metric of effect size. The *Defense Systems Multimedia Lesson* had an effect size $d=1.32$, meaning that on average students improved **1.32 standard deviations** from pre to post. Cohen's d effect sizes greater than or equal to **0.80** are considered large intervention effects.

Figure 1 shows the average pre and post scores and their associated 95% confidence intervals.

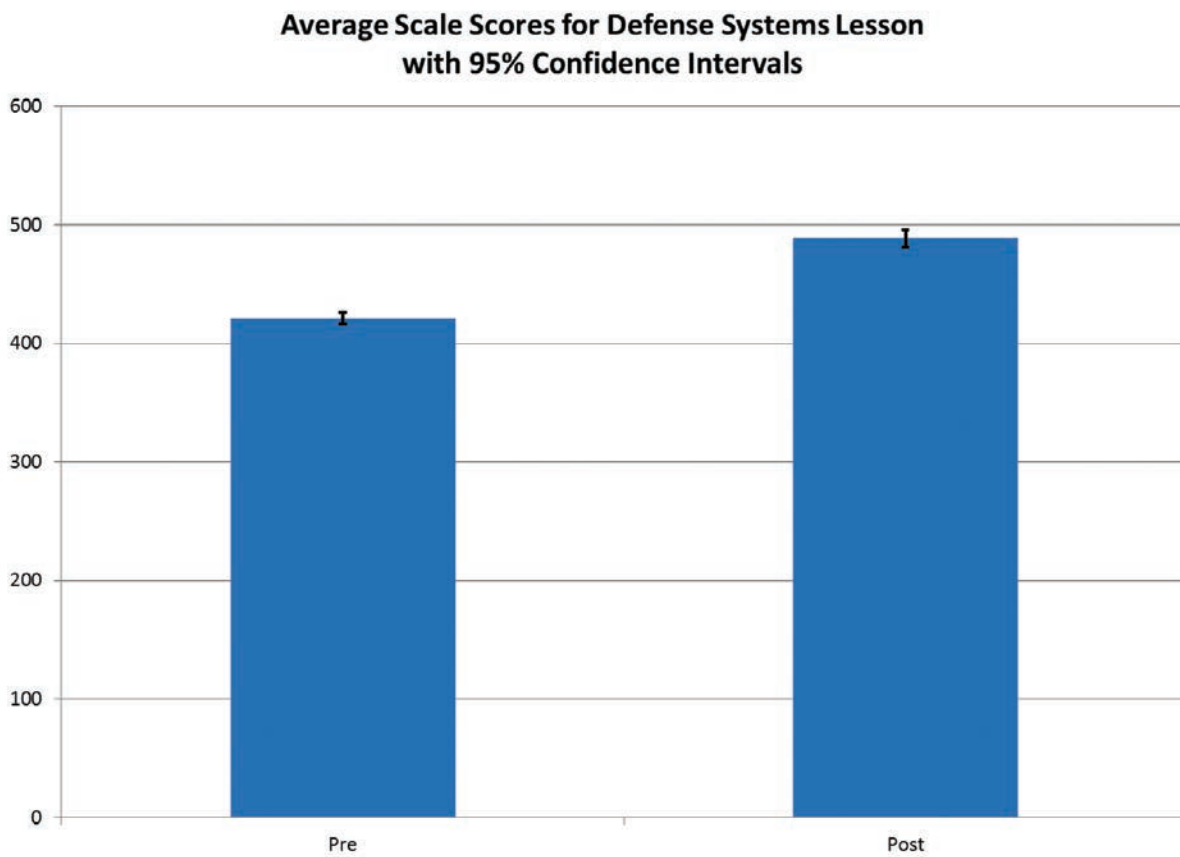


Figure 1. Pre-Post Scale Score Field Testing Results

Nervous System Multimedia Lesson

Students improved **115.42 points in the scale score**. The pre- to post-test improvement was statistically significant ($t=25.78$, $p<0.001$). To make comparability to the literature and to other lessons easier these scale change scores were transformed into a Cohen's d effect size, a widely used metric of effect size. The Nervous System Multimedia Lesson had an effect size $d=1.61$, meaning that on average students improved **1.61 standard deviations** from pre to post. Cohen's d effect sizes greater than or equal to **0.80** are considered large intervention effects.

Figure 2 shows the average pre- and post-test scores and their associated 95% confidence intervals.

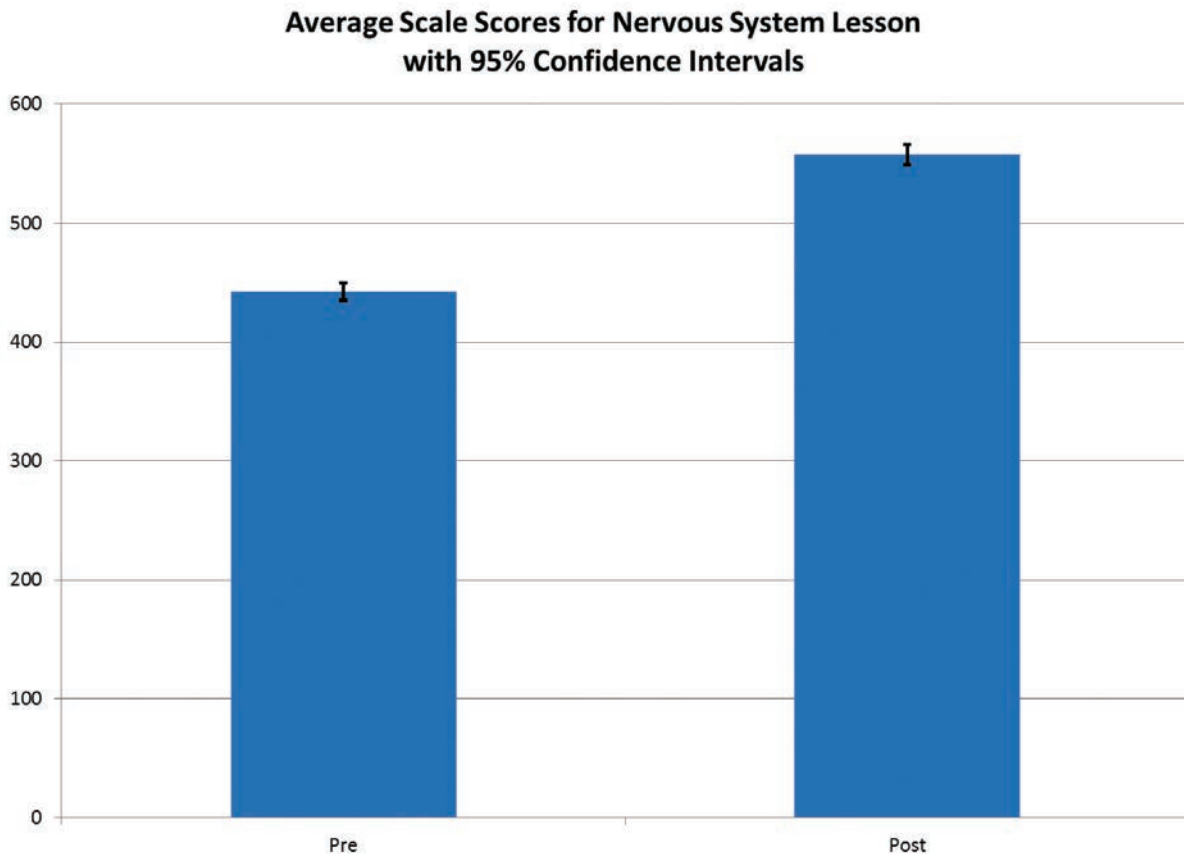


Figure 2. Pre-Post Scale Score Field Testing Results

Blood and Blood Typing Multimedia Lesson

Students improved **93.04 points in the scale score**. The pre- to post-test improvement was statistically significant ($t=15.12$, $p<0.001$). To make comparability to the literature and to other lessons easier these scale change scores were transformed into a Cohen's d effect size, a widely used metric of effect size. The *Blood and Blood Typing Multimedia Lesson* had an effect size $d=0.98$, meaning that on average students improved **0.98 standard deviations** from pre- to post-test. Cohen's d effect sizes greater than or equal to **0.80** are considered large intervention effects.

Figure 3 shows the average pre- and post-test scores and their associated 95% confidence intervals.

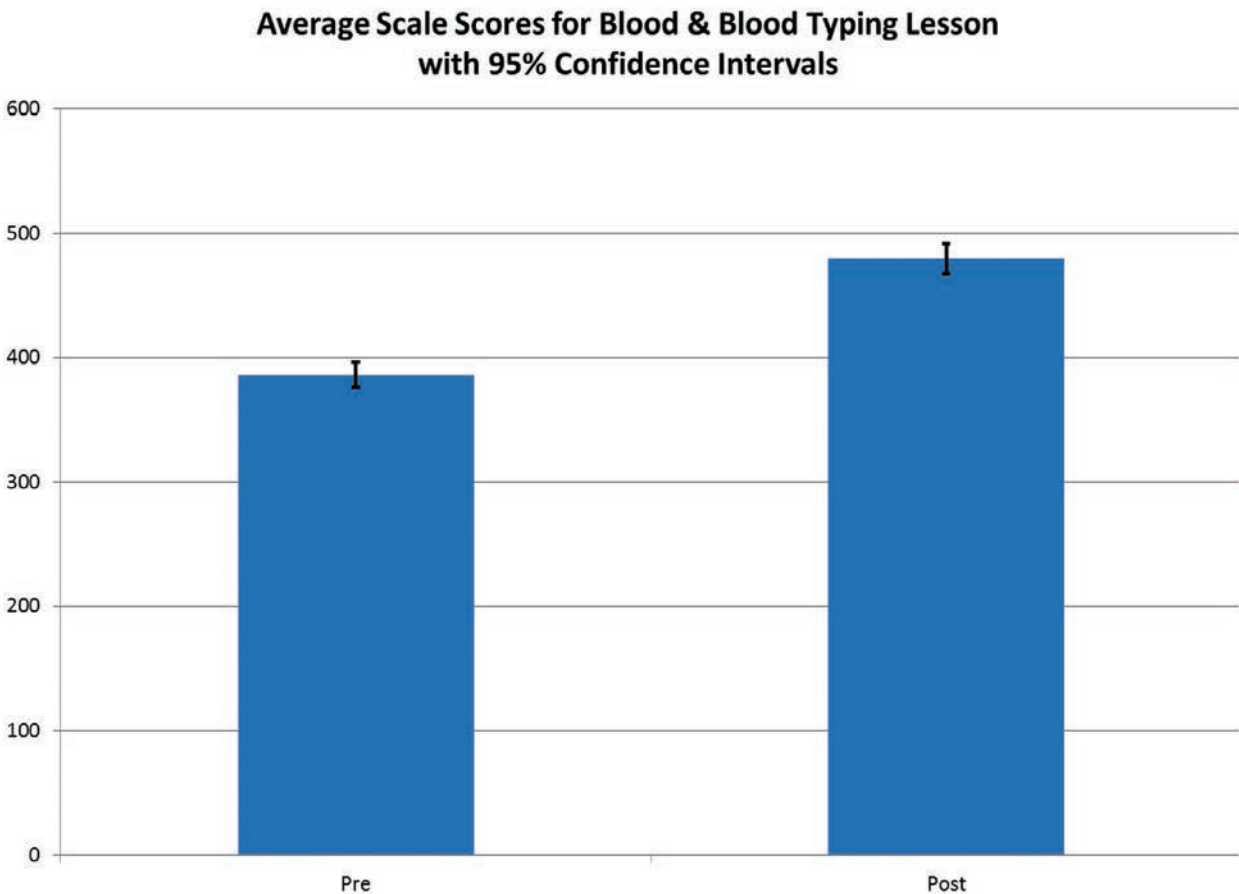


Figure 3. Pre-Post Scale Score Field Testing Results

COMPARISON OF RESULTS WITH ESTABLISHED BENCHMARKS IN GRANT PROPOSAL

Based upon previous experience and published academic literature, our grant proposal established expected pre- to post-test Cohen's d effect sizes of " **$d=0.3$** or above" (i.e. we expected improvements around 1/3 one standard deviation). The **Defense Systems Multimedia Lesson** clearly exceeds this benchmark with an effect size of **$d=1.32$** . The **Blood and Blood Typing Multimedia Lesson** also exceeded the established benchmark with an effect size of **$d=0.98$** while the **Nervous System Multimedia Lesson** had an effect size of **$d=1.61$** .

Field testing demonstrated that all three multimedia Lessons substantially and significantly increases students' understanding of the concepts presented in these lessons.

Dr. Guillermo Montes

Guillermo Montes, Ph.D., is an Associate Professor in the Ed.D. Program in Executive Leadership at Saint John Fisher College in Rochester, NY. Dr. Montes teaches doctoral-level courses in the program, conducts research, supervises doctoral students in field-based experiences, provides dissertation advisement for doctoral students, and chairs dissertation committees. Dr. Montes has an extensive background in quantitative research methods. Prior to joining Fisher, Dr. Montes was a Senior Research Associate and Co-Director of Research at the Children's Institute.

Dr. Montes received his Ph.D., M.A., and B.A. in Economics from the University of Rochester. His research interests include studying services for children with autism spectrum disorders in school and community settings using large scale nationally representative datasets. He has published the results of his research in a number of prestigious peer-reviewed journals and had support for his research from national and state grants.

APPENDIX A

NEWPATH'S MULTIMEDIA LESSONS

The perfect complement to any LIFE SCIENCE, BIOLOGY, PHYSICAL SCIENCE, CHEMISTRY or EARTH SCIENCE curriculum!

The lessons follow a research-based instructional method providing students with the most up-to-date effective way to learn. Each lesson is aligned to key state and national educational standards and includes comprehensive array of narrated animated tutorials, interactive activities, virtual investigations, visual resources key vocabulary terms, and assessments, along with a student study guide. Designed for multisensory learning and extensively piloted in the classroom, they are perfect for individual student instruction, one-to-one computing initiatives, flipping the classroom model, or for instructing the entire class on interactive whiteboards.

The multimedia lessons are also available online via a subscription by visiting www.newpathlearning.com

SYSTEMS OF THE HUMAN BODY MULTIMEDIA LESSONS		
Title	Single Computer License	Site/Single Building License
Systems of the Human Body I	54-6221	54-6421
Systems of the Human Body II	54-6222	54-6422
Systems of the Human Body III	54-6223	54-6423
LIFE SCIENCE MULTIMEDIA LESSONS		
Cells: Animal and Plant Cell Structure	54-6201	54-6401
Mitosis: Cell Growth and Division	54-6202	54-6402
Osmosis & Diffusion	54-6203	54-6403
Meiosis	54-6205	54-6405
Photosynthesis and Respiration	54-6206	54-6406
Chromosomes, Genes and DNA	54-6207	54-6407
Genetics: The Study of Heredity	54-6208	54-6408
Six Kingdoms of Life	54-6209	54-6409
Food Chains & Food Webs	54-6210	54-6410
Protists: Pond Microlife	54-6204	54-6404
PHYSICAL SCIENCE MULTIMEDIA LESSONS		
Properties & States of Matter	54-6601	54-6801
Atoms & Chemical Bonding	54-6602	54-6802
Elements and the Periodic Table	54-6603	54-6803
Chemical Reactions	54-6604	54-6804
Energy: Forms & Changes	54-6605	54-6805
Forces & Motion	54-6606	54-6806
Work, Power & Simple Machines	54-6607	54-6807
All about Sound	54-6608	54-6808
All about Light	54-6609	54-6809
Electricity and Magnetism	54-6610	54-6810
EARTH SCIENCE MULTIMEDIA LESSONS		
Minerals	54-6301	54-6501
Rocks	54-6302	54-6502
Plate tectonics	54-6303	54-6503
Earthquakes	54-6304	54-6504
Volcanoes	54-6305	54-6505
Earth's Surface	54-6306	54-6506
Earth's Atmosphere & Weather	54-6307	54-6507
Earth's Climate	54-6308	54-6508
Our Solar System	54-6309	54-6509
The Sun-Earth-Moon System	54-6310	54-6510

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