A methodology is a model of the abstract generalization of a specific process created by an expert to assist novices on their way to becoming experts in the practice of that process.

The Importance of Process

Our understanding of the importance of process and its quality was significantly advanced by the work of W. Edwards Deming, which formed the basis for the total quality management (TQM) movement in the 1980s (Deming, 2015). In working with higher education, Pacific Crest initially focused on improving the processes of teaching, learning, design, and assessment (Kramer & Beery, 1990) and soon realized that when it comes to modeling and improving educational processes, methodologies are critical. The first methodology published by Pacific Crest was the Problem Solving Methodology (PSM), published in *Introduction to Problem Solving Using PC:SOLVE* (Apple, 1990); this was aimed at teaching students how to use a methodical process when working to solve problems.

The next and probably most far-reaching methodology formally published was the Learning Process Methodology (LPM). It began as "The Learning Process Model," published in *Learning Through Problem Solving* (Apple, Beyerlein & Schlesinger, 1992), and was an intermediate step in the development of the full LPM published in the pre-market edition of *Foundations of Learning* (Pacific Crest, 1995). See the section **Learning Process Methodology** for more information.

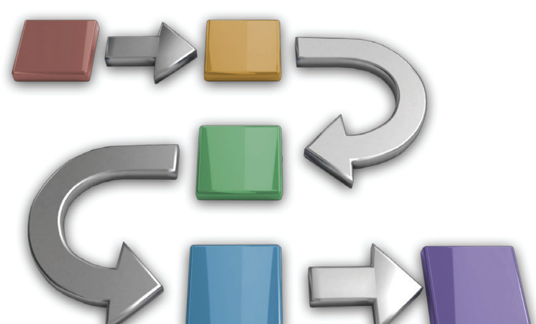
The Collection Grows

An additional set of process methodologies were introduced in the next edition of *Foundations of Learning* (Krumsieg & Baehr, 1996): these were writing, information processing, assessment, personal development, communication, teamwork, reading, and management. The process used to create these different methodologies was formalized as a methodology for creating methodologies; this appeared in the *1995 Teaching Institute Handbook* (Apple & Krumsieg). Also available in that handbook was the first iteration of a methodology for designing learning activities. The *1998 Teaching Institute Handbook* (Apple & Krumsieg) offered additional methodologies: course design, facilitation, and creating a productive learning environment. The 2000 *Teaching Institute Handbook* (Apple & Krumsieg) introduced methodologies for mentoring, constructing knowledge tables, and carrying out evaluations. The *Faculty Guidebook* project (2003 through 2007) saw the upgrade and publication of a series of methodologies listed in the following order of development:

- *Methodology for Course Design* (Davis, 2007a)
- *Methodology for Creating a Quality Learning Environment* (Apple & Smith, 2007b)
- *Methodology for Designing a Program Assessment System* (Collins & Apple, 2007)
- *Elevating Knowledge from Level 1 to Level 3* (Nygren, 2007)
- *Facilitation Methodology* (Smith & Apple, 2007)
- *Learning Processes Through Methodologies* (Leise & Beyerlein, 2007)
- *Methodology for Program Design* (Davis, 2007)
- *Assessment Methodology* (Apple & Baehr, 2007)
- *Designing Process-Oriented Guided-Inquiry Activities* (Hanson, 2007)
- *Teamwork Methodology* (Smith, Baehr & Krumsieg, 2006)
- *Personal Development Methodology* (Leise, 2007)

During the process of converting the Learning to Learn Camp into the course and curricula, *Learning to Learn: Becoming a Self-Grower* (Apple, Morgan & Hintze, 2013), it became obvious that an additional methodology was needed: that of preparing for a performance. The Preparation Methodology was created and appears in the context of Experience 9, "Performing when Being Evaluated." This same course conversion also saw the upgrade of the Reading Methodology in order to more fully support the process of reading for learning.

In addition to being useful for teaching general processes, methodologies can also be used to help students learn to use more specific processes within the context of a course: *Foundations of Mathematics* (Fremeau, 2007) incorporated 27 methodologies covering processes



such as rounding a whole number and solving problems with proportions; *Foundations of Algebra: Active Learning Workbook* (Ellis & Apple, 2012) included 22 methodologies; and *Quantitative Reasoning and Problem Solving* (Ellis, Apple, Watts, Hintze, Teeguarden, Cappetta, & Burke, 2014) contained 30 methodologies. For example, Figure 1 shows the Data Analysis Methodology. While methodologies are extremely effective in learning, internalizing, and generalizing process knowledge, the fact is that not only are methodologies rarely presented in student curricula without accompanying modeling of the use of the methodology; students are also challenged to step through the methodology themselves, in a problem that is similar to the modeled use. See Figure 2 for an example from *Foundations of Algebra: Active Learning Textbook* (Ellis, Teeguarden, Apple & Hintze, 2013).

Figure 1 Data Analysis Methodology

Step	Explanation
1. Clarify the data	What does each variable and row represent? Are there issues of quality such as errors or missing data? What are the values being measured? What are the relevant units? Are there any outliers that were removed? Is bias a problem?
2. Clarify the context	Who is asking for the analysis, what is the agenda, and what are the types of results that they want or expect to see? Identify the objectives (3 to 5) and always consider possible reasons for bias in the reporting of this data.
3. Develop inquiry questions	Identify three to five key questions central to the inquiry to clarify what results you want to produce. What are the fundamental questions that you hope to answer? What characteristics of the data set are you looking to identify?
4. Produce relevant graphs	Choose to construct a collection of histograms, box plots, pie charts, or bar graphs to help answer the original research question.
5. Identify data analysis tool	Select spreadsheet, stat package, modeling language, database, or specialized software.
6. Transform the data	Make structural changes in your table to facilitate better view, perspective, and understanding of what the data is representing.
7. Produce a preliminary analysis	Perform the basic descriptive statistics to go along with the graphs produced.
8. Identify data shortcomings	What are the concerns associated with using this data, are there agendas for people producing the data, concerns about the data collected, and data that has not been included?
9. Report findings and generate new questions	Summarize the top 3 to 4 findings that you can make with confidence. Also add 3 to 5 new issues or questions that need to be addressed based upon the findings.
10. Find additional data	Go back to the original source for the data and see if they have additional data that can supplement to answer some of the advanced questions.
11. Identify findings	Identify the top 3 to 5 findings that are most significant related to the initial objectives and determine the outline you will use to present your findings.
12. Perform an additional analysis	What are the key questions in the presentation that are currently unanswered and what are the statistical tools used to answer these questions?
13. Generalize the implications	What can we say about implications outside our current context of analysis? Determine whether it is fair to generalize the results to a wider population.
14. Produce an analytical report	Report the findings of the data analysis, documenting and justifying your process, techniques, and conclusions, including any issues or concerns, or ideas for future investigation.
15. Lessons learned	In the process of analyzing your data, assess your performance, identifying what you did well and why, what can you improve upon, and what you learned.

Figure 2 Presentation of a Methodology with Modeled Use and "Your Turn" for Student Practice

Methodology 2.3

Solving a System of Linear Equations in Two Variables by Substitution

The purpose of this methodology, which we refer to as the ***substitution method***, is to solve a system of two equations in two variables by using the Substitution Principle twice.

Limitation/Caution: When you solve one of the equations for one variable in terms of the other, you should not substitute the result back into that same equation.

	Example 1	Your Turn
Solve the system:	$\begin{cases} x+2y=-3 \\ 3x-5y=13 \end{cases}$	$\begin{cases} -3x+4y=17 \\ x+5y=7 \end{cases}$

Steps	Discussion
1 Select a variable and an equation	**Select a variable for the first substitution and an equation to use to determine an expression for the selected variable.**
Ex 1: $\begin{cases} x+2y=-3 \\ 3x-5y=13 \end{cases}$ Select x and the first equation (we choose this equation because x has a coefficient of 1 and can easily be solved for).	**Your Turn**
2 Solve one of the equations	**Solve the selected literal equation for the selected variable.**
Ex 1: $x+2y=-3$ $x=-3-2y$	**Your Turn**
3 Substitute expression	**Substitute the expression for the variable solved for in Step 2 into the other equation.**
Ex 1: $3x-5y=13$ $3(-3-2y)-5y=13$	**Your Turn**

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