APPENDIX A

LITERATURE REVIEW--ANNOTATED BIBLIOGRAPHIES

Annotated Bibliography of New Article #1 of 13:

Burgher, J. K., Finkel, D., Adesope, O. O., & Van Wie, B. J. (2015). Implementation of a Modular Hands-on Learning Pedagogy: Student Attitudes in a Fluid Mechanics and Heat Transfer Course. *Journal of STEM Education: Innovations and Research, 16*(4), 44-54.

Regarding the article entitled "Implementation of a Modular Hands-on Learning Pedagogy: Student Attitudes in a Fluid Mechanics and Heat Transfer Course", it was concluded that lecture was a necessary precursor to hands-on us of the Desktop Learning Modules (DLMs). But, after the foundation had been adequately paved, then the DLMs were much more successful than lectures alone. According to Burgher, et al, (2015), "Results indicate that 72% of students receiving the hands-on DLM treatment thought it helped more than lecture; of those receiving lecture, 40% thought that it helped more than the DLM to learn heat transfer concepts. With respect to conceptual understanding, 72% of students agreed they understand and can apply principles related to heat exchangers well, with 28% unsure of their own conceptual understanding".

This article aligns nicely with our procedures, where we continue to use traditional lectures to transmit information to the control group, whereas the treatment group instead receives an initial, short lecture segment, quickly followed by guided hands-on learning experience, using the Leighton-Graham Method of planning and wiring electrical circuits.

Annotated Bibliography of New Article #2 of 13:

Pranab, R., Smadrita, B. et al, (2014) A novel wiring planning technique for optimum pin utilization in Digital Microfluidic Biochips. *IEEE Computer Society* for the 27th IEEE Conference on VLSI Design held in Mumbai, India, 510-515.

The paper from this IEEE Conference on VLSI Design includes major elements of wire planning techniques needed to optimize interconnection wiring in digital electronic circuits. It is similar to the treatment to what we are proposing in our research study. While it is done on a micro-fluidic droplet basis, it can be scaled up to represent out topic, on a larger scale. Double-layer, dual wiring schemes are discussed via algorithms to develop a feasible wiring plan for a given circuit layout, enhance wire routing, and to optimize pin layouts for interconnection.

While much of the article is focused on applications of digital micro-electronics, the universal wire routing and planning can be transferred to the full-scale electrical circuits, such as we are proposing to optimize, using the Leighton-Graham Method of planning and wiring of electrical circuits. The algorithms are virtually the same, and the alternate wiring plans can also be applied to our treatment. This article further adds to the scaffold of supportive information mentioned in the previous Burgher article about the effectiveness of hands-on training experiences.

Annotated Bibliography of New Article #3 of 13:

Hightower, D. W., (1974) The interconnection Problem: A Tutorial. *Computer 7(4)* 18-32.

This IEEE peer-reviewed article, on **The Interconnection Problem**, gives extensive information on interconnection problems and is still relevant today. It covers Pin Assignments, Wire List Determination, Spanning Trees, Layering, Ordering, Rectilinear Steiner Trees, and Wire Layout. We need to cover many of those topics in our guided experiential learning methods of instruction for teaching students how to wire electrical systems. It covers several new ideas that are presented and could provide for better wire layout, including algorithms for better accomplishing wiring tasks, with diagrams and examples. These are well presented and easy to understand. The references also include a large body of supporting information, which is closely related to our research. But, wiring is usually only taught in university engineering settings. So, it would seem to be badly needed at the community college level, for technicians and maintenance personnel who may never attend an engineering university. This runs parallel to our contention that the teaching of planning and wiring of electrical systems is badly needed, and supports our Leighton-Graham Method, and ties nicely together with the other articles, but from a technological standpoint, rather than merely an educational one.

Annotated Bibliography of New Article #4 of 13:

Hyun, J., Ediger, R., & Lee, D. (2017). Students' Satisfaction on Their Learning Process in Active Learning and Traditional Classrooms. *International Journal of Teaching And Learning In Higher Education*, *29*(1), 108-118.

Active Learning Environments (ALEs) enhance student engagement and more effectively increase student performance than traditional lectures alone. But, changing modern classrooms to fit the needs of an Active Learning Environment is expensive. Education never seems to have a surplus of money with which to enhance programs that are perceived as already being successful. The authors ask what can be done in this regard, considering limited resource availability. The results of their study show that ALEs increase student satisfaction directly, and also serve to boost student learning, productivity, and retention positively.

Student satisfaction was not the goal that drove our use of hands-on guided learning, or the later performance testing in our study. But, it certainly helped the students to stay engaged. While student retention and completion rates are driving forces in most community colleges these days, the lack of hands-on active learning environments is slow to catch on, where traditional lecture-based instruction is still the norm for teaching electrical and electronics theory. It is believed that hands-on learners demand more hands-on activities in programs where they want to remain loyal. So, the guided learning experiences of the Leighton-Graham Method of planning and wiring electrical circuits both satisfies our CTE hands-on learners, and engages them in their own natural learning styles, which makes the experience even more meaningful and memorable for them.

Annotated Bibliography of New Article #5 of 13:

Hunter, W. J. (2015). Teaching for Engagement: Part 3: Designing for Active Learning. *College Quarterly*, *18*(4).

This is the third part of three related articles about active learning in college. This article was chosen because it focused more on the classroom Active Learning Environment (ALE) than on Constructivism and Teaching Engagement, as did the first two. Here, Hunter outlined the theory behind his rationale an subsequent research, using case-based methods of teaching and problem learning, as he termed it. He went on to described means of facilitating contemporary technologies in traditional classrooms to support ALE. His questions were pragmatic regarding the implementation of ALEs in college courses. However, he left out a lot of the details regarding the transition from lecture-based teaching to ALE learning, especially for teachers who are used to the old ways. Herein, Hunter searched for answers about how to design and implement ALE in traditional classroom spaces.

Active Learning for CTE students means that hands-on activities will be included to both establish and maintain full engagement with these hands-on learners, but also so that true learning may begin through tactile feedback from the objects being manipulated. It is as though the devices are revealing their secrets to the learners via an immersive communications link, akin to telepathy for these learners—that is, experiential learning. Furthermore, the memory of first hand experiences such as these are more lasting and personally internalized by hands-on learners.

Annotated Bibliography of New Article #6 of 13:

Cattaneo, K. H. (2017). Telling Active Learning Pedagogies Apart: From Theory to Practice. *Journal of New Approaches in Educational Research*, *6*(2), 144-152.

Cattaneo said that active learning really starts with foggy definitions that are often confused, intertwined, and contested. His solution was to implement Project-Based Learning (PBL, not to be confused with problem-based learning) by converting theory into practice. He believes that inquiry and discovery are strong tools for learning that are rooted in student projects, where hands-on discovery learning, and experiential learning modalities naturally occur. He classified five ALE pedagogies that are based on six constructivist ideas, related to PBL. By comparative content analysis, the viability of adaption was made to sound very convincing. His goal was learner-centered teaching, using PBL in an ALE. One drawback that Cattaneo mentioned was a dissonance that made it difficult to differentiate the meanings and confused the terms, making it difficult to explain to college STEM program administrators. However problematic that might be, most students enjoyed PBL in the ALE. Students also believed that PBL in ALE would be more transferrable to other classroom and career environments, which spoke well of its acceptance. Employable skills are important to students and the relevance is not lost on them.

Annotated Bibliography of New Article #7 of 13:

Lawanto, O. & Santoso, H., (2012). Self-Regulated Learning Strategies of Engineering College Students While Learning Electric Circuit Concepts with Enhanced Guided Notes. *International Education Studies* 6(3) 2013 88-104.

Peer Review Journal Article

This peer-reviewed article discusses comparisons of traditional lectures with more student interaction during lectures. Researchers were also comparing traditional student note taking versus the newer enhanced guided notes (EGN) that were generated by the instructor. The students had to complete them during the lecture rather than generate all the notes themselves. This newer concept is part of the Self-Regulated Learning Strategies (SRL), that seem more effective today. Aside from the methods of teaching, and aides to assist the lecturer, there was also much discussion about methods and materials for conveying efficient and effective wiring methods, which is what we are after for our research study. They had 115 students start Fundamental Electronics for Engineers in Fall, 2011. Completing it were 97 students which were 87 males and 10 females. They did learn to interconnect circuits via wiring. Data collection and analysis began by using SRL survey questionnaires. Three exams and the final were also used to measure student performance. The analysis consisted of "descriptive statistics, parametric tests and cluster analysis." Interviews were also conducted, yielding some qualitative results at the end of the term. We can use portions of this study to enhance more effective methods of teaching wiring.

Annotated Bibliography of New Article #8 of 13:

Asunda, P. A. (2012). Standards for Technological Literacy and STEM Education Delivery Through Career and Technical Education Programs, *Journal of Technology Education (JTE) (23)2.*

This article focuses on STEM Literacy as the CTE cornerstone of our modern economy, and the skills needed to keep it growing, which is right on target for our research project. According to Asunda (2012), "Given the pressing needs for a high-quality STEM workforce in 21st century economies, proposals for science, technology, engineering, and mathematics are being developed to meet and create pathways to a wide range of interesting and exciting career opportunities." and, "At a minimum, employers rely on career and technical education (CTE) and workforce training systems to supply workers able to perform in their jobs

(Rojewski, 2002)." This amalgamation of forces seeks to apply STEM-literacy as a force driven by our government to keep our economy growing amid the mass retirements of Baby-Boomers who possess all the skills so desperately needed by our currently unprepared entry-level workers. This includes electrical circuit wiring skills. Even most of the electricians in our control group could not get their circuits wired successfully in a span of three hours, when only 17 wires were needed, according to the schematic diagram they were given. This points to a very real need for the Leighton-Graham Method of planning and wiring electrical circuits.

Annotated Bibliography of New Article #9 of 13:

Safadi, R., & Yerushalmi, E. (2014). Problem Solving vs. Troubleshooting Tasks: The Case of Sixth-Grade Students Studying Simple Electric Circuits. *International Journal of Science And Mathematics Education*, *12*(6), 1341-1366.

This article explored the comparison of troubleshooting (TS) and problem-solving (PS) tasks. It also explored the impact on student conceptual understanding. While the study involved two sixth-grade classes with the same teacher, it was adequate for our purposes in the use of the Leighton-Graham Method (LGM), because it was related to the conceptual understanding of electric circuits, related to troubleshooting (TS) and problem solving (PS). For those, it used comparative analysis techniques. The study found student performance on transfer problems was much higher for the TS class, especially for students with less prior knowledge. It described the research questions, the participants, exercises, the statistics, data analysis methods, and conclusion. It used pre-tests and post-tests to capture much of the data, including self-reports. There were many goals and questions being sought in this study, none of which seemed particularly relevant to what we need to know for our study. But, the methods were similar with what we may use to answer parallel questions, with any age-group, regarding basic electrical circuit wiring.

It discussed the concept difficulties in elementary children when it came to simple electric circuits. This points out a need for the LGM to simplify it, so that it does not take an expert to be able to troubleshoot and repair a circuit fault. The implications of this article support the fact that the LGM is needed, and can improve the ability of students, and professionals, for that matter, to troubleshoot wiring errors by following the rules of our technology. While this article discussed troubleshooting and problem solving in a different context than we intend to use, it is still significant that low-levels of understanding are all that are needed to be successful with LGM. Even sixth graders can be taught to be successful in TS and PS.

Annotated Bibliography of New Article #10 of 13:

Sokoloff, D. R. (2016). Active Learning Strategies for Introductory Light and Optics. *Physics Teacher*, *54*(1), 18-23.

In this article, Sokoloff contended that there was an abundance of evidence to support the idea that traditional lecture-base teaching methods were not effective at teaching concepts of the physical sciences. Electricity and Electronics falls into that domain, and so does wiring, for that matter. The major focus of the work in this study was interactive lecture demonstrations, which is how our LGM works, in teaching planning and wiring. But, instead of Interactive Lecture Demonstrations (ILDs), in work-groups, as this article suggests, it would be more desirable to have individuals replicating our behaviors to accomplish the training objectives. However, the use of ILDs in groups is acceptable as part of a holistic plan that includes a mix of both groups and individuals. Sokoloff (2016) enumerated three steps in his process: “(1) use of a learning cycle in which students are challenged to compare predictions--discussed with their peers in small groups--to observations of the physical world; (2) use of guided hands-on work to construct basic concepts from observations; and (3) use of computer-based tools." We would merge their Real-Time Physics (RTP) Labs with ILDs, and omit his step-1, and focus mainly on step-2, while supporting the use of step-3, in the form of our pre-written Excel spreadsheet templates for Wire-listing and Translation-Matrices, as needed. This would work along with the use of a Computer Aided Design (CAD) program for drawing the node-layout of our method. The key to both this article, and our LGM to teach the planning and wiring of electrical circuits is to stress ILDs of guided hands-on work in the planning and construction of working electrical circuits. Sokoloff contends that there are over 200 physics departments in the U.S. that are using RTP and ILDs to more effectively teach physics students. The same can be done with LGM in planning and wiring.

Annotated Bibliography of New Article #11 of 13:

Liu, H., & Su, I. (2011). Learning Residential Electrical Wiring through Computer Simulation: The Impact of Computer-Based Learning Environments on Student Achievement and Cognitive Load. *British Journal of Educational Technology*, *42*(4), 598-607.

This article indicates that computer simulations are widely used as tools to support science learning, but not for teaching wiring practices. This study focused on computer simulations to teach residential electrical wiring. It was intended to determine if computer simulations taught residential electrical wiring better than traditional Face-to-Face (F2F) classroom environment. It was a quasiexperiment employed with 169 high school students. The treatment group experienced simulations, but the control group had only lectures and demonstrations from their teacher. It also measured cognitive loading on students, which showed that it was elevated by multimedia tasks, as compared to the traditional approach for learning residential wiring. It turned out that statistics demonstrated that the simulation group had better learning and higher cognitive load and higher efficiency than the control group, as well as scoring higher on achievement tests.

While this study focused on computer simulations, these lessons could also include computer applications to streamline the planning and execution of wiring via Excel and Word charts that could accomplish the same results, using our proposed LGM. Either computer applications, or traditional F2F lectures, could be employed with our materials for teaching wiring. While many of the cited references are old, they still establish the validity of tried and true methods of instruction and materials like those we propose for teaching wire-planning and execution. Other multimedia elements can also be employed to good effect, said the article.

The article also spoke of the small sample size, methodology, assessment instruments, treatment materials, and procedures. The duration of the study was 6 weeks, and 90 minutes per week of training in residential wiring on the computer simulator, or in the traditional F2F classroom environment. T-test data analysis provided statistics by methods indicated in the text. The results indicated no difference in the foundational electricity concepts testing of the treatment group versus the control group. But, there were significant differences in overall achievement on the residential wiring tests. Cognitive loading and instructional efficiency was much higher, and deemed to be beneficial for the simulation treatment group, as opposed to the control group. However, the virtualized environment of simulations may not offer real world choices to students that the traditional F2F environments might, where real components would be used. This is a weakness of this study that may not affect the results of our approach, because our LGM would utilize real electrical components and wiring. At the end of the article, the need for future studies was suggested.

Annotated Bibliography of New Article #12 of 13:

Gritzmann, P., Ritter, M., & Zuber, P. (2010). Optimal wire ordering and spacing in low power semiconductor design. *Mathematical Programming*, *121*(2), 201-220.

In its 21 pages, this article mentions that the key issue for integrated circuit (IC), semiconductors is the low power constraints owing to mandatory heat removal, reliability, and/or battery life specifications. Because power requirements are affected heavily by capacitances between adjacent wiring, optimal spacing and ordering of parallel traces (wires) is vital to the design of low power IC's. Optimal trace spacing represents a convex issue in optimization. Optimal trace ordering is combinatorial and related to the Minimum Hamilton Path issue, natural to IC design constraints. This relates to our LGM for circuit design, documentation, and wiring, and is fundamental to our research. We can use this for documenting optimal wiring, planning for execution of a wire plan, as well as for troubleshooting of an existing circuit that has failed. Our technological solutions can be scaled to work in microelectronics, full-sized electrical distribution rooms within industrial buildings, as well as residential wiring systems. This article begs for its applicability, even on the sub-micron level, in the production of integrated circuits, down to the 70-nanometer-scale. It also mentions the causes of power loss in IC's, and the related capacitive reactance between traces, and switching frequencies that affect it. It discusses optimal wire placement within the IC with formulas to describe optimal wire spacing to reduce inter-electrode capacitance. Minimum Hamilton Path routing and sequencing are described by algorithmic solutions to various configurations.

This paper admits being somewhat derivative, rather than completely original. It defines and describes algorithms for overcoming issues related to wire trace positions, spacing and sequencing. It mentions permutation networks to solve wiring problems in low power semiconductor IC fabrication planning. This will support our contention that the LGM can also work at the sub-micron level of IC planning and implementation, in addition to its applicability to the Macro-world of electronics and electrician devices, circuits, and application solutions.

Annotated Bibliography of New Article #13 of 13:

Herron, S., & Gopal, T. (2012). Pretest/Posttest Plus Prompts: Tools for Research and Evaluation. *Journal of Computers in Mathematics and Science Teaching*, *31*(2), 175-204.

This research study emphasized the need for biological researchers and educators to learn the new language of biology that embraces computer-based experiments. This study came from a summer series of bioinformatics workshops using biological information computing systems. It used pre-tests and post-tests related to the Human Genome Project and experiential learning and educator reflections. The goal was to ease the transition of educators into the area of computer-based experimentation, so they could have a more positive impact on their own students who would presumably also be involved with these methods and tools of guided inquiry and hands-on, problem-based learning with role-playing to teach bioinformatics. Even the scores of the teachers increased because of this training.

What really caught our attention during this literature review was the high degree of effectiveness cited in the area we also will be using—that is guided, hands-on, experiential learning with the Leighton-Graham Method (LGM) to teach wiring of electrical circuits. This encouraged us even before we began our Action Research project.