PARTNERS IN INNOVATION: HELPING TEACHERS TO INTEGRATE TECHNOLOGY IN THE TEACHING OF STATISTICS[1]

Dani Ben-Zvi
University of Haifa, Israel

ABSTRACT

"Partners in Innovation" (PI) is an experimental approach and plan of action to support and empower teachers in integrating innovative technology in the teaching of statistics in primary school. PI was designed and implemented in the Connections Project during the last four years to overcome novice and experienced teachers' challenges in integrating innovative technology in the teaching of statistics (e.g., Davies, 2008) and to address current guidelines for teaching statistics (e.g., Franklin & Garfield, 2006). Three aspects of teachers' knowledge are taken into account in PI: content, pedagogical, and pedagogical-content knowledge. Technology is an important component in PI and in the expected change in the teaching and learning of statistics. In this presentation, a brief background on the Connections Project is first provided, followed by an account of the various technology-related components of PI: teachers' preparation and learning, ongoing partnership, technological support, tool selection, and scaffolding activities. A brief discussion of the PI approach and suggested research issues conclude this report.

THE CONNECTIONS PROJECT

In the *Connections* Project (grades 4–6, 2005–2008), the investigators, mathematics educators and statistics education researchers from the University of Haifa, worked with primary school mathematics teachers and students to trace students' evolving ideas of statistical reasoning within an empirical statistical enquiry cycle in a computerized learning environment. Students actively experienced some of the processes involved in experts' practice of data-based enquiry by working on data scenarios, investigated by peer collaboration and classroom discussions. The sixth grade learning trajectory (Gil & Ben-Zvi, 2007), for instance, provides ample opportunities for students throughout the 5weeks intervention to account for, describe and argue about sample variability, sampling bias, randomness, and sample representativeness as they make informal inferences about how these samples relate to the population from which they were drawn, and whether these samples lead them to infer claims about what that population might be. Students generate and (re)formulate the questions they wish to investigate about a population, (re)formulate hypotheses, analyze additional samples of data, interpret the results and draw conclusions about the population. A central feature of learning is the use of *TinkerPlots* (Konold & Miller, 2005), a statistical dynamic visualization tool that is designed to help students develop statistical reasoning and learn new ways of representing data and inferring meanings from them.

PARTNERS IN INNOVATION

PI is an experimental approach and plan of action, part of the *Connections* Project, aimed at supporting teachers in integrating technology in the teaching of statistics in the primary school. Helping teachers become partners in the implementation of an innovative curriculum is a challenging task that requires thoughtful and deliberate planning as well as creativity and enthusiasm (Garfield & Ben-Zvi, in press). *PI* is based on a comprehensive perception of teachers' role in the teaching of statistics that takes into account aspects of content, pedagogical, and pedagogical-content knowledge. The content aspect emphasizes Exploratory Data Analysis (e.g., Shaughnessy, Garfield, & Greer, 1996) and Informal Inferential Reasoning (Ben-Zvi, Gil,

---

[1] Ben-Zvi, D. (2008). Partners in innovation: Helping teachers to integrate technology in the teaching of statistics. In C. Batanero , G. Burrill, C. Reading & A. Rossman (Eds.), *Proceedings of the Joint ICMI /IASE Study on Statistics Education in School Mathematics: Challenges for Teaching and Teacher Education*. Monterrey, Mexico: ITESM.

& Apel, 2006). The pedagogical aspect emphasizes inquiry-based learning and collaborative learning (e.g., Roseth, Garfield, & Ben-Zvi, 2008). The pedagogical-content aspect refers to the understanding of how particular statistical topics or problems are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction (Shulman, 1987). The use of technology in *PI* is an important aspect of the suggested change in the teaching and learning of statistics, and is considered in this wider context. The following section provides several technology-related components of *PI* that are intended to improve the effective utilization of technology, teacher teaching and student learning of statistics.

Teachers' Preparation and Learning

Teachers in the *Connections* Project received only brief preparatory sessions beforehand, in which EDA and *TinkerPlots* were introduced by experts, and some of the data activities were experienced from student's perspective. The goals of these sessions were mainly to gain teachers' trust and agreement to become "*Partners in Innovation*", and excite them about the program and the technological tool. Teachers' training and learning occurred mostly during the actual implementation of the curriculum (on-the-job training). They observed experts modeling teaching in class, moderating a whole class discussion or orchestrating and providing support to students in the computer lab. Thus, experts' pedagogical knowledge and statistical reasoning and dispositions were made explicit to teachers. The teachers were also able to often discuss with the experts their own teaching experiences, students' difficulties and emerging statistical reasoning, and the use of the software. Teachers' learning and involvement were, therefore, reinforced by the ongoing active and multifaceted participation and coaching of experts in the classrooms and in after-class reflection and training discussions.

Ongoing Partnership

During the four-year implementation period of the *Connections* Project, ongoing cordial and professional relationships were developed and maintained between the teachers and the experts, which formed a community of practice[1]. A sense of ongoing partnership was constructed in multiple ways. The experts were attentive to teachers' technological and pedagogical challenges and enquiries and made them feel comfortable in negotiating their way with the new curriculum and technology. Teachers' feedback on how the activities were experienced by their students and what they thought needed to be changed was taken seriously and resulted often in a change of the activities or the way the software was used. Teachers appreciated experts' model teaching in class as described above. A variety of issues were discussed in frequent partners' (teacher-expert) meetings, such as, analysis options for certain types of data sets, less familiar software functions and their meanings to data organization and analysis, students' typical difficulties and misconceptions, innovative students' solution paths, and teaching methods.

Technological Support

Since technological failure is a major concern to many teachers, several avenues of support were readily provided to *PI* teachers. Experts helped teachers in computer lab tasks (e.g., students' file management), and in modeling how problems can be solved. They also provided on-demand and focused technological training. Teachers received additional support from a group of student assistants, who were trained to support younger peers in their use of *TinkerPlots*. This ongoing support, sense of partnership, and experts' enthusiasm and willingness to work shoulder to shoulder with the teachers, gradually made the teachers more confident and autonomous users of technology in their personal and professional life. The following excerpt, taken from an interview with the teacher M. at the end of her third year participation in the *Connections* Project, provides a window to this ongoing challenging process[2].

[2] The transcripts presented in this paper were translated from Hebrew.

> "… In general, every new technological tool seems threatening for me since I don't control it. When I am not in command of the tool, I feel less comfortable using it in front of a class. However, I can certainly attest that I made some progress with many computerized tasks [during my involvement in the *Connections* Project], but I'm still far from full control. The options provided by computers are endless, which is part of their attractiveness, but at the same time, a source of fear for me. I feel better to teach in the computer lab when an expert in technology is beside me."

Tool Selection

Choice of a particular technological tool should be made based on several features, such as ease of use, interactivity, dynamic linkages between data, graphs, and analyses, and portability. Good choices if used appropriately can enhance teachers' effective utilization of technology in the teaching of statistics, and enhance student collaboration and student-instructor interactions (Chance, Ben-Zvi, Garfield, & Medina, 2007). *TinkerPlots* (Konold & Miller, 2005) was selected as the key technology in the *Connections* Project not merely because it enables students to begin using it without knowledge of conventional graphs or different data types and without thinking in terms of variables or axes, but also because it supported teachers' smooth adaptivity to the tool. All teachers (as well as students) were provided with a copy of the software to install at home, which made it easier for them to prepare for class and gain confidence in using it. Teachers were relieved to observe how their students "dived" independently into utilizing the software. Although the teachers were slower than the students in acquiring creative and skilled use of *TinkerPlots*, they gradually became technologically fluent, as the teacher M. said in her interview.

> "Unlike any other software used in class, there is always a surprise factor in *TinkerPlots*. One never knows what to expect how students will use it and what graph will be seen on their monitor. The students are undoubtedly more adept than me, work faster with the software and know more how to solve technological bugs. However, I shall integrate *TinkerPlots* in all my current and future elementary classes, since I find this tool efficient, essential, and friendly, and I believe statistical literacy is important. I flow with this thought…"

Scaffolding Activities

Carefully designed instructional activities were used in the *Connections* Project to guide and scaffold student interactions with statistical ideas, statistical methods, and the software. They included hands-on experiences before using the computer, guided explorations of data in teams in the computer lab, whole-class discussion on computer output and students' investigations and informal inferences. Teachers prepared for class by using both student and instructor books and the software to help them provide appropriate technological and pedagogical support to their students. As they gained more confidence and fluency with the tool and the statistical language and reasoning, teachers encouraged students to conduct and make sense of their own open-ended explorations, with less guidance and structure, and thus turn their students to also become "*Partners in Innovation*".

DISCUSSION

As partners in the *Connections* Project team, the teachers had multiple roles, beyond traditional responsibilities of teachers. For example, the teachers observed their students' learning and emergent reasoning and discussed these observations in the team's meetings, in which selected learning situations were collaboratively analyzed and changes in the learning trajectory were offered. The open nature of the inquiry-based learning environment provided many opportunities for teachers and students to experience innovations, surprises, and uncertainty. Dealing with these challenging and unfamiliar situations was made easier for teachers by the readily-available supports and the innovative technology described above.

The *PI* approach provides an example how technology can give teachers license to experiment and tinker (Means and Olson, 1995). Teachers in the *Connections* Project were

stimulated to think about the processes of learning, whether through a fresh study of their own learning or a fresh perspective on students' learning. The barriers between what students, teachers and experts do were lowered with the use of an intuitive technology, the different supports provided to teachers, and the sense of partnership among the different team members. Time was an important factor in teachers' learning how to utilize technology, and extended periods of time for training and experimentation are recommended.

By pairing content area experts with "accomplished novices" whose area of expertise lies elsewhere – teaching mathematics –the circles of expertise in school were expanded: expertise not only in using technology for teaching, but also in content knowledge, pedagogical knowledge, and pedagogical-content knowledge. As these processes maturated, experts gradually faded out and a growing sense of autonomy and responsibility on the teachers' part became evident. The idiosyncratic circumstances of the *Connections* Project and the *PI* approach call for more studies on effective ways of empowering teachers' role in integrating technology into statistics courses in developing students' reasoning, and determining appropriate ways to assess the impact on student learning in these contexts.

NOTES

[1] The concept of a community of practice (often abbreviated as CoP) refers to the process of social learning that occurs when people who have a common interest in some subject or problem collaborate over an extended period to share ideas, find solutions, and build innovations.

[2] The teacher interviews are translated from Hebrew, therefore they may not sound as authentic as in the original.

REFERENCES

Ben-Zvi, D., Gil, E., & Apel, N. (2007). What is hidden beyond the data? Helping young students to reason and argue about some wider universe. In D. Pratt & J. Ainley (Eds.), *Reasoning about Informal Inferential Statistical Reasoning: A collection of current research studies*. Proceedings of the Fifth International Research Forum on Statistical Reasoning, Thinking, and Literacy (SRTL-5), University of Warwick, UK, August, 2007.

Chance, B., Ben-Zvi, D., Garfield, J., & Medina, E. (2007, October). The role of technology in improving student learning of statistics. *Technology Innovations in Statistics Education Journal, 1*(1). Retrieved April 12, 2008, from: http://repositories.cdlib.org/uclastat/cts/tise/vol1/iss1/art2/

Davies, N. (2008). Technology in the teaching of statistics: potentials and challenges in preparing the teachers. *Statistics Education in School Mathematics: Challenges for Teaching and Teacher Education*, Proceedings of the Joint ICME/IASE Study. Monterrey, Mexico: Instituto Tecnológico y de Estudios Superiores.

Franklin, C., & Garfield, J. (2006). The Guidelines for Assessment and Instruction in Statistics Education *(*GAISE) project: Developing statistics education guidelines for pre K-12 and college courses. In G.F. Burrill, (Ed.), *Thinking and reasoning about data and chance: Sixty-eighth NCTM Yearbook* (pp. 345–375). Reston, VA: NCTM.

Garfield, J., & Ben-Zvi, D. (in press). *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice*. Springer.

Gil, E., & Ben-Zvi, D. (2007). *Informal Statistical Inference: Data Analysis for Sixth Grade Using TinkerPlots – Student's Workbook* (Hebrew). Haifa, Israel: University of Haifa.

Konold, C., & Miller, C.D. (2005). *TinkerPlots: Dynamic Data Exploration* (Version 1.0) [Computer software]. Emeryville, CA: Key Curriculum Press.

Means, B., & Olson, K. (1995). Technology's role in student-centered classrooms. In H. Walberg and H. Waxman (Eds.), *New Directions for Research on Teaching* (pp.297–319). Berkeley, CA: McCutchan.

Roseth, C.J., Garfield, J.B., & Ben-Zvi, D. (2008). Collaboration in learning and teaching statistics. *Journal of Statistics Education, 16*(1). Retrieved April 12, 200s, from: http://www.amstat.org/publications/jse/v16n1/roseth.html

Shaughnessy, J.M., Garfield, J., & Greer, B. (1996). Data handling. In A.J. Bishop, K. Clements, C. Keitel, J. Kilpatrick & C. Laborde (Eds.), *International handbook of mathematics education* (Vol. 1, pp. 205-237). Dordrecht, Netherlands: Kluwer.

Shulman, L.S. (1986). Those who understand: Knowing growth in teaching. *Educational Researcher*, *5*(2), 4–14.