Changes in Middle School Teachers' Thinking after Engaging in Professional Development Emphasizing Computer Vision

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Abstract:

As part of a professional development experience, inservice teachers were provided with lessons and activities emphasizing computer vision. Lessons focused on image processing, machine learning for visual data, and applications in robotics and visual media. Personal Construct Theory (Kelly, 1955) was used to answer the following research question: After middle school teachers engaged in professional development emphasizing computer vision, what changes in thinking occurred in relation to computer vision? Results showed changes in thinking in the form of a more refined understanding of computer vision and its role in STEM education.

Keywords: computer vision, inservice teachers, Personal Construct Theory

Overview

Computer vision is a ubiquitous technology underlying self-driving cars, social media, and medical imaging. This field utilizes engineering and computer science, especially artificial intelligence (AI), to help computers automatically understand and extract information from digital images/video to perform tasks such as object identification, detection/tracking, and 3D reconstruction (Szeliski, 2010). Recently, computer vision has been the focus of AI teaching in grades K-12 as the AI4K12 organization's Big Idea #1: Perception (Touretzky et al., 2019). However, there are several challenges with incorporating AI education, particularly computer vision, into the K-12 grade levels. These topics are typically studied at a graduate or advanced undergraduate level in computer science and engineering majors, and most teachers have little to no exposure in their career. Further, AI and computer vision requires technological tools and resources including computer programming and access to digital images and video which might not be accessible for a classroom.

The ImageSTEAM program is a set of professional development (PD) workshops for middle school teachers to prepare them to introduce topics surrounding computer vision and artificial intelligence into their classrooms. Similar workshops that have been conducted for the middle school students showed that such experiences can support students' engagement and conceptual learning of AI, shifting attitudes toward AI, and fostering conceptions of future selves as AI-enabled workers (Lee et al., 2021). In the ImageSTEAM program for 3 to 4 weeks, teachers co-created curriculum with research experts, and tested this new curriculum with middle school students in online classroom settings during the workshop. Technological experiences included using several websites such as Pixlr, Google Colaboratory, and NVIDIA's GauGAN software that is readily accessible to illustrate several computer vision concepts. Education research was conducted to test the efficacy of this PD. The research question for this research was: After middle school teachers engaged in professional development emphasizing computer vision, what changes in thinking occurred in relation to computer vision?

Methods

This research was conducted across two United States universities, one university was located in the south and the other in the southwest. Six participants from each university participated in the PD, all agreed to participate in the study. Of those 12, eight completed all data collection components of the repertory grid used to create the repertory grids.

Data were collected and evaluated following Personal Construct Theory techniques (Beail, 1985; Kelly, 1955). First, we defined various elements. Here, we focus solely on computer vision. Second, pairwise comparisons were completed by the participants to elicit the constructs. The participants were asked to compare elements using pairwise comparisons. For example, they were asked, "How are middle school lessons that use artificial intelligence similar to lessons that are STEM based? How are they different?" Third, a repertory grid was created that two researchers created using the participants' responses to the pairwise comparisons. Fourth, the results of the repertory grid were used to create a dendrogram the encompassed all participants' (n = 8) grid scores. Fifth, hierarchical cluster analysis resulted in clusters within each dendrogram.

Results/Discussion

Results indicated that participants demonstrated a more refined definition and perception of computer vision. There were changes in thinking, as mapped in the dendrogram. The constructs that were identified are seen in Table 1 including the labels that were used in the dendrograms. Figure 1 highlights the pre-PD dendrogram. Figure 2 highlights the post-PD dendrogram. There were four clusters pre-PD as well as post-PD. However, these clusters became more defined as indicated by the dendrograms and the means and standard deviations. The pre-PD dendrogram showed more distance between clusters, while the post-PD highlighted more similarity across clusters (in other words, the post-PD clusters were closer in terms of Euclidian distance). There were shifts in construct membership across clusters. Table 2 highlights the changes in mean and standard deviation across clusters. The results showed increases in means across all four clusters and decreases in standard deviations.

Table 1

Constructs Ranked by Participants

Label	Construct
Q6_1	Acquire knowledge through experience in the form of past data
Q6_2	Are biased
Q6_3	Can adapt and learn just like a human can
Q6_4	Can be integrated into science and mathematics
Q6_5	Can be used to enrich the lives of students
Q6_6	Can be used to personalize a student's learning experience
Q6_7	Connect to real world issues
Q6_8	Emphasize problem solving
Q6_9	Empower students to learn via experiments
Q6_10	Encourage collaboration among schools and others
Q6_11	Encourage students to develop their creative and intellectual potential
Q6_12	Engage students
Q6_13	Identify errors that are analyzed and corrected
Q6_14	Include gray areas with lots of subjective opinions
Q6_15	Incorporate computer use/computer programming
Q6_16	Involve critical thinking
Q6_17	Will only do what a programmer tells it to do

Figure 1
Pre-PD Dendrogram showing Changes in Thinking

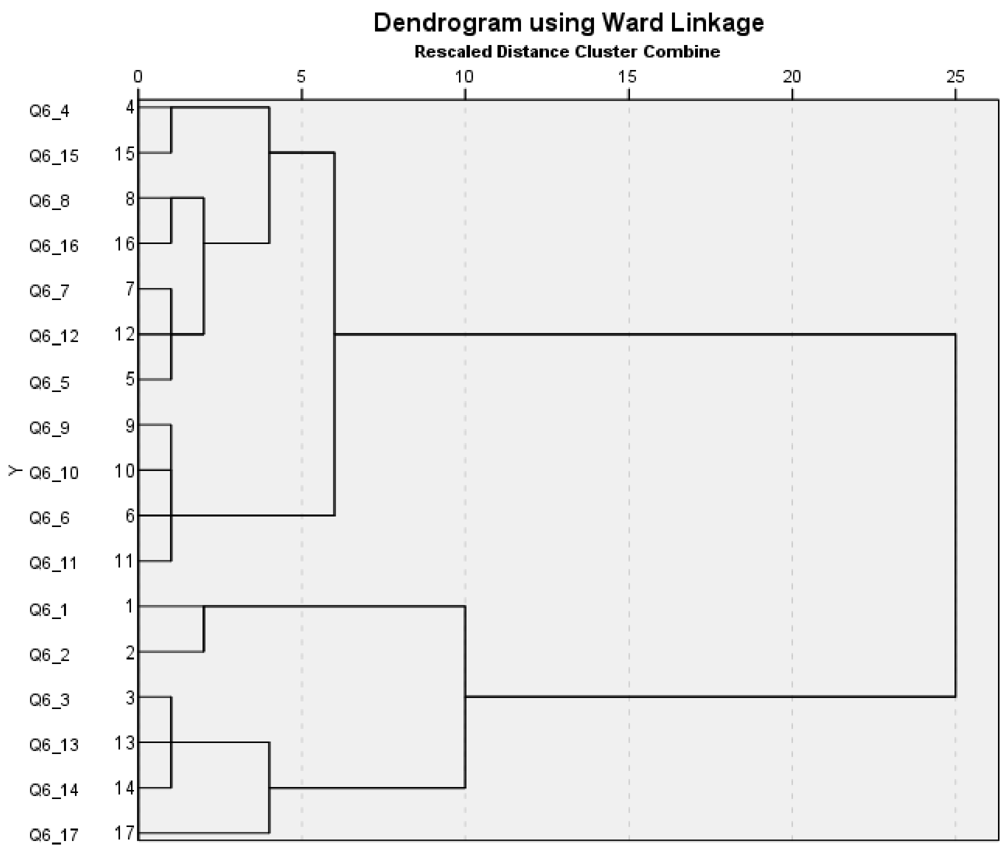

Figure 2
Post-PD Dendrogram showing Changes in Thinking

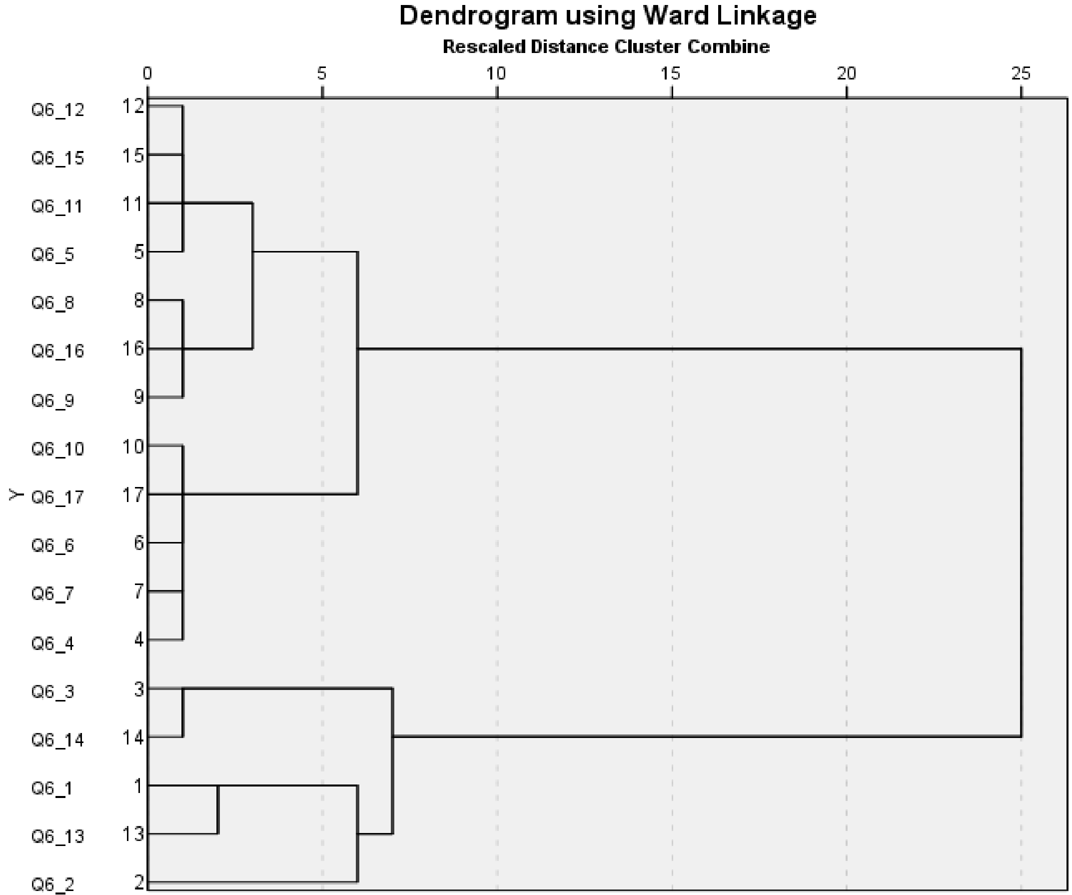

Table 2
Constructs in each Clusters within each Dendrogram

	Pre-exposure			Post-exposure		
	Constructs	*M*	*SD*	Constructs	*M*	*SD*
Cluster 1	4, 15, 8, 16, 7, 12, 5	4.24	.80	12, 15, 11, 5, 8, 16, 9	4.73	.43
Cluster 2	9, 10, 6, 11	4.04	.82	10, 17, 6, 7, 4	4.58	.49
Cluster 3	1, 2	3.06	1.08	3, 14	4.01	.67
Cluster 4	3, 13, 14, 17	3.44	.68	1, 13, 2	3.88	.69

Conclusion

After participating in PD designed to emphasize computer vision, inservice STEM teachers showed improved understanding of computer vision as evidenced by hierarchical cluster analysis. This was also observed informally by the researchers in conversation with the teachers. As the ImageSTEAM program proceeded, teachers were more confident and assured in their opinions and contributions to the co-created curriculum. However, there are still remaining challenges to incorporating this classroom into the main classroom, as teachers did not yet indicate a willingness to change their lesson plans permanently (although this requires further development and research).

PD that focuses on computer vision has the potential to help teachers gain awareness of the features (constructs) of computer vision. As AI becomes more central to STEM education in grades K-12, further opportunities for STEM teachers to investigate computer vision and its application in the classroom will be invaluable in the future. We hope that this research provides the first steps to understanding how such an integration can take place.

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