

## **Outreach & Education efforts to improve science literacy in Kentucky**

### **Designing and implementing 3 Dimensional educational content aligned to NGSS in a learning progression, middle to high school and college courses by using CURE/ALLURE/URE and ACURE with high schoolers, undergraduate and graduate students**

By Robin L. Cooper

The initial implementation of Next Generation Science Standards (NGSS) as part of the high school science curriculum resulted in severe angst for many teachers. They wondered how they were going to be supported in making the curricular and pedagogical shifts necessary to teach and assess in a 3 dimensional way. Fortunately, in Kentucky, the Partnership Institute for Math and Science Education (PIMSER) housed at Eastern Kentucky University (EKU) was able to provide the infrastructure support for many teachers from funded educational grants. A key to the success of the professional learning was the leadership team. The leadership team whose role was to design and lead the professional learning. The team was comprised of PIMSER master teachers in science, trained through a National Science Foundation Master Teacher project, and faculty at institutions of higher education from community colleges and universities.

As a professor, I have found the educational workshops a valuable experience because I learn so much about teaching from the master teachers and from the other teachers in the professional learning sessions. As a faculty member at a university in the life sciences, one is not necessarily encouraged to participate in workshops involving middle and high school teachers or volunteer time for activities because our priority is research, teaching and service obligations within the university. However, I have found, and encourage other faculty, to explore how your research aligns with the NGSS and explore how they can support classroom teachers and student learning. The efforts are maximized and the gains are spread out in various ways if one plans accordingly. This approach benefits the mission of the secondary institution (service to the community) and the individual faculty member with research productivity and teaching involvement.

In this note, I share some reminiscing and approaches I have used for consulting in workshops for middle/high school teachers and outreaching efforts as well as developing novel educational experiences for undergraduates and graduate students at a college level. This is a culmination of different activities over the past 23 years as a faculty member at the University of Kentucky (UK).

As with most parents, one only starts to get involved in the local school systems when their own children are involved. This was the case for me with my daughter's science fair projects which started in 4<sup>th</sup> grade and continued until she graduated high school. This led to developing the regional Central KY INTEL affiliated Science and

Engineering Fair which I directed for 5 years and then became more involved with the State INTEL Fair for a few years. During this time I met wonderful teachers across the state who asked me to come to their class rooms to talk about research or bring some hands on activities. In 2007 I was asked to help manage workshops with a middle and high school Community-Based Science Program lead by Dr. Carol Hanley (UK Agriculture) and a Science Alliance Program led by Dr. Kim Zeidler-Watters, Director of PIMSER. It was at this time, when conducting these workshops, that a seed was planted to construct activities for teachers that would support student learning of required standards but in a 3 Dimensional way. I was able to continue to beta test the curriculum with other teacher workshops I was being invited to participate and consult. With EKU's PIMSER and faculty in the College of Education Department of STEM at UK we developed a number of modules and presented them in workshops as well as implemented them in schools. A good degree of planning is needed to keep implementing new projects and to test them out prior to presenting in a workshop or a classroom. One cannot waste valuable time of teachers in their classrooms or during paid workshops. So, I started to use the undergraduates conducting experiential research for credit in my lab as developers of modules. This resulted in graduate students wanted to also be involved. Graduate students in my lab already knew it was a given to help mentor high school students and undergraduate projects in the lab as I made it part of their graduate training. A number of high school science projects have made it to INTEL and have placed in international competition. Well this turned out to be a good approach as everyone who participated benefited. In fact, the undergraduate who developed a fruit fly education module published the project as a 1<sup>st</sup> author along with collaborators in EKU's PIMSER.

*Potter, S., Krall, R.M., Mayo, S. Johnson, D., Zeidler-Watters, K., and Cooper, R.L. (2016). Population dynamics based on resource availability and founding effects: live and computational models. The American Biology Teacher 78(5): 396–403, ISSN 0002-7685*

Working with high school teachers (Ms. Anderson, Ms. Wilson, Ms. Holsinger) developing projects for their classrooms opened up the development of new experimental labs which are now published along with the teachers as authors:

*Holsinger, R.C., and Cooper, R.L. (2012). Effect of Environment and Modulators on Hindgut and Heart Function in Invertebrates: Crustaceans and Drosophila. Tested Studies for Laboratory Teaching, Volume 33 (K. McMahon, Editor). Proceedings of the 33rd Conference of the Association for Biology Laboratory Education (ABLE). <http://www.ableweb.org/volumes/vol-33/v33reprint.php?ch=7>*

*Titlow, J.S., Anderson H. and Cooper, R.L. (2014). Lights and Larvae: Using optogenetics to teach recombinant DNA and neurobiology. The Science Teacher, National Science Teacher Association, NSTA. 81(6):3-9. Cover of Issue*

Majeed, Z., Koch, F., Morgan, J., Anderson, H., Wilson, J., and Cooper, R.L. (2017) A novel educational module to teach neural circuits for college and high school students: NGSS-neurons, genetics, and selective stimulations. *F1000Research*. F1000Research: Immediate & Transparent Publishing for Life Scientists. F1000 Research Ltd, Middlesex House, 34-42 Cleveland St, London W1T 4LB, UK. <https://f1000research.com/articles/6-117/v1>

Numerous presentations at KSTA (KY Science Teachers Association) and NSTA (National Science Teachers Association) meetings have also been made with the various teachers from various counties across KY over the years.

Having teacher's direct highly motivated students to conduct research in my lab has not only benefited the high students but also my own graduate students and my research program. One high school student Clara de Castro even made 1<sup>st</sup> author on a publication which has had a great impact for the field in physiological research of *Drosophila* (fruit flies). She was also the presenting author at an international neuroscience meeting in Poland. (Below in bold are the high school students).

Dasari, S., Viele, K., **Turner, A.C.** and Cooper R.L. (2007) Influence of p-CPA and MDMA on physiology, development and behavior in *Drosophila melanogaster*. *European Journal of Neuroscience*. 26: 424–438.

**Cooper, A.S., Rymond, K.E.,** Ward, M.A., Bocook, E.L. and Cooper, R.L. (2009) Monitoring heart function in larval *Drosophila melanogaster* for physiological studies. *Journal of Visualized Experiments (JoVE)* 32: <http://www.jove.com/video/1596/monitoring-heart-function-larval-drosophila-melanogaster-for> ,

Chung, Y-S. **Cooper, R.M., Graff, J.** and Cooper, R.L. (2012) The acute and chronic effect of low temperature on survival, heart rate and neural function in crayfish (*Procambarus clarkii*) and prawn (*Macrobrachium rosenbergii*) species. *Open Journal of Molecular and Integrative Physiology* 2:75-86.

**de Castro, C.,** Titlow, J., Majeed, Z.R., and Cooper, R.L. (2014). Analysis of various physiological salines for heart rate, CNS function, and synaptic transmission at neuromuscular junctions in *Drosophila melanogaster* larvae. *Journal of Comparative Physiology A*. 200:83–92.

More recently I have even used high school students as well as other undergraduates to help develop laboratory projects for college class. In blending in undergraduates to develop teaching labs in which they know others will be using and having their photos or movies of them included in the content increased the care of the students in developing good exercises and protocols. So, now I saw the ability to use the outreaching with developing modules for the middle and high school teachers to then focus in developing more advanced ones for the college level. At a primary research institution one also has

to be careful to maintain a publication record. So with some forethought these educational modules were turned into peer reviewed publications with undergraduate, graduate and high school students as co-authors.

Cooper, A.S., and Cooper, R.L. (2009) Historical view and demonstration of physiology at the NMJ at the crayfish opener muscle. *Journal of Visualized Experiments (JoVE)*. JoVE. 33. <http://www.jove.com/index/details.stp?id=1595>; doi: 10.3791/1595.

Bierbower, S.M. and Cooper, R.L. (2009) Measures of heart and ventilatory rates in freely moving crayfish. *Journal of Visualized Experiments (JoVE)* 32: <http://www.jove.com/index/details.stp?id=1594>, doi: 10.3791/1594.

Cooper, A.S., Rymond, K.E., Ward, M.A., Bocook, E.L. and Cooper, R.L. (2009) Monitoring heart function in larval *Drosophila melanogaster* for physiological studies. *Journal of Visualized Experiments (JoVE)*. 32: <http://www.jove.com/index/details.stp?id=1596>,

Leksrisawat, B., Cooper, A.S., Gilberts, A.B. and Cooper, R.L. (2010) Response properties of muscle receptor organs in the crayfish abdomen: A student laboratory exercise in proprioception. *Journal of Visualized Experiments (JoVE)*. 45: <http://www.jove.com/index/details.stp?id=2323> doi:10.3791/2323

Wu, W.H. and Cooper, R.L. (2010) Physiological recordings of high and low output NMJs on the Crayfish leg extensor muscle. *Journal of Visualized Experiments (JoVE)*. Jove 45: <http://www.jove.com/index/details.stp?id=2319> , doi:10.3791/2319

Robinson, M.M., Martin, J.M., Atwood, H.L. and Cooper, R.L. (2011) Modeling biological membranes with circuit boards and measuring conduction velocity in axons: Student laboratory exercises. *Journal of Visualized Experiments (JoVE)*. Jove. 47: <http://www.jove.com/details.php?id=2325>, doi: 10.3791/2325

Cooper, A.S., Leksrisawat, B., Mercier, A.J., Gilberts, A.B. and Cooper, R.L. (2011) Physiological experimentations with the crayfish hindgut. *Journal of Visualized Experiments (JoVE)*. Jove 47: <http://www.jove.com/details.php?id=2324> doi: 10.3791/2324

Baierlein, B., Thurow, A.L., Atwood, H.L. and Cooper, R.L. (2011) Membrane potentials, synaptic responses, neuronal circuitry, neuromodulation and muscle histology using the crayfish: Student laboratory exercises. *Journal of Visualized Experiments (JoVE)*. Jove 47: <http://www.jove.com/Details.php?ID=2322> doi: 10.3791/2325,

Titlow, J., Majeed, Z.R., Nicholls, J.G. and Cooper, R.L. (2013). Identifiable neurons in the central nervous system of a leech via electrophysiology and morphology, sensory field maps in skin and synapse formation in culture: Student laboratory exercises. *Journal of Visualized Experiments (JoVE)*. (81), e50631, doi:10.3791/50631. Professional movie and peer reviewed

manuscript.<http://www.jove.com/video/50631/intracellular-recording-sensory-field-mapping-culturingidentified>

Titlow, J., Majeed, Z.R., Hartman, H.B., Burns, E., and Cooper, R.L. (2013). Neural Circuit Recording from an Intact Cockroach Nervous System. *Journal of Visualized Experiments (JoVE)*. (80), e51050, doi:10.3791/51050. Professional movie and peer reviewed manuscript. <http://www.jove.com/video/50584/neural-circuitrecording-from-an-intact-cockroach-nervoussystem>

Majeed, Z.R., Titlow, J., Hartman, H.B. and Cooper, R.L. (2013). Proprioception and tension receptors in crab limbs: Student laboratory exercises. *Journal of Visualized Experiments (JoVE)*. (80), e51050, doi:10.3791/51050 Professional movie and peer reviewed manuscript.

At the time I did not know having teams of undergraduates working on research and educational projects had special acronyms. These are now hot buzz words for universities promoting undergraduates to be more research involved. A course-based undergraduate research experience (CURE) and active-learning laboratory undergraduate research experience (ALLURE) as well as undergraduate research experience (URE) are a few of these terms.

All this effort in developing new labs, I later realized these lab become routine and needed some of the CURE experience. So, I thought why not turn some of the teaching lab experiences into authentic research projects. Which I now term **ACURE**. This is a benefit for the class as well as my own research interests. This past year I looked into where short semester long undergraduate class research projects could be published. Such undergraduate student based driven research projects can be submitted to journals such as IMPULSE (The Premier Undergraduate Neuroscience Journal. <https://impulse.appstate.edu/issues/2017>), American Journal of Undergraduate Research (AJUR) and BIOS by students. If the authentic research being addressed is substantial then even publishing in a research based journal while providing detailed methods can be an approach. Extreme care is needed to provide accuracy in student driven laboratories for data acquisition and analysis in primary research journals.

So this endeavor was just now undertaken and was successful with all the 16 undergraduate students and a TA as authors in a neurophysiology course producing five nice publications.

Dayaram, V., Malloy, C., Martha, S., Alvarez, B., Chukwudolue, I., Dabbain, N., D.mahmood, D., Goleva, S., Hickey, T., Ho, A., King, M., Kington, P., Mattingly, M., Potter, S., Simpson, L., Spence, A., Uradu, H., Van Doorn, J.L., and Cooper, R.L. (2017). Stretch activated channels in proprioceptive chordotonal organs of crab and crayfish are sensitive to Gd<sup>3+</sup> but not amiloride, ruthenium red or low pH. *IMPLUSE The Premier Undergraduate Neuroscience Journal*. <https://impulse.appstate.edu/issues/2017>

Dayaram, V., Malloy, C., Martha, S., Alvarez, B., Chukwudolue, I., Dabbain, N., D.mahmood, D., Goleva, S., Hickey, T., Ho, A., King, M., Kington, P., Mattingly, M., Potter, S., Simpson, L., Spence, A., Uradu, H., Van Doorn, J.L., and Cooper, R.L. (2017). The effect of CO<sub>2</sub>, intracellular pH and extracellular pH on mechanosensory proprioceptor responses in crayfish and crab. *American Journal of Undergraduate Research*. 14(3):85-99.

Malloy, C., Dayaram, V., Martha, S., Alvarez, B., Chukwudolue, I., Dabbain, N., D.mahmood, D., Goleva, S., Hickey, T., Ho, A., King, M., Kington, P., Mattingly, M., Potter, S., Simpson, L., Spence, A., Uradu, H., Van Doorn, J.L., Weineck, K. and Cooper, R.L. (2017). The effects of potassium and muscle homogenate on proprioceptive responses in crayfish and crab. *J. of Exp. Zoology*. 327(6):366–379.

Grau, E., Stanback, A.E., Bradley, A., Cantrell, D., Eversole, S., Grachen, C., Hall, K., Hawthorne, D., Kinmon, C., Ortiz Guerrero, P., Patel, B., Samuels, K., Suryadevara, C., Valdes, G., Wycoff, S., Cooper, R.L. (2018) Investigating the effects of homocysteine as a agonist on invertebrate glutamatergic synapses. *IMPLUSE The Premier Undergraduate Neuroscience Journal*. pp.1-12

Wycoff, S., Weineck, K., Conlin, S., Grau, E., Bradley, A., Cantrell, D., Eversole, S., Grachen, C., Hall, K., Hawthorne, D., Kinmon, C., Ortiz Guerrero, P., Patel, B., Samuels, K., Suryadevara, C., Valdes, G., Ray, A., Fleckenstein, L., Piana, E., Cooper, R.L. (2018) Investigating potential effects of clove oil (eugenol) in model crustaceans. *IMPLUSE* pp. 1-21

Newer projects with teams of undergraduates taking a joint research class for credit, so the university makes money and students get credit, are contributing to developing citizen science projects for the coming year where data will be shared via www and various classes around the world as well as with our own students analyzing raw data. This research is part of my own projects on synaptic transmission but can use others to help peer review data analysis so when publishing the findings we can state it was peer reviewed randomized data by many individuals without bias to the findings. So stay tune for the follow up on this adventure.

So where is this report going with this monolog of what could appear as self-inflation you are asking yourself? Well, the point I am making is being involved with outreaching with middle and high school teachers either by contacting them are even going to KSTA or NSTA meetings or participating the Science Education division of KAS can be a start of a wonderful adventure. If one plans carefully, high school and undergraduate students can be participants in developing educational modules to not only be used for outreaching or consulting with teacher workshops but for one's own courses within the university setting. Then you too can use the buzz words but don't forget the new one,

ACURE. Yes, think of productivity and tangible evidence to show the administrators you are contributing to the university's mission and the citizens of the world.

Acknowledgments: Thanks to PIMSER's Director, Dr. Kim Zeidler-Watters and Ms. Diane Johnson, PIMSER Master Teacher for editorial comments.

Web site with various middle and high school teacher ready modules as well as publications listed above.

<http://web.as.uky.edu/Biology/faculty/cooper/Teacher%20training.htm>