Knowledge Integration and
Inter-Disciplinary Communication in Action Research

Heidi Ann HAHN, Ph. D.
Engineering Sciences Directorate, Los Alamos National Laboratory
Los Alamos, NM, 87545, USA

ABSTRACT

In a plenary talk at WMSCI 2012 entitled "Planning for Action Research: Looking at Practice through a Different Lens," this author asserted that behavioral science practitioners, often "back into" action research – they start out doing a process improvement or intervention and discover something along the way, i.e., generalizable knowledge, that seems worthwhile to share with their community of practice. It was further asserted that, had the efforts been conceived of as research from the outset, the contributions to the body of knowledge would be more robust and the utility of the projects would improve as well. This paper continues on that theme.

Action research and process improvement methods are briefly described and compared. A comparison of two Los Alamos National Laboratory engineering ethics training projects – one developed using a process improvement framework, the other using an action research framework – is put forth to provide evidence that use of a research "lens" can enhance behavioral science interventions and the knowledge that may result from them. The linkage between the Specifying Learning and Diagnosing stages of the Action Research Cycle provides one mechanism for integrating the knowledge gained into the product or process being studied and should provide a reinforcing loop that leads to continual improvement.

The collaborative relationships among researchers and the individual, group, or organization that is the subject of the improvement opportunity (the "client"), who are likely from very different backgrounds, and the interpretive epistemology that are among the hallmarks of action research also contribute to the quality of the knowledge gained. This paper closes with a discussion of how Inter-Disciplinary Communication is embedded within the action research paradigm and how this likely also enriches the knowledge gained.

Keywords: Action Research, Process Improvement, Case Methods, Engineering Ethics

1. ACTION RESEARCH AND PROCESS IMPROVEMENT METHODS

Action research, as defined by Kock [1], simultaneously improves the subject of study and generates knowledge. The action research paradigm is used in evaluating social science interventions, such as educational initiatives, organizational development efforts, and behavioral health programs, or the effectiveness of changes to systems with humans in the loop, such as human-computer systems or enterprise business systems.

The classic Action Research Cycle put forward by Gerald Susman and Roger Evered in 1978 [2] is shown in Figure 1. It comprises five stages:

- Diagnosing – identifying improvement opportunity or a general problem to be solved
- Action Planning – considering alternative courses of action to attain the improvement or solve the problem
- Action Taking – selecting and implementing a course of action
- Evaluating – studying the outcomes of the selected course of action, and
- Specifying Learning – reviewing the outcomes of the evaluation stage and building knowledge by describing the situation under study

The output of Specifying Learning may lead to additional iterations of the cycle, serving as input to a new diagnosis.

One typical process or product improvement cycle is the PDCA or Plan-Do-Check-Act cycle that was derived from W. Edwards Deming's work [3] beginning in the early 1950's. As the name implies, the PDCA quality management cycle is a four-step process:

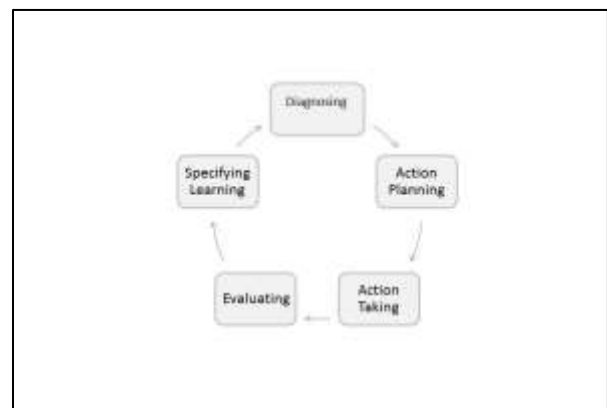- Plan – identify the targeted improvement and the expected output

Figure 1. The Action Research Cycle [2]

- Do – implement the change and collect data needed to confirm or refute the satisfaction of the expected output
- Check – compare the actual results collected in the Do step to the expected results
- Act – analyze the causes of differences between actual and expected results

Corrective actions may be requested, leading to another iteration through the PDCA cycle. Corrective actions most often take the form of additional improvements to the product or process under study, however, it is also possible that the goal state will need to be altered based upon improved information. Figure 2 provides a representation of the PDCA cycle.

Figure 2. The PDCA Cycle[1]

2. COMPARISON OF ACTION RESEARCH AND PROCESS IMPROVEMENT METHODS

On the surface, it appears that the primary difference between action research and process improvement is the inclusion in action research of the step "Specifying Learning." And, it is true that the PDCA cycle generally limits knowledge-sharing to the enterprise rather than contributing to the generalizable body of knowledge. However, the differences are actually deeper and more subtle than that.

Although both paradigms sound a lot like the scientific method, they are epistemologically different. The PDCA cycle is built on a positivist epistemology. Positivists generally assume that reality is objectively given and can be described by measurable properties that are independent of the researcher. Positivist research is characterized by formal propositions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from a sample to a stated population [4].

In contrast, action research reflects an interpretive epistemology. Interpretivists generally attempt to understand phenomena through the meanings that people assign to them. Interpretive

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[1] Attribution for Figure 2: By Karn-b - Karn G. Bulsuk (http://www.bulsuk.com). Originally published at http://www.bulsuk.com/2009/02/taking-first-step-with-pdca.html (Own work) [CC-BY-SA-3.0 (www.creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

research does not predefine dependent and independent variables, but focuses on making sense of emerging situations [5]. Generally, practice- or theory-based questions, rather than formal hypotheses, are used to guide the data collection and analysis.

This difference in perspective influences the types of data collected in the two paradigms. Generally, the data used in PDCA is quantitative and focused on attributes of the process or product. In action research, observation of participants, surveys, and interviews are the most common data collection methods. This is not to say that the methods are strictly limited to either quantitative or qualitative data. In PDCA, for example, qualitative assessments of the subjects' perceptions of the "goodness" of the process or product may also be performed. In action research, quantitative measures, such as throughput of an educational intervention, may supplement more subjective or qualitative metrics. But, the preponderance is toward quantitative data for PDCA and qualitative data for action research.

One final important difference between the two paradigms is with respect to the relationship between the researcher and the subjects of the study. A hallmark of action research is tight collaboration between the researcher and the individual, group, or organization that is the subject of the improvement opportunity (the "client"). This occurs in all steps, with the possible exception of Specifying Learning, which may be the sole responsibility of the researcher. In positivist research like PDCA, the practitioner is more likely a detached spectator, and the client is an object to study [2]; direct interaction with the subjects is usually limited or even non-existent.

3. ENGINEERING ETHICS TRAINING PROJECT OVERVIEW

In 2012, this author presented a paper [6] titled "Adapting the Case Model Approach for Delivery of Engineering Ethics Professional Development Units (PDUs)" describing how engineering ethics case studies were used to meet a need that members of the Los Alamos National Laboratory's (LANL's) workforce had to obtain professional development units for maintaining professional engineering licenses and other professional certifications.

A needs analysis conducted in accordance with the Systematic Approach to Training (SAT) [7] concluded that given the large target population (about 120) who need ethics PDUs on a biennial basis to meet New Mexico (NM) State licensing requirements and cost and logistical constraints related to LANL's remote geographical location, lack of vendor-provided training in the area, and the inability to tailor vendor-provided online training to incorporate LANL-specific requirements, in-house delivery of engineering-ethics training that could be used to fulfill PDU requirements was the preferred solution. Because of the recurring nature of the requirement and the static nature of the information (i.e., the core principles of engineering ethics are relatively constant), it was determined that workers should be exposed to an initial, in-depth training followed by annually updated refresher training (which is defined as a "short-term course aimed at recall and reinforcement of previously acquired knowledge and skills" [5]).

Developed in accordance with SAT [7], the initial training covers the elements of the NM *Code of Professional Conduct – Engineering and Surveying* (NMAC); ethical obligations to the engineering profession and other professionals; and various federal legal requirements, most especially export control law, that have the potential to impact the practice of engineering at the Laboratory. It has been delivered both in classroom and online settings. Although the initial training does incorporate some case-based "test your knowledge" exercises, it is primarily a lecture- or presentation-based pedagogical model.

Unlike general ethics courses, which are fairly flexible in the content they present in any given year, the content of the engineering ethics course is relatively static – for instance, the NMAC, which changes only infrequently, must be addressed each time. While the NM state requirements could have been met by having the target audience retake the initial training each year, this would not have been very satisfactory from the learner's point of view. This is especially true in light of the literature from the field of "androgogy," or the art of teaching adults, which suggests that lectures, and especially lectures in which the same information is repeated, may not be the ideal instructional model for adult learners [8]. Therefore, as the engineering ethics refresher training was being designed, other instructional designs were considered.

Case-based instruction was the preferred pedagogical model because it was seen as best meeting the needs of adult learners, as described by Knowles, Holton, and Swanson [8]. Online delivery was preferred to enable the greatest throughput, at the learners' convenience, and with the least cost. Because there was a concern about online delivery of cases not affording the richness of classroom discussion, the online cases were initially designed with branching, which enabled learners providing incorrect responses to explore the case further or to receive feedback as to why their selected response was not the best answer.

Both the initial training and the refresher were developed using a PDCA-like paradigm – the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model from the Systematic Approach to Training [7]. As a result of using a process improvement frame, the success metrics selected were all quantitative and were aimed at answering the questions of whether the intervention had been effective at delivering PDUs to the target audience and whether the training was good at transferring the knowledge. Participants were not surveyed about the efficacy of online delivery of case studies, so it was not possible to answer questions such as whether the trainees found the case method to be pedagogically more appealing than traditional lecture-based methods, as had been theorized, or whether the branching incorporated into the instructional design was an adequate surrogate for the feedback provided via dialogue in traditional face-to-face case methods.

In a keynote address entitled "Planning for Action Research: Looking at Practice through a Different Lens" delivered at WMSCI 2012 [9], this author speculated as to what the engineering ethics training project would have looked like had an action research lens been used instead of the PDCA paradigm, stating:

- The Diagnosis would have been the same – there was a need to provide PDUs for the target audience and to refresh trainees' knowledge on engineering ethics principles as a result of their experience with the intervention
- Action Planning and Action Taking would also have been the same – the literature on adult learning and cost and logistical requirements guided the choices
- Evaluation would have been different, as explicit consideration of the pedagogical value of the intervention would have been included
- As a result, Specifying Learning would have had added value in terms of the knowledge gained over and above that obtained when using a process improvement frame of reference

Because the need for delivery of engineering ethics PDUs is ongoing, this project provided a rare opportunity for a do-over. As described in the WMSCI 2014 *Proceedings* [10], the 2012 version of the engineering ethics case studies was designed incorporating an action research perspective from the outset. Both the intervention itself and the data collection scheme were modified. A moderated discussion board was included as part of the courseware in the hope of augmenting the richness of the case experience beyond what the branching used previously could provide. Data collection included some of the more qualitative measures suggested by the action research paradigm. In addition throughput and correct response rate data, formal participant reaction regarding the effectiveness and utility of the course, the effectiveness of case studies in meeting the needs of adult learners, and the value of the discussion board were also solicited. The survey used (see Figure 3) was a modified version of Thalheimer's learner survey [11]. Unlike many "smile sheets," which ask general questions about the learning experience, this survey format asks learners to respond to specific learning points covered in the learning intervention. The learning objectives for the refresher training were used as the key learning points to survey against.

Capturing data about the *value* of individual key concepts provides more meaningful information about changes that should be made in future learning interventions [11]. In addition to addressing general ratings, the evaluation form also asks two critical questions related to how likely the concepts learned will be utilized on the job and how likely the concepts will be shared with others. This provides information regarding whether the training is likely to have an impact where it was intended.

Modifications to Thalheimer's [11] basic structure included questions related to participant preferences regarding case-based learning as compared to other instructional methods along the andragogical factors suggested by Knowles [12] and questions related to the utilization and value of asynchronous discussion augmentation of the online cases. It was hoped that this would validate the conclusion that a case-based model is the most appropriate method for delivering the educational experience to an adult target population and to gauge the effectiveness of threaded dialogue in improving the richness of the learner's experience and the quality of the feedback provided.

Impressions of the Learning Experience for the Engineering Ethics Case Study Refresher	
Value of Specific Information	
Learning Concept	Circle ONE Number Below
Making better decisions when faced with ethics related situations.	1. Most people already know this. 2. I already use this concept regularly. 3. Provided a nice reminder. 4. Deepened earlier understanding. 5. Concept was new to me.
Being knowledgeable regarding the Rules of Professional Conduct that apply to Professional Engineers licensed in the state of New Mexico.	1. Most people already know this. 2. I already use this concept regularly. 3. Provided a nice reminder. 4. Deepened earlier understanding. 5. Concept was new to me.
Knowing how to identify and resolve business situations requiring ethical judgment.	1. Most people already know this. 2. I already use this concept regularly. 3. Provided a nice reminder. 4. Deepened earlier understanding. 5. Concept was new to me.
Knowing where to go to get help when I am unsure about my best could of action.	1. Most people already know this. 2. I already use this concept regularly. 3. Provided a nice reminder. 4. Deepened earlier understanding. 5. Concept was new to me.
Overall Ratings	
Rate the overall value of the learning experience. *(Circle ONE number to the right. Please don't circle the words.)*	Very Little Value 1 2 Average 3 4 Very Valuable 5
Rate the likelihood that you will use what you learned within the next two weeks. *(Circle ONE percentage to the right.)*	0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Rate the likelihood that you will share what you learned with a coworker or friend within the next two weeks. *(Circle ONE percentage to the right.)*	0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Overall Comments *(Provide specific comments on any aspect of the learning experience in the space below.)*	

Figure 3. Thalheimer's Basic Learner Survey

4. DIFFERENCES IN KNOWLEDGE GAINED USING A PROCESS IMPROVEMENT FRAME OF REFERENCE VERSUS AN ACTION RESEARCH FRAME

Learnings that would not have been available had a process improvement framework continued to be used were attained in each of the following areas: value of the information imparted, likely impact of the training, the effectiveness of case models in meeting the needs of adult learners, and value of the discussion board. (Results on the quantitative measures of throughput and retention are detailed in the WMSCI 2014 Proceedings paper [10] and will not be repeated here.)

Of the 59 trainees who took the 2012 refresher, 29 completed the survey, for a response rate of 49%. Table 1 shows the results regarding the value of specific information relative to the learning objectives. The most common response across all learning objectives was that the materials "provided a nice reminder." This result is not surprising given that the case studies were intended to refresh knowledge gained through prior training. The results on the questions related to the likely impact of the training were positive – trainees generally reported a high probability that they would use what they learned in their job

and that they would share what they had learned with their coworkers.

Learnings about the case method's support of adult learners are shown in Table 2. There were two adult learning principles for which the case method provided better support than presentation-based methods: the tendency toward movement from dependency upon an instructor to greater autonomy and self-directedness and the orientation toward learning as being problem-centered and contextual. The methods were viewed as equally supporting the remainder of Knowles' [12] principles by a plurality, if not a majority, of respondents. In no case was the presentation-based method of instruction viewed as best supporting the andragogical principles by a plurality of respondents. These results were somewhat surprising. It was thought that case methods would be seen as better supporting Knowles' principles related to incorporation of learners' experience bases and incorporation of the various roles that they had played in their professional lives, especially because the cases had been designed to allow the trainees to explore the cases from the point of view of involved workers, managers, and others. Comments on the case method received in response to an open-ended question were consistently positive:

TABLE 1. VALUE OF SPECIFIC INFORMATION

Learning Objective	Rating				
	Most people already know this	I already use these concepts regularly	Provided a nice reminder	Deepened earlier understanding	Concepts were new to me
Making better decisions when faced with ethics-related situations	3.6%	7.1%	57.1%	32.1%	0.0%
Being knowledgeable regarding the Rules of Professional Conduct that apply to Professional Engineers licensed in the State of New Mexico	3.4%	13.8%	41.4%	41.4%	0.0%
Knowing how to identify and resolve business situations requiring ethical judgment	3.4%	13.8%	48.3%	31.0%	3.4%
Knowing where to go to get help when I am unsure about my best course of action	0.0%	17.2%	41.4%	34.5%	6.9%

TABLE 2. RATINGS OF INSTRUCTIONAL DELIVERY METHODS

Adult Learning Instructional Design Principle	Rating		
	Most people already know this	I already use these concepts regularly	Better supported by presentation-based instruction
The need to know not only the subject matter, but also the why, what, and how underlying it	37.9%	44.8%	17.2%
The tendency toward movement from dependency upon an instructor to greater autonomy and self-directedness	58.6%	37.9%	3.4%
The need to incorporate the learner's experience base as an integral part of the instruction	37.9%	51.7%	10.3%
The orientation toward learning as being problem-centered and contextual	55.2%	37.9%	6.9%
The need to incorporate the various roles that the learners play/have played in their professional lives	41.4%	51.7%	6.9%
The basis of the learner's motivation being in the intrinsic value of the learning and personal pay-off	24.1%	69.0%	6.9%

"The case method puts a real world perspective on the lessons and, especially when consequences of failure to behave ethically are demonstrated, it makes the lesson have meaning."

"For this subject matter, case studies seem to be more meaningful."

The only negative comments received had to do with learners being uncomfortable with the lack of a definitively right or wrong answer for many of the scenarios:

"Ethics can be black/white, but sometimes it is gray (or striped or polka-dotted)... these gray areas are the hardest thing for engineers to come up with the 'right answer.'"

These were consistent with comments that had been received informally in prior years, including relative to the initial presentation-based training, and served to substantiate a hypothesis that the discomfort was due to the nature of the subject matter rather than an inherent weakness in the case method, as had been postulated by the Food and Agriculture Organization of the United Nations [13].

About 20% of survey respondents reported visiting the discussion board, and 100% of those who did visit rated the experience as being of average or greater value. But, not one of those who reported visiting actually contributed – all of the comments there were planted by the instructor. Based on the number of hits on the site it is clear that some trainees did visit, but they lurked.

Figure 4 shows that changes resulting from use of the action research frame of reference were more substantive than had been anticipated. Not only did the evaluation change, going even beyond what had been predicted, but diagnosing and action planning and action taking changed as well. And the result was, in fact, that the knowledge gained in specifying learning was far more robust than had been possible previously.

5. INTERDISCIPLINARY COMMUNICATION IN THE ENGINEERING ETHICS PROJECT

One important difference between the process improvement and action research paradigms is with respect to the relationship between the researcher and the subjects of the study, with action research being characterized by tight collaboration between the researcher and the client.

The engineering ethics project affords an opportunity to illustrate the differences in communication and involvement of the subjects in generating knowledge when a process improvement framework was used versus when an action research frame was employed.
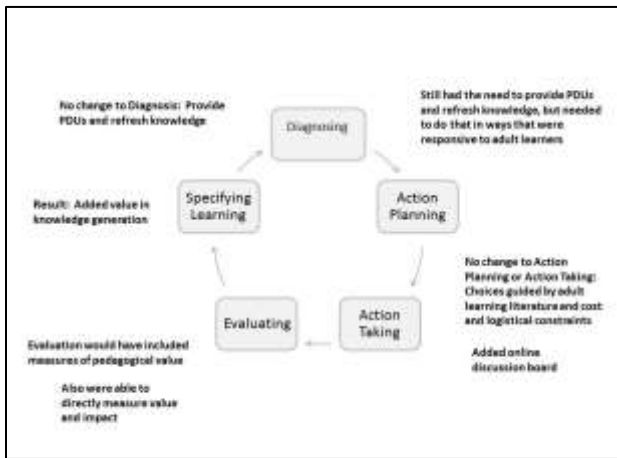
Figure 4. Changes to Engineering Ethics Intervention Resulting from Use of an Action Research Frame of Reference
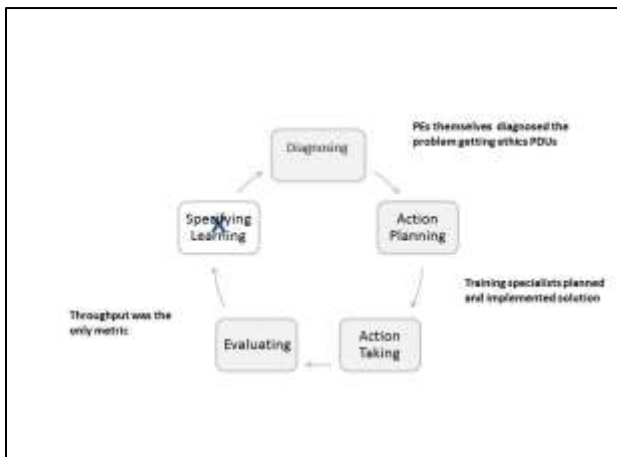

Figure 5. Communication in the Process Improvement Paradigm

As shown in Figure 5, in the process improvement case, the initial problem identification came in the form of queries from the engineers needing PDUs regarding how they could fulfill their continuing education requirements. This problem was turned over to the training specialists, who planned and implemented the initial solution – an online presentation on the NM Professional Code and various professional society and institutional policies related to ethical situations pertinent to the engineering workforce. The only metric applied was the number of people who took the course. There really was no specification of learning – the training team discussed the courseware and throughput among themselves; this led to the additional diagnosis of the need for refresher training.

The cycle was repeated again, still with communication within the training community, but without engaging the trainees. The training specialists included the need for refresher training in the diagnosis; modified the solution to include refresher training using case studies (and action that had been suggested by research into adult learning); and added a metric, correct

response rate, intended to assess whether information was being retained.

That mode probably would have continued had not something else happened: The call for papers for WMSCI 2012 prompted a realization that there were learnings from the project that might be of interest to the ethics education community of practice. Engagement with a different community of practice led directly to knowledge generation that would not have happened had the researchers within the single discipline communication "cocoon."

In addition, this author was invited to present a keynote on action research at WMSCI 2012. This caused a change in thinking about the project, from using a process improvement frame to using an action research frame. That, in turn, led to a richer diagnosis as well as much greater engagement with the "subjects" of the research.

While the training specialists still had responsibility for planning and implementing the solution, the action taking phase was designed to afford the opportunity for direct engagement with the learners through a discussion board.

The evaluation phase was the area most affected by adoption of an action research paradigm. Learners were directly involved in evaluating the value and impact of the intervention as well as the degree to which the case method meets the needs of adult learners.

The inclusion of the learners' perspective added to the knowledge generated in a way that had not been possible using the observational methods employed under the process improvement paradigm. The information about the value, impact, and effectiveness of the case models is more robust than throughput and response rate data could provide. In addition, new knowledge was obtained about the efficacy of case models vis a vis other methods in meeting adult learners' needs. This is shown graphically as Figure 6.

As stated previously, there was, however, a void in the knowledge gained when it came to the efficacy of the discussion
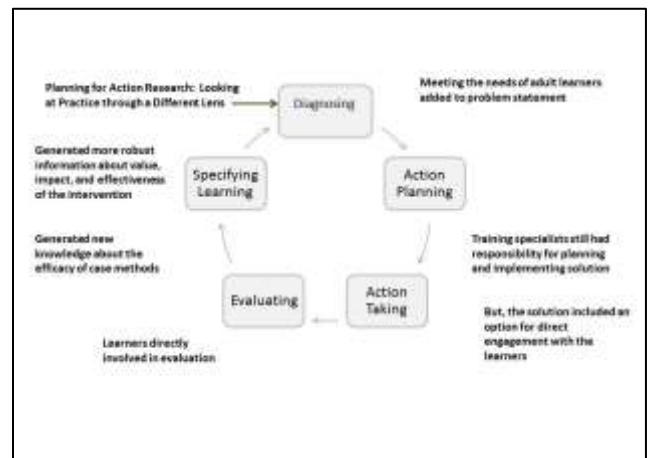

Figure 6. Communication in an Action Research Frame

board. Recall that there had been a concern from the start of the project that online delivery of the case studies would not provide the richness of experience afforded by the opportunity for dialogue in a classroom setting. The idea of using branching to allow further exploration of the cases was the first solution to this "problem," then an online discussion board to facilitate direct engagement among the community of learners was added. The plan was to evaluate the quantity and quality of posts and to ask learners about the value of the discussion board. When no learner posts materialized, the only evaluation method was learners' perceptions of the value of the discussion board, which gave contradictory results when perception and behavior were compared, as was described previously.

The root of the problem most likely resides in the absence of inter-disciplinary communication regarding this aspect of the "problem." In this case, the training specialists were back to talking among themselves. The question of whether the online delivery of cases suffered from a lack of richness was never formally included in the problem statement, nor was consideration of what effect branching might have had on mitigating the problem if there was one! Feedback from the learners on this topic could have provided invaluable knowledge that might have influenced the trainers' instructional design decisions.

To summarize the communication patterns in the two paradigms, as Figure 7 shows, when all of the communication occurred within the Training Community of Practice, it was possible to solve the problem that had been identified – getting the engineers PDUs and refreshing their learning annually. Research into pedagogical models and assessment of their fit with the characteristics of adult learners generated learnings worthy of contribution to the generalizable body of knowledge.

Interactions with the Action Research Community of Practice led to a whole new approach, influencing the Training Community of Practice, in particular with regard to how the intervention was evaluated. This, in turn, led directly to the trainers' engagement with the Community of Learners, which generated additional knowledge about the suitability of case

Figure 7. Interdisciplinary Communication in Action Research

methods for meeting the needs of adult learners, and provided feedback to the Training Community regarding the value and impact of the intervention.

5. CONCLUSIONS

In this paper, convincing evidence has been provided indicating that looking through the lens of action research when planning social science interventions or process improvement initiatives can both enhance the effectiveness of the initiative and improve the value of the resulting contributions to the practitioner community's body of knowledge. Greater knowledge is gained through action research than is typically attained using traditional PDCA methods. The knowledge can then be incorporated within the Action Research Cycle to improve the intervention under study.

The interpretivist frame of reference that is characteristic of action research causes inter-disciplinary communication to be embedded into action research projects, by encouraging interaction between the researchers and their subjects as well as between the discipline-specific communities of practice associated with the subject of the intervention and the action research community itself. Inter-disciplinary communication, too, contributes to enriching the knowledge gained.

And so, for the LANL engineering ethics training project, the cycle continues. In the WMSCI 2014 *Proceedings* paper [10], it was noted that consideration was being given to actions to incentivize trainees to contribute to the discussion board – such as offering additional PDUs for substantive participation. As a result of renewed interaction with the Action Research Community of Practice, that idea has been rethought. Instead, the trainers will engage with the learners to understand whether there actually is a problem with the richness of the online case experience; the likely effectiveness of mitigations, including branching and the discussion board, in addressing the problem if it exists; and to understand the dynamic involved in learners placing value on the discussion board but not actively participating in it, before making any additional modifications to the intervention.

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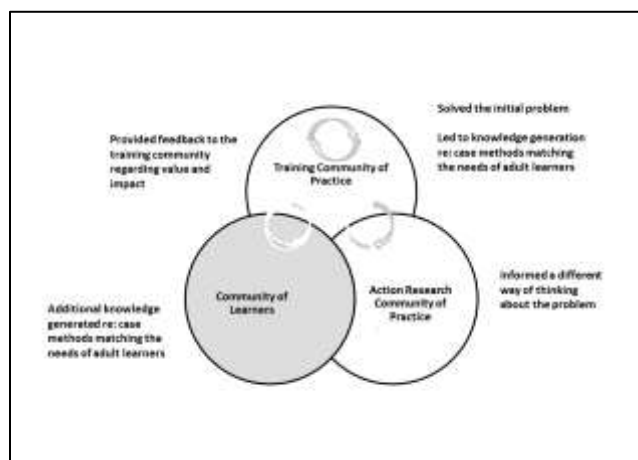
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