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THE TEACHERS' VOICE: FORMING A THEORETICAL FRAMEWORK COMBINING A PREKINDERGARTEN STEM CURRICULUM AND A LEARNING CURRICULUM

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Abstract: The purpose of this paper is to describe the use of the results of the photovoice evaluation of a robotics, programming, and problem solving curriculum to form a theoretical framework for the curriculum designed for 4- to 5-year-old children. Concept maps of the photovoice evaluation indicated that the teachers thought the most important themes of the 3-month project were when children were engaged, worked independently of the teachers and cooperatively with classmates, were persistent, learned academic knowledge and skills, and developed problem solving skills when using KIBO. A comparison of the project evaluation plan and the teachers' academics theme found that the evaluation plan predominantly assessed the teachers' statements about academics. Researchers reviewed the research bases of the remaining themes and used concept mapping to combine the new research bases with the academic knowledge and skills theme to form a theoretical framework for the project. The framework combined the robotics, programming, and problem solving curriculum and a learning curriculum emphasizing the development of children's productive dispositions towards learning. The addition of the learning curriculum reinforces that the key to successful implementation of this STEM initiative was the classroom teachers' integration of the RAPP lessons into the established prekindergarten curriculum within the morning center rotations. With the addition of the teachers' voice we can add a vibrant description of the learning curriculum rather than the short statement, *a positive, authentic classroom environment* that we now use. The discussion presents possible next steps and uses of the new theoretical framework for the robotics, programming, and problem solving curriculum.

1 Introduction

The purpose of this paper is to describe the formation of a theoretical framework that incorporates the results of the photovoice evaluation of the Robotics and Programming for Prekindergarten (RAPP) pilot project. RAPP is a series of lessons designed to introduce 4- to 5-year-old children to robotics, programming, and problem solving. Using photovoice enabled the researchers to hear the teachers' voice concerning the importance of their students' participation in RAPP activities. We first describe RAPP and the elements of the evaluation plan. The lessons provided activities designed to teach children about engineers, problem solving, and programing within the context of a positive, authentic classroom environment. The focus of this paper is limited to the five important themes resulting from the photovoice evaluation. Gaining greater insight from these results required that we dig deeper into the research bases of the four non-academic themes to establish a theoretical framework that incorporates all of the importance of RAPP identified in the photovoice evaluation. But first, we briefly describe the RAPP project, the participants, the complete extent of the evaluations, and the approach used to establish a theoretical framework incorporating the photovoice results and the relevance of that framework to the evaluation of future RAPP implementations.

2 Robotics, Programming, Problem Solving, and Evaluation

The purpose of RAPP was to develop and implement innovative STEM lessons for children in prekindergarten classrooms. Promoting science in prekindergarten prepares children for later science learning and is a developmentally appropriate endeavor that capitalizes on young children's natural curiosity (Bers, 2008). However, children's natural curiosity and intuitive sense of technology and engineering are rarely nurtured in typical prekindergarten classrooms. Moreover, the introduction of engineering and programming coupled with the use of robots helps children learn about abstract mathematics and science concepts in concrete ways and assists the development of children's technological fluency (Rogers & Portsmore, 2004). Children as young as 4-years old can understand programming rules and create commands for robots to follow. Moreover, programming directly relates to foundational concepts including patterns, sequencing, modularity, and cause-and-effect.

The RAPP research team selected KIBO, a robot developed at DevTech, Tufts University (Boston, Massachusetts, USA) and commercially available at KinderLab. KIBO is an interactive robot, designed specifically for 4- to 7-year olds, that uses programming blocks with bar codes and descriptions of their functions—icons for prereaders and words for readers. KIBO has an embedded bar code scanner that requires no screen interface. During the 3-month pilot project, three RAPP researchers designed and implemented 12 robotics and programming lessons and one concept-map-assisted review of the lessons in the participating classrooms. (See McLemore & Wehry, 2016 for more complete RAPP details and results from other evaluations.) The remainder of this section provides information about the RAPP participants and evaluations.

2.1 Prekindergarten and Preschool Participating Teachers

The RAPP pilot project involved developing, iteratively refining, and evaluating RAPP using a partnership between a university research team and six experienced prekindergarten teachers from three childcare centers located in an American urban area. All three childcare centers enrolled children from low-income families. In this area, the typical non-public-school-based childcare center teacher has no more than an Associate's Degree. During February 2016, the teachers attended a 3-hour professional development workshop designed to teach about KIBO and programming. Each attending teacher received a KIBO kit to use in her classroom.

2.2 *Evaluation*

The evaluation of RAPP includes data collected from the researchers, the participating teachers, and the children in the classes of the six teachers working directly with the researchers. A fuller description of the evaluation is included in Table 1.

2.3 *Photovoice*

Photovoice (photo voicing our individual and collective experience) is a highly flexible research methodology with roots in health education and community advocacy. The use of photovoice provides visual images as evidence and promotes participation as a means of sharing knowledge and experiences (Evans-Agnew & Rosemberg, 2016; Wang & Burris, 1997). As adapted for RAPP, photovoice is a process by which childcare center teachers with access to KIBO kits could identify, represent, and enhance their experiences through photographs of children learning by interacting with KIBO. Ten teachers, all female, participated in the photovoice evaluation: six prekindergarten teachers working with the researchers and four using KIBO without the researchers (including two working with children slightly younger than prekindergarten children).

As part of the photovoice evaluation, the RAPP research team asked teachers with KIBO to email two photographs per week (during 12 selected weeks) that they thought were most representative of importance relative to KIBO use in their classrooms. During the second full week in April after the children had completed six lessons, and after the third week of May when the children had completed all RAPP lessons including a concept-map-assisted review of all lessons, the researchers conducted discussions with each teacher using the pictures from the photograph submissions. The first step in the process, at both discussion times, involved asking the teacher to narrow the field by selecting the three most important pictures and then to discuss with her researcher why the selected pictures were the most important.

2.4 Using Concept Mapping to Organize and Present Knowledge

Coffey *et al* (2003) suggested that knowledge mapping, one purpose for using concept maps, is useful in recording both explicit and implicit knowledge. The implicit knowledge is knowledge that is held internally and, thus, not easily communicated. In using photovoice, researchers used photographs to elicit both types of knowledge from participants and concept mapping to organize their collective thinking. RAPP researchers also used concept mapping to form the framework for the photovoice results. Concept mapping is an efficient and effective way to organize and present knowledge. In fact, visual presentation of knowledge is often more concise and easily understood than text (Coffey, 2015).

2.5 Results

The steps in forming the summary of the researcher/teacher discussions included the summary of the discussions, the concept maps formed from the teachers' summaries, and a table of the concept map's propositions. The researcher who summarized the discussions concept mapped all ten transcripts in an effort to synchronize teachers' language across transcripts. For consistency, the first level of all concept maps was *Children* and the second level was *KIBO & Parts*. The listing of propositions function in the CmapTools helped identify similar language. The five themes that emerged from the teachers' conversations are shown in Figure 1. In order of importance to the teachers, the children:

Source	Measure	Frequency	Assesses
Researchers	R1. Lesson Rubrics (R1LR)	12 times	Immediate measure of learning objectives. For example, the number of children who could identify the *forward* and *shake* blocks and could identify the *begin* and *end* blocks at the end of lesson 4.
	R2. Reflection Notes (R2LN)	12 times	Used to rewrite curriculum as needed
Teachers	T1. Qualtrix Survey (T1QS)	Twice 3rd week in March & 2nd week in May (6 teachers)	Use of KIBO Student engagement when using KIBO Student interactions with KIBO affordances Students' happiness when doing RAPP activities Open-ended questions about the teachers' implementation of KIBO
	T2. Photovoice (T2PV)	Twice 2nd full week in April & 2nd week in May (10 teachers)	Results provided five themes about RAPP that the teachers thought were most important.
Students Children in the six classes of the teachers working with the researchers.	C1. Happy Bowls (C1HBa,b,c, d)	Twice 3rd week in March & 2nd week in May	Using 3-pt Likert scale (*not happy*, *happy*, & *very happy*) by placing a happy face bean bag in a small, medium, or large bowl to respond. a. How happy are you when you learn about engineers and what they do? b. How happy are you when you scan a program using KIBO? c. How happy are you when you see KIBO act out your program? d. How happy are you when you draw and write in your Engineering Journal?
	C2. KinderLab Challenges (C2KLa,b,c)	Twice 3rd week in March & 2nd week in May	Three challenges modified from KinderLab a. Assessing knowledge that a program must have a beginning and end. b. Assessing knowledge that other programming blocks go between the beginning and end blocks. c. A story presenting a problem for KIBO that the students must make and scan a program to solve.
	3. Child Interviews (C3CI)	Twice 2nd week in March & 2nd week in May (mostly in pairs)	Resulting concept maps and scores provided data used to evaluate increases in knowledge about problem solving and KIBO.
	4. BBCS-3:R scores (C4BBCS)	Twice Fall & spring of the school year	Scores from 12 RAPP children included in a random sample of children receiving state-subsidized childcare. Of particular interest were the gains in the Position/Direction and Time/Sequence scales.

Note. Text in parentheses represent acronyms that are used in the concept map presented in Figure 2. BBCS-3:R is the *Bracken Basic Concept Scale-Third Edition: Receptive*

Table 1: The evaluation plan for the spring 2016 RAPP implementation.

- Exhibit engagement,
- Work independently of the teacher and cooperatively with classmates,
- Persist when working with KIBO,
- Learn academic knowledge and skills, and
- Develop problem solving skills.

The photovoice evaluation provided valuable insight about RAPP because the list of important aspects of KIBO use was entirely generated by the teachers' voice. For the most part, their voice stems from their KIBO implementation, without the presence of the researchers, as they integrated RAPP into their morning instruction. The information provided from these entirely open-ended discussions is essential to further efforts to use robotics with prekindergarten children because it is bottom-up statements of importance from the teachers rather than top-down statements of importance and promise from researchers and policy makers.

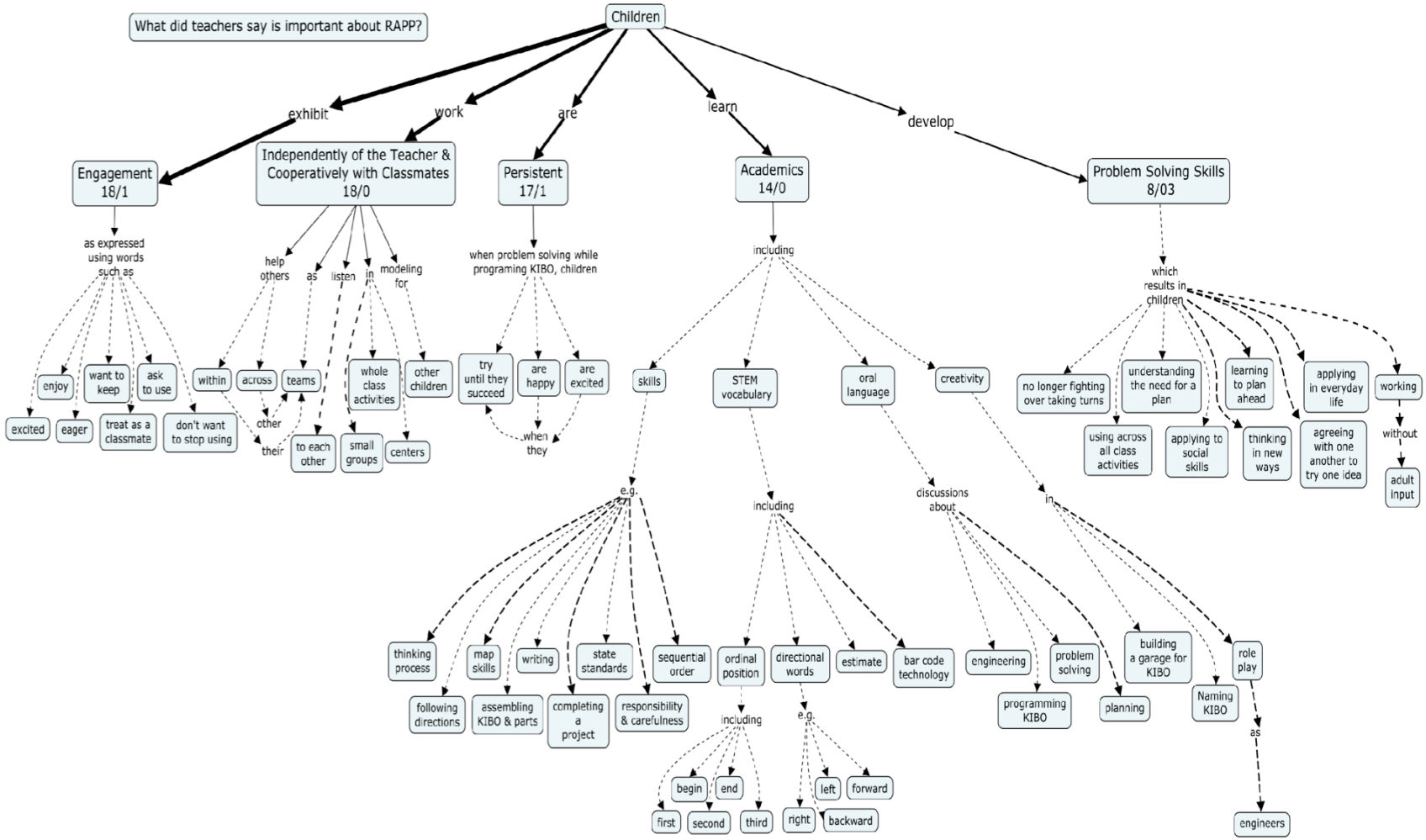

Figure 1: Concept map detailing what teachers most frequently indicated was most important to them in using KIBO. The concept most frequently mentioned, engagement, is on the left side of the map with the heaviest line. The first number under the concept indicates the number of teachers who explicitly mentioned the concept during both discussions, and the second number represents the number of teachers who implicitly acknowledged the concept during either discussion. Words that the teachers used during the first discussions are connected using a dotted line, and those mentioned only in the second discussion are connected using a bolded, dashed line.

The elements of the evaluation plan somewhat addressed children's engagement from both the teachers' and children's perspectives using Likert-type scales. However, the main focus was the academic content of the lessons. Thus, children being engaged, working independently of the teachers and cooperatively with their classmates, being persistent, and learning problem solving with transfers to other domains were not addressed.

3 Photovoice Results, the RAPP Evaluation, and the Theoretical Framework

The first step in making fuller sense of the photovoice findings is to match the academics branch of the concept map in Figure 1 to the evaluation elements detailed in Table 1 to make sure we did evaluate the academics that the teachers described as important. The final step is then to form the theoretical framework that incorporates all five of the teachers' themes.

3.1 Mapping RAPP Assessments to Photovoice Themes

The RAPP assessment plan includes qualitative data collected from the implementing researchers, childcare center teachers, and the children. These data include the researchers' lesson rubrics and reflections, teachers' Qualtrix survey results, and child happy bowl surveys. Quantitative data include children's KinderLab challenges; interviews, concept mapped and scored; and BBCS-3: R scores (Bracken, 2006). The evaluation plan directly addressed child engagement at the basic level using the Qualtrix teacher survey and the children's happy bowl assessment and indirectly through the researchers' lesson rubrics and reflection notes. The theme that one would expect the evaluation plan to address is the *Academics* theme, which 70% of the teachers mentioned at either one or both of the discussions. Figure 2 shows the relationship between the Academics theme and the RAPP evaluation.

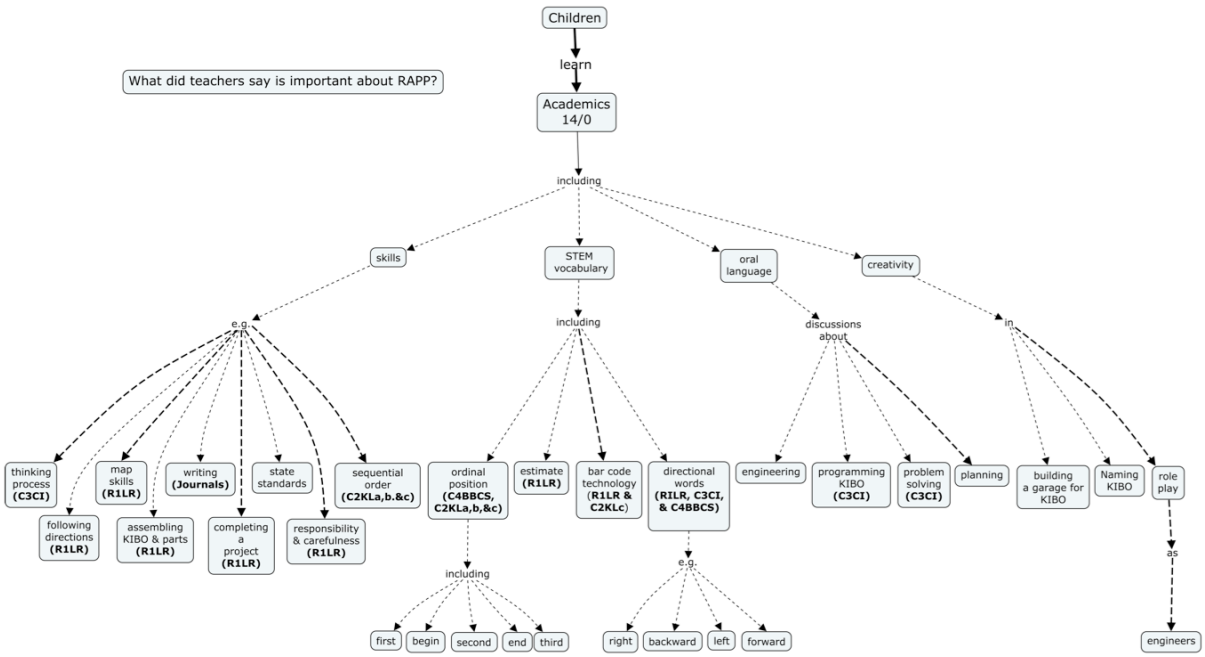

Figure 2: Concept mapping of the photovoice Academic theme and the RAPP evaluations. Words that the teachers used during the first discussions are connected using a dotted line, and those mentioned only in the second discussion are connected using a bolded, dashed line. Bolded text underneath the concept labels represent the part of the RAPP evaluation mapped. *Journals*, an assessment of writing, is the children's Engineering Design Journal which are not part of the RAPP assessment plan. The RAPP children were part of a larger project developed to encourage the development of young children's writing. RAPP participants, at the beginning of RAPP, changed the emphasis of their writing to engineering in their journals. At this time, those journals have not been evaluated, but when the writing project data are complete, the journal writing will be available as part of the RAPP evaluation elements.

As can be seen in Figure 2, most of the academic skills, STEM vocabulary, and oral language concept map branches link to some part of the evaluation plan. R1LR assessments can form an explicit or implicit link. For, example, 'map skills' were part of one of the later lessons in which the researchers provided a flip chart paper map (red tape marking a path with at least one right or left turn) with several locations (e. g., McDonalds, a gas station, and a playground), and a beginning point. The challenge was to program a trip for KIBO to the various locations. The challenge required multiple tasks including the ability to follow direction in understanding the challenge, understanding the representation on the map, completing the project through solving the identified

problem by forming a program with the correct sequence of block with debugging as needed. Thus, children who met the lesson objectives demonstrated a broad group of academic skills and knowledge.

In addition to these themes and assessments, statements from two of the prekindergarten teachers are very important to the purpose of this paper. We removed the words of the researcher for brevity and what is presented is in a narrative form rather than a discussion.

Researcher: Can you tell me anything about the impact that working with KIBO this year has had on student learning?

> First Discussion Early in the project, the children learned that engineers solve problems and to make sure that the class was using the '*Think*' [emphasis added] part of the Solve-It 4, I had them design a program without using the blocks but rather just the vocabulary words. (No help from the teacher.) The object was to make sure the children *thought the program out* [emphasis added] first. Then they created the program using the blocks. … The children learned to *think—the thought process* [emphasis added] and began transferring the process to everyday life problems. If they can't do something one way, then they *think* [emphasis added] of another.
>
> Second Discussion It's given them an opportunity to learn how to work independently and self-strategize—not always having somebody tell them what to do. They can plan for themselves. It's really helped in my classroom—KIBO and building partnerships with classmates as in working together, making a plan, following it, using someone else's suggestions and not always being a leader but learning how to work together in positive ways. The children are using the KIBO terminology throughout the day and they're always singing the little songs, and it reflects through different activities whether it's with LEGOs, or we're getting ready to do an illustration dictation. They are thinking ahead, and then they are planning and implementing. It has really shown up not only with KIBO but throughout other areas in the classroom … KIBO provides them a new opportunity. I don't think that many of them have ever been able to just take a piece of equipment like that and handle it so freely without a parent or adult saying, "oh no, that's wrong." They're able to work hands-on and create something on their own without so much direction from an adult.
>
> What KIBO has brought into my classroom is the integration of factors we hadn't really counted on—like using the vocabulary from KIBO lessons on engineering, problem solving, and programming. When the children start to argue on the playground, they use the strategies of problem solving from the KIBO lessons. So that has been very helpful in our regular curriculum.

The first teacher speaks to the issue of the children's thinking, *learning how to think*, as being very important to her. For many decades, educators have been criticized for producing graduates who know a lot of facts but cannot think. It was a pleasant surprise to hear this prekindergarten teacher express how important it is to her that the young children she teaches learn 'how to think'. The second teacher speaks of the children's unique opportunity to independently explore (without interference from adults) and learn with KIBO. These children frequently transfer KIBO learning, including problem solving skills, to other classroom experiences.

3.2 Theoretical Framework for the Photovoice Themes and the Robotics and Programming Project

The photovoice evaluation, and more specifically, the statements made by the two teachers whose narratives are provided above, led the RAPP research team to use the photovoice results to form a theoretical framework incorporating the teachers' voice. The framework would position the photovoice results in a broader knowledge structure than that provided by solely using the STEM, robotics, and early childhood education research bases.

The first step in the process was to search the existing research concerning engagement, persistence, working independently and cooperatively, and transfer of knowledge across domains of learning. In combining the old framework and the new findings, we realized that what the teachers voiced is a 'learning curriculum' in which students learn how to learn. The engaging robotics, programming, and problem solving academic curriculum occurs simultaneously with the learning curriculum which is centered on the goal of learners acquiring and continually developing productive dispositions towards learning—or children approaching learning *ready, willing, and able to learn*.

We placed the concepts from the learning curriculum and the academic parts of the RAPP curriculum in a concept mapping 'parking lot' and organized the concepts into the theoretical framework depicted in Figure 3. As can be seen, using robots and problem solving from the academic curriculum encourage the development of students' productive dispositions.

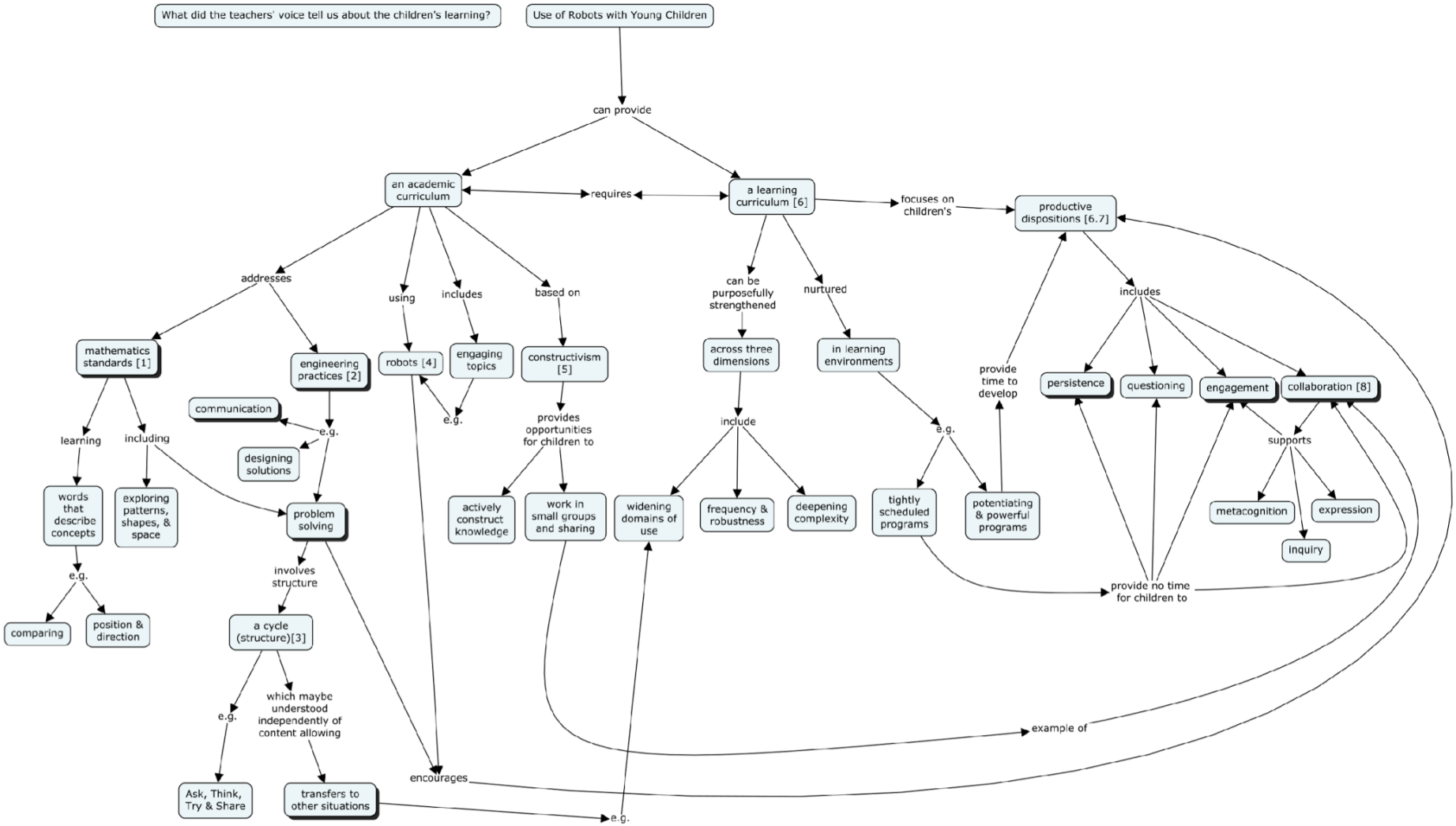

Figure 3: The theoretical framework for the five themes identified from the teachers' voice. The concepts with the dark shadows represent concepts directly linked to the concept map in Figure 1. The number in square brackets represent citations. [1] NCTM (2000), pp 73-143; [2] the NGSS Framework: Appendix 12 (2013); [3] Day & Goldstone (2012); [4] Toh et al. (2016); [5] Wheatley (1991); [6] Claxon & Carr (2009); [7] Sarama & Clements (2009); and [8] Finn & Zimmer (2012).

4 Discussion

While the RAPP researchers accomplished teaching the basic skills, the key to successful implementation of this STEM initiative was the classroom teachers' integration of the RAPP lessons into the established prekindergarten curriculum within the morning center rotations. The fact that the teachers chose to incorporate RAPP during the morning instruction is important because those are the hours funded by the state which emphasized literacy in the statutes creating the program. As soon as the program was created state prekindergarten standards were created. The state officers did not include engineering, robotics, or programming in the state standards. Given the perceived standards-based pressures, the RAPP teachers still acknowledged the benefits of implementing the RAPP lessons—most likely resulting from the tangible results of the learning curriculum—to exchange some of the existing lessons for the engineering, robotics, and programming lessons in their tightly scripted morning schedules.

The assessments, presented in Table 1, worked as intended and support each other to form a fairly complete evaluation of the RAPP lessons. RAPP researchers actually acknowledged the learning curriculum by using the phrase, *within the context of a positive, authentic classroom environment*, in the introduction to this paper and other publications. The photovoice results provided assessment of the learning curriculum as well as the academic curriculum. We certainly plan to modify the Qualtrix survey items and the happy bowl questions to include more items relative to the photovoice results. Also, we will continue to use photovoice as part of evaluations of future RAPP implementations as the research team adds more lessons and expands this 3-month curriculum to at least a 6-month curriculum. If future results obtained from different teachers in new settings produce similar results than the presented results and framework have greater validity.

We have no doubt that we will use this expanded theoretical framework in grant writing and discussions with policy makers. The photovoice results are very encouraging and the resulting framework provides us with a way to talk about the results within the research community and positions the project in a broader knowledge structure than that provided by solely using the STEM, robotics, and early childhood education research bases.

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References

Bers, M. (2008). Blocks to Robots: Learning with Technology in the Early Childhood Classroom. New York: Teacher's College Press.

Bracken, B. A. (2006). *Bracken Basic Concept Scale-Third Edition: Receptive*. San Antonio, TX: Harcourt Assessment, Inc.

Claxton, G., & Carr, M. (2009). A Framework for Teaching Learning: The dynamics of disposition. *Early Years, 24*(1) 87-97.

Coffey, J. W., Carnot, M. J., Feltovich, P. J., Feltovich, J., Hoffman, R. R., Cañas, A. J. & Novak, J. D. (2003). A Summary of Literature Pertaining to the Use of Concept Mapping Techniques and Technologies for Education and Performance Support. Technical Report submitted to the US Navy Chief of Naval Education and Training, Institute for Human and Machine Cognition, Pensacola, FL.

Coffey, J. W. (2015). Concept Mapping and Knowledge Modeling: A Multi-Disciplinary Educational, Informational, and Communication Technology. *Systemics, Cybernetics and Informatics 13*(6), 122-128.

Day, S. B., & Goldstone, R. L. (2012). The Import of Knowledge Export: Connecting Findings and Theories of Transfer of Learning. *Educational Psychologist, 47*(3), 153-176.

Evans-Agnew, R. A., & Rosemberg, M. S. (2016). Questioning Photovoice Research: Whose voice? *Qualitative Health Research 26*(1) 1-12.

Finn, J. D., & Zimmer, K. S. (2012). Student Engagement: What is it? Why does it Matter? In S. L. Christenson, A. L. Reschly, & C. Wylie, (Eds.). *Handbook of Research on Student Engagement*. Springer Science & Business Media.

McLemore, B., & Wehry, S. (2016). Robotics and programming in prekindergarten (RAPP): An innovative approach to introducing 4- and 5-year olds to robotics. In *Proceedings of Global Learn* 149-155. Association for the Advancement of Computing in Education.

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, by States: Appendix F*. Washington, DC: National Academies Press. http://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

Rogers, C., & Portsmore, M. (2004). Bringing Engineering to Elementary School. *Journal of STEM Education: Innovations and Research 5*(3), 17.

Sarama, J., & Clements, D. H. (2009). *Early Childhood Mathematics Research: Learning trajectories for Young Children.* Routledge: N. Y.

Toh, L. P. E., Causo, A., Tzuo, P. W., Chen, I. M., & Yco, S. H. (2016). A Review on the use of Robots in Education and Young Children. *Educational Technology & Society, 19*(2) 148-163.

Wang, C., & Burris, M. A. (1997). Photovoice: Concept, Methodology, and use for Participatory needs Assessment. *Health Education & Behavior 24*(3), 369-87.

Wheatley, G. H. (1991). Constructivist Perspectives on Science and Mathematics Learning. *Science Education 75*(1) 9-21.