Collaborative Professional Development Improves High School Teachers' Knowledge of Invasive Species Ecology

Allison Schmidt
allisoncschmidt@ufl.edu

Dr. Kathryn Stofer
215 Rolfs Hall
PO Box 110540
Gainesville, FL 32611
352-273-3690
stofer@ufl.edu

Introduction

Due to a growing collection of research and terminology related to invasive species, teachers may find it difficult to strengthen their knowledge of the subject. However, invasive species can provide authentic, locally-relevant context for secondary agriscience students (Rivet et al., 2008). Ecologists recommend that teachers avoid certain terminology to enhance precision and reduce confusion in invasive species education (Iannone et al., 2020).

To assist teachers with issues-based education (Thoron et al., 2016), we created a collaborative workshop (Desimone, 2009) to renovate high school teachers' terminology, curriculum, and knowledge, with a goal of integrating recommended terminology into teacher lesson plans. We conducted three-day workshops at a public university in the southeastern United States during 2017, 2018, and 2019 for a total of 36 teachers. The workshops, taught by ecology and education researchers, consisted of information sessions focused on university research and collaborative sessions to modify existing curricula.

Framework and Research Questions

Before and after the workshops, teachers constructed personal meaning maps (PMMs) (Falk et al., 1998), a post-positivist knowledge assessment designed to help understand changes among teachers with varying background in a topic. We developed three primary research questions: How did teachers' use of precise scientific terminology change? How did teachers' knowledge change based on extent of nodes (number of nodes, nodes per map, number of words, words per map)? How did teachers' knowledge change based on themes present in their maps?

Methodology

PMMs consisted of individual concepts surrounding invasive species, *nodes,* and the words and phrases that connect nodes, called *links*. We analyzed teachers' terminology through their use of designated precise and imprecise terms based on Iannone et al. (2020). The list of precise terminology consists of seven terms: *native, nonnative*, *introduced*, *established*, *invasive*, *nuisance*, *range change*. Imprecise terms include: *native invasive*, *invasive exotic*, *invasive weed*, *alien*, *foreign*, and *nonindigenous*. Author 1 counted each use of said terms for further analysis. Author 1 performed two-tailed Wilcoxon signed rank tests in Microsoft Excel for all quantitative analyses as listed in Table 1.

Author 1 used qualitative analysis to categorize pre-workshop and post-workshop PMM nodes into codes and central themes. Authors 1 and 2 created a codebook together where we matched codes to terms and drew definitions from the EcoCore ecology database in OntoBee (Xiang et al., 2011). Author 1 then grouped codes into larger themes, reviewing themes with Author 2. Thirty-seven codes formed 10 themes: *organisms*, *qualities*, *causes*, *effects*, *management*, *environment*, *ecology*, *biology*, *intention*, and *other*.

Results

Our first research objective was to determine how the teachers' use of scientific terminology changed from pre- to post-workshop. Teachers used more precise than imprecise terminology pre-workshop, but we did not have enough data for statistical analysis. We found the teachers used significantly more precise than imprecise terms post-workshop. See Table 1. In addressing our second research objective, we found not only did teachers increase their use of precise terms, but they used significantly more words overall in the post-workshop maps. The number of nodes and words increased post-workshop. The number of nodes per map and words per map increased significantly post-workshop. See Table 2. Our final research objective was to determine how the workshop changed the teachers' knowledge based on the themes their maps comprised. The nodes per theme and words per theme increased significantly post-workshop, as

did the average nodes and average words per theme. Maps most frequently had themes of *organisms*, *qualities*, *effects*, and *management* both before and after the workshops. See Table 3.

Table 1.
Terminology Analyses

Test	Total Nodes Variable 1[1]	Total Nodes Variable 2	Test statistic	Direction
Precise: pre[1] vs post	56	81	N/A[2]	
Imprecise: pre vs post	0	1	N/A	
Pre: precise vs imprecise	67	0	N/A	
Post: precise vs imprecise	88	1	0*	Precise is higher

Note. [1]. Variable 1 is listed first in the Test column [2]. N/A = not enough data for statistical analysis. *Significant at $\alpha = 0.1$

Table 2.
Map Size Analyses

Test	Total Nodes Variable 1[1]	Total Nodes Variable 2	Test statistic	Direction
Nodes per map: pre[1] vs post	756	1049	195*	Post is higher
Words per map: pre vs post	1330	1817	195*	Post is higher

Note. [1] Variable 1 is listed first in the Test column. *Significant at $\alpha = 0.05$

Table 3.
Theme Analyses

Test	Total Nodes Variable 1[1]	Total Nodes Variable 2	Test statistic	Direction
Nodes per theme: pre[1] vs post	780	1046	8	
Words per theme: pre vs post	1403	1836	8	
Average nodes/theme: pre vs post	23.57	29.56	8*	Post is higher
Average words/theme: pre vs post	41.04	51.79	5*	Post is higher

Notes. [1] Variable 1 is listed first in the Test column, *Significant at $\alpha = 0.05$

Conclusion and Recommendations

Our results suggest that the workshops did increase teachers' knowledge of invasive species ecology post-workshop because of the significant increase in precise terminology, average nodes per map, words per map, average words per theme, and average nodes per theme. Map size increases, or larger maps in terms of nodes or words, indicate that teachers relayed more information about invasive species ecology post-workshop. More nodes and words per theme indicated greater depth of knowledge. Collaborative professional development does not have to come at the expense of content improvement for teachers.

Although teachers used significantly more precise terms in the post-workshop maps, a larger sample size would give us stronger results. Future studies could also benefit from more geographically diverse groups of teachers, particularly for studying the effects on terminology.

Next we will analyze specific themes and theme variety that teachers used to determine what kind of knowledge they gained through the workshops. In future studies we could analyze students' invasive species terminology after lessons from teachers who attend such workshops.

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