Individual Learning Style and Systems Tool Preferences

Dr. Sheldon Friedman
St. Joseph College
1678 Asylum Avenue
West Hartford, CT. 06117
(860) 231-5289
Email: Sfriedman@sjc.edu

Steven A. Cavaleri Ph.D.
Professor
Department of Management & Organization
Central Connecticut State University
1615 Stanley Street
New Britain, CT 06050
Tel (860) 832-3283
E-mail: 'cavaleri@ccsu.edu'

Mike Raphael Ph.D.
Department of Management & Organization
Central Connecticut State University
1615 Stanley Street
New Britain, CT 06050
Tel (860) 832-3283

Learning Styles and Modeling

Abstract:

Research was carried out in order to determine if a relationship existed between the use of specific system thinking tools and Kolb learning styles. Subjects were university students who played the B & B Enterprise game, took the Kolb Learning Styles Inventory and responded to a questionnaire. These questions related to both the frequency and preferences of use of specified system thinking tools and learning styles. The results revealed that for some of the learning style orientations a significant relationship with use and preferences of system thinking tools existed. These results indicate that further study is needed to clarify any differences in relationships between groups and between frequency and preferences. It is thought that if a set of relationships can be identified, such knowledge could facilitate the introduction of systems thinking and system dynamics to selected groups within an organization.

Keywords [Systems thinking, system dynamics, Kolb Learning Styles]

Introduction

Typically, there is not a clearly known path to improving people's systems thinking abilities or their competency in using systems thinking tools to perform analyses of dynamic problems. Conventional training and educational approaches ignore individual factors that may influence the rate at which someone may master systems thinking, such as action learning style and preference for using certain types of systems thinking tools. This study examined the extent to which frequency of use of certain systems thinking tools, and individual learning styles were correlated and the extent to which they influence performance on a management flight simulator.

The conventional method of helping people to become better at systems thinking is to teach them to use various systems thinking tools and expose them to simulated environments, such as those found in Microworlds (Kim, 1994). While there is some evidence that participation in such training can be useful, this approach often fails to consider the learning styles or cognitive limitations of training participants. Sterman (1994) has argued that effective learning depends on making correct interpretations of dynamic feedback and argues that such misinterpretations may be the causes of barriers to learning It has been suggested that one way to improve learning is the use of computer simulations, such as Management Flight Simulators, and designing formal system models**.** Such formal models have advantages over either informal or mental models, especially when it comes to learning. These advantages are- formal models are explicit and communicable. System dynamics models are capable of transparently exposing assumptions being held by modelers about the causal reasons for underperformance. They can also be subject to criticism, experimentation, and reformulation. Formal models have the added benefit of being able to handle complexity fairly easily (Pugh and Richardson, 1981). Simulations have the advantage of being able to present numerous variables for evaluation-something that the human mind cannot easily do. The use of simulations is based on the expectation that, during the use of a flight simulator, users will have an integrative experience of how the system operates to cause its behavior. Additionally, there may be greater awareness of the interdependencies among parts of an organization that would not otherwise be possible with traditional teaching methods (Graham, 1990). The use of Microworlds as a learning tool became popularized after the publication of Senge's (1990), acclaimed book, *The Fifth Discipline*. The effect of Microworlds on the ability of people to learn systems thinking has previously been explored by researchers, such as (Morecroft and Sterman, 1994). Further investigations aimed at assessing the impact of Microworlds on systems thinking competencies have been reported by Huz, Anderson, Richardson and Boothroyd (1997), Doyle (1997), Durham (2002, 2003), Cavaleri and Sterman, (1997), Cavaleri (2002) and Friedman and Cavaleri (2003). Such studies suggest that there are still, as yet unexplained, complexities found in those cognitive processes inherent in learning systems thinking and in formulating policy in complex dynamical social systems.

Richmond (1993) defines systems thinking in terms of competencies, "The systems thinkers' forte is interdependence. Their specialty is understanding the dynamics generated by systems composed of closed-loop relations. Systems thinkers use diagramming languages to visually depict the feedback structures of these systems. They then use simulation to play out the associated dynamics." (p.113) He also identifies seven core systems thinking skills including: 1. dynamic thinking, 2. closed-loop thinking, 3. dynamic thinking, 4. structural thinking, 5. operational thinking, 6. continuum thinking, and 7. scientific thinking.

This exploratory study considers how such cognitive and learning processes influences frequency of use and preference for using certain *systems thinking tools*. According to Kim (1994) "There are at least ten distinct types of systems thinking tools…They fall under four broad categories: brainstorming tools, dynamic thinking tools, structural thinking tools, and computer-based tools." (p. 10) While there are other systems thinking tools besides those identified by Kim, this research is delimited by the fact that the ten types of tools identified by Kim were the focus of the systems thinking training explored in this research. Students were asked to rate the frequency of use of tools and their perceived value toward achieving sustained profitability in a management flight simulator experience.

Limits to Growth in Learning

Conventionally, the term *Limits to Growth* is used to describe a system archetype in which constraints on capacity restrict the potential of systems to grow at a desired rate. However, this term can also be used to describe the effect of constrained learning capacity on the growth of one's systems thinking capabilities. The notion of cognitive limits are quite popular in system dynamics literature, as expressed by concepts such as Simon's (1957) *bounded rationality* and Senge (1990), who used the *term learning disability* to describe the difficulties experienced by individuals and organizations, in making sense of feedback gained from experience in ways that yield valid conclusions about how causal patterns are likely to work in practice in the future. While we concur that the aforementioned concepts are important contributions to the field of system dynamics, we propose there is also another class of limit to learning that stems from the inherent learning styles of individuals. There has been much written on the effects of action learning styles ranging from David Kolb's seminal work to Reg Revans writing in the 1980s, to Cavaleri and Seivert's (2005) concept of *knowledge bias*. The concept of knowledge bias describes tendencies or patterns of individuals to learn from experience to ways that favor certain parts of the action learning process at the expense of limiting other parts.

> "Research on learning styles has shown that managers on the whole are distinguished by very strong active experimentation skills and are very weak on reflective observation skills" (Kolb, Rubin and Osland, 1991: 67).

The difficulty inherent in managing amidst high levels of complexity has been described by Doerner (1980), while on the other hand, cautionary warnings of the effects of misperceptions of dynamic feedback, and information processing limitations have been issued by Sterman (1994) -- though some choose to ignore these signs altogether. Even recommendations that policy makers should decide whether they wish to make decisions based on results obtained from using their unaided mental models, or alternatively, from results obtained from some combination of formal and mental models" (Radzicki 1998 :8) are not heeded by practitioners.

An open systems view of organization is related to the interaction of the organization and its environment. As such, organizations have two sets of complexity to deal with, those that represent internal dynamics and those that deal with external environmental changes. The ability to deal with complexity requires the ability to learn from observed patterns of change over time. In turn, groups that learn and engage in collective sense-making together should, by all standard accounts, be more effective. That is, more able to improve effectiveness of their decisions in such complex environments by leveraging the value of contemporary tools, techniques, and technologies to their advantage. For example, developing shared mental models, learning as a group, and using systems thinking comprise some of the core elements suggested by Senge (1990) as being necessary for performance improvement and in learning organizations. Can the same sorts of tools be applied with equal benefit by learners in the process of developing greater capabilities for systems thinking? Is there a way of teaching people to become better systems thinkers that accounts for individual learning needs and preferences?

Integrating Tools for Modeling and Learning

It is common among system dynamics practitioners to assume that all systems thinking tools have equal values to learners. However, learners may have preferences to choose certain tools over others due to their intrinsic learning styles. If the assumption of all systems tools having equal values to learners is unjustified, it portends the need for a type of meta-model for learning systems thinking that can address variations in learning style. Part of the process of system thinking and systems dynamics requires the conceptualization of a working hypothesis for the system under study and the development of a reference mode for a simulation model. For example, Saeed (2003) has suggested that "the conceptualization of a reference mode requires the same learning process as the development of a dynamic hypothesis, the construction of a model, the creation of the model understanding and the design of a policy for system improvement".

In this paper, Saeed reverses the directions originally envisioned by Kolb and creates a means of connecting thought and action. Using the Kolb model it was suggested that careful observation of facts and patterns should drive thinking. That the interpretation of these facts must be tested through experimentation and that the results be turned into generalizations that could then be reused to start a new learning cycle. (Saeed, 2003). Figure 1 is extracted from Saeed's diagram, to which was added the Learning Style associated with the Kolb quadrants of orientation.

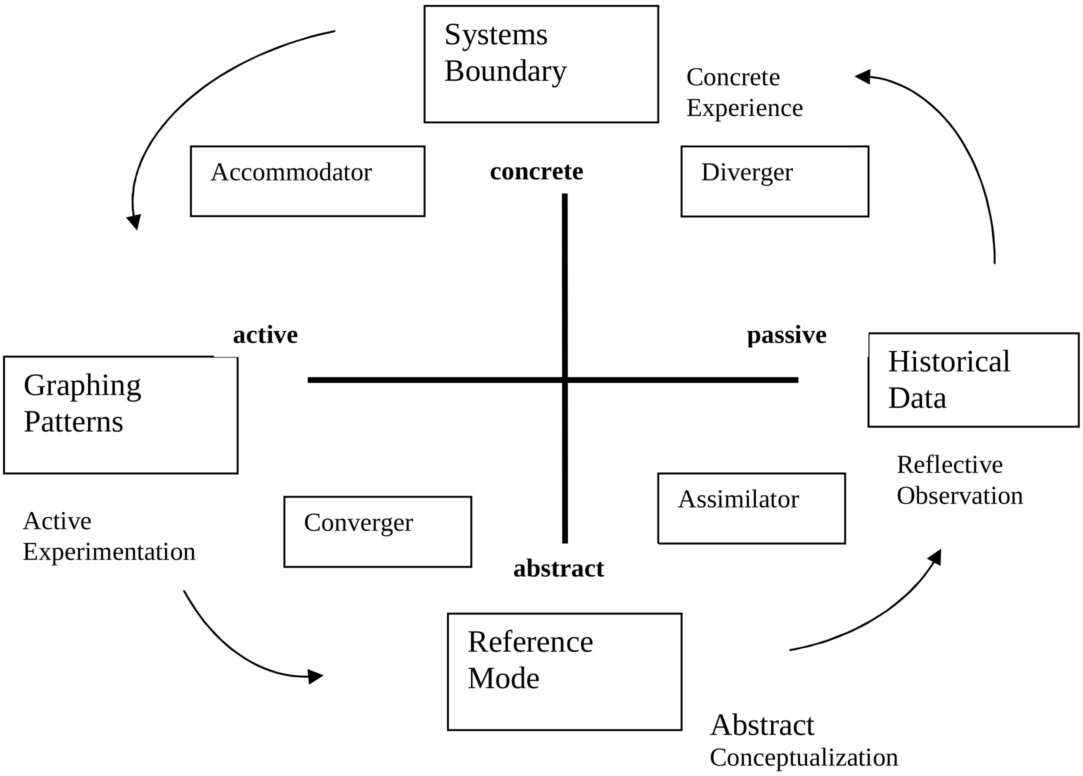

Fig. 1 **Learning Styles and Model Development Process**
(From Saaed 2003 and Kolb, 1991**)**
(Note: The Kolb model normally has the direction of arrows moving clockwise).

Lawrence (1995) uses the concept of learning style to describe four aspects of psychological makeup. These are:

- A preferred or habitual pattern of mental functioning, information processing, formation of ideas and judgments.
- Patterns of attitudes and interests that influence what a person will attend to in a potential learning situation.
- A disposition to seek out learning environments compatible with one's cognitive style, attitude and interests.
- A disposition to use certain learning tools, to use them successfully and to avoid other tools. (:39).

It is this final characteristic that serves as a key block of the foundation for the research conducted for this paper. It is proposed that people exhibit patterns of learning from experience that reflect the manifestation of certain proclivities to seek information, assign meaning, and attend to certain cues at the exclusion of others. These tendencies often mirror personal beliefs and intrinsic traits that differentiate people, yet whose origins are not well understand. Koestler (1945), for example, identifies leaders as holding worldviews that tend toward being belonging to a constellation of attributes which he describes as being either akin to that of a *Yogi* or a *Commissar*. In a similar way, other typologies distinguish between natural human tendencies to perceive the world, make sense, and learning in quite divergent ways that we often refer to as learning styles.

Learning Styles

In order to evaluate learning style, several inventories are available including those developed by Honey and Mumford (1995), Dechant and Marsick (1993), Murrell (1987) and Glacel (2001). However, the inventory selected for use in this study was Kolb's KLSI (1991) which chosen based on the work Saeed (2003). The interpretation of scores is given as an orientation while combined orientations give a resulting learning style. The following is a summarization of the orientations developed from the Kolb learning style inventory model.

Orientation I.

An orientation toward *concrete experience* focuses on being involved in experiences and dealing with immediate human situations. There is an emphasis on feelings and doing, or being in an experience.

Orientation II

An orientation towards *reflective observation* focuses on understanding the meaning of ideas and situation. It emphasizes understanding as opposed to practical application and thinking over doing.

Orientation III

An orientation towards *abstract conceptualization* focuses on using logic, ideas and concepts. Persons with this orientation are good at systematic planning.

Orientation IV

An orientation to toward *active experimentation* focuses on actively influencing people and changing a situation. There is an emphasis on practical application. There is a value in the ability to impact the environment. (Kolb, et. al., 1991: 62) A person s learning style is based on the balances achieved by the orientations.

Systems Thinking and Learning Styles

When the potential impact of learning style on systems thinking is considered, a number of different possibilities emerge for patterns of capacity development.

Convergent Style

Convergent styles enjoy problem solving and prefer technical tasks and seem to do best where there is a single correct answer or solution (Kolb, 1991). It is proposed here that the problem with such styles in systems thinking is that there can be several solutions to a systems problem, depending on the leverage points that are identified. Could this style have difficulty in using any of the tools or in the development of system thinking skills?

Divergent Style

The divergent style emphasizes concrete experience and reflective observation. There strength lies in awareness of meaning and values. The primary adaptive ability on this style is to view concrete situations form many perspectives and to organize many relationships into a meaningful "Gestalt" *(sic: whole*). One might suspect that the attraction to such a style would be the initial development of behavior over time graphs as a way of viewing the situation.

Assimilation Style

Assimilation is a style where abstract conceptualization and reflective observation are preferred. The strength of this style lies in deductive reasoning and the ability to create theoretical models. Could this style be more attracted to the development and use of causal loop diagramming or the process of connecting the dots, so to speak, in the picture of the system?

Accommodation Style

Finally, the accommodation style has emphasizes concrete experience and active experimentation. The strength lies in doing things. The emphasis is on risk taking. Does this style enjoy playing the game and using direct feedback? (Kolb, et. al., 1991)

Research

An experiment was conducted in order to determine the relationship that may exist between action learning styles and the choice of system thinking tools. Data was collected from a sample using a questionnaire designed to assess individual preferences for systems thinking tools and learning styles and types. The sample was taken from undergraduate management students at a university.

Sample and Treatment

The sample was composed of fifty students who were registered in a course on systems thinking for managers. These students volunteered to participate in this research and understood that their participation in the study would not influence their course grade. Prior to completing the questionnaire used for this research students were provided with approximately fifteen hours of training in the use of the ten systems thinking tools. They also read the first seven chapters of the book by Peter Senge (1990) *The Fifth Discipline***.** Finally, they played several management flight simulators, including Thompson's (2004) *Two Brothers Pizza* and Sterman's (199X) *B&B Enterprises* individual and as part of a team for a period of approximately nine hours each.

Students were asked in the questionnaire to rate the frequency of use and perceived value of each of the ten systems thinking tools in contributing to profitability in the B&B Enterprises flight simulator. The rating scale used was not a forced choice scale and did not require that student choose one tool as being more important than any others. It is acknowledged that systems thinking tools are usually used in conjunction with each other and this will potentially produced interactive effects. However, the purpose of this research is to simply explore the following questions: 1. Are there preferences in the choice and use of some systems thinking tools, and 2. Are preferences for systems thinking tools influenced by individual learning styles, and 3. Is performance, as measured by profit, in a management flight simulator influenced by more frequent use of certain systems thinking tools.

Method

In order to evaluate if a relationship exists between learning styles and a "disposition to use certain systems thinking tools, to use them successfully and to avoid other tools. (:39)", research was conducted using the Kolb Learning Style Inventory (KLSI). The same students had completed approximately nine hours of playing just the B& B Enterprises Microworld -- developed by Sterman (www.forio.com). The questionnaire was designed to capture the types of system thinking tools available for use in the game, and the frequency of use of these systems thinking tools. It is hypothesized that frequency of use is one indicator of system tool preference – thought not exclusively so. Frequency of use may indicate preference, but there are other factors that contribute to preference, such as tool simplicity, ease of use, and perceived value relative to other tools. Also, by their intrinsic nature some tools, such as assigning link polarities, are generally used more often than tools, such as drawing Behavior Over Time graphs. However, it is also equally feasible that tools with relative advantages in terms of ease of use or perceived value are likely to be used more often. Since this is an exploratory student in uncharted waters, our initial effort was streamlined in order to focus on the defining the basic relationships in the study. Finally, the questionnaire also measured of economic performance (cumulative profit) in the B&B flight simulator was recorded for both individuals and teams.

Both sets of data, from the KLSI and the records of decision made to select certain system thinking tools were analyzed. Participants were grouped in several ways. First, participants were grouped according to their learning styles, (i.e. Accomodator, Converger, Diverger, or Assimilator). A second classification was created using the orientations that make up each style, such as whether a participant prefers to act by using concrete experience or active experimentation, or prefers abstract conceptualization to engaging in reflective observation. The results of the analysis are discussed below.

Results

Introduction

Being an exploratory research investigation, the data were analyzed in a logical process to assess the hypotheses and research questions. Initially, the frequency and preference of use of the various tools, across the various learning styles were analyzed. Due to the small sample sizes in several learning style categories, the additional analyses were conducted used Kolb's dichotomies of concrete vs. conceptual and active vs. passive categories. For each of these dichotomies the frequency of use and preference of use were analyzed.

Part I

The first analysis looked at the rating of the frequency of use of the various tools across all learning styles. The results are shown in Table 1, which shows the average (mean) and standard deviation for each style. The Analysis of Variance indicates an F = 8.262 (df = 9, 420), which is significant beyond the .01 level. Thus the data indicate that there are differences amongst the various tools based on the rating of the frequency of use.

Table 1

SUMMARY **Frequency of Use -- All styles**

Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
FCausLoop	43	165	3.837	1.194
FTimeDelay	43	173	4.023	0.886
FBOT	43	142	3.302	1.166
FSysArch	43	138	3.209	1.125
FPolarities	43	155	3.605	1.116
FCausEffec	43	185	4.302	0.741
FStckFlow	43	116	2.698	1.186
FMental	43	157	3.651	1.131
FDiscov	43	171	3.977	0.988
FKeepLog	43	162	3.767	0.972

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	83.54419	9	9.283	8.262	0.000	1.902
Within Groups	471.8605	420	1.123		Signif	
Total	555.4047	429				

Part II

The next analysis looked at the rating of the preference of the various models across all learning styles. The results are shown in Table 2, which shows the average (mean) and standard deviation for each style. The Analysis of Variance indicates an F = 6.689 (df =

9, 420), which is significant beyond the .01 level. Thus the data indicate that there are differences amongst the various tools based on the rating of the preference of the tools.

Table 2

SUMMARY **Preference of Method -- All styles**

Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
PCausLoop	43	175	4.070	1.121
PTimeDelay	43	181	4.209	0.773
PBOT	43	164	3.814	0.958
PSysArch	43	147	3.419	1.118
PPolarities	43	163	3.791	1.125
PCauseEffect	43	190	4.419	0.731
PStckFlow	43	130	3.023	1.080
PMental	43	162	3.767	1.065
PDiscov	43	173	4.023	0.938
PKeepLog	43	166	3.860	1.037

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	60.67209	9	6.741	6.689	0.000	1.902
Within Groups	423.2558	420	1.008		Signif	
Total	483.9279	429				

Due to very small sample sizes in many categories no analyses were performed for frequency of use or preference of methods for individual learning styles. Instead the following sets of tables report the analyses based on the dichotomy of categories of conceptual vs. concrete and active vs. passive.

Part III.

Table 3 presents the analysis for the rating of frequency of use for a conceptual orientation. The data in Table 3 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 1.429 (df = 9, 70), which is not significant beyond the .01 level. The data indicate that there are no differences amongst the various tools based on the rating of the frequency of use of the various tools.

Part IV

Table 4 present the analysis for the rating of frequency of use for a concrete orientation. The data in Table 4 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 7.628 (df = 9, 340), which is significant beyond the .01 level. Thus the data indicate that there are differences amongst the various tools based on the rating of the frequency of use of the various tools for those individuals who have a concrete orientation.

Table 3

SUMMARY		**Frequency of Use -**		**Conceptual**
Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
FCausLoop	8	27	3.375	1.598
FTimeDelay	8	30	3.750	1.035
FBOT	8	20	2.500	1.512
FSysArch	8	26	3.250	1.389
FPolarities	8	30	3.750	1.282
FCausEffec	8	32	4.000	0.756
FStckFlow	8	20	2.500	1.414
FMental	8	29	3.625	1.302
FDiscov	8	30	3.750	1.282
FKeepLog	8	31	3.875	0.991

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21.0625	9	2.340	1.429	0.193	2.017
Within Groups	114.625	70	1.638		Non-Signif.	
Total	135.6875	79				

Table 4

SUMMARY			Frequency of Use - Concrete	
Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
FCausLoop	35	138	3.943	1.083
FTimeDelay	35	143	4.086	0.853
FBOT	35	122	3.486	1.011
FSysArch	35	112	3.200	1.079
FPolarities	35	125	3.571	1.092
FCausEffec	35	153	4.371	0.731
FStckFlow	35	96	2.743	1.146
FMental	35	128	3.657	1.110
FDiscov	35	141	4.029	0.923
FKeepLog	35	131	3.743	0.980

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	69.85429	9	7.762	7.628	0.000	1.907
Within Groups	345.9429	340	1.017		Signif	
Total	415.7971	349				

<u>Part V</u>

Table 5 present the analysis for the rating of preference for tools for those who have a conceptual orientation. The data in Table 5 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 1.675 (df = 9, 70), which is not significant beyond the .01 level. Thus, the data indicate that there are no differences amongst the preferences among the various tools for those with a conceptual orientation.

<u>Part VI</u>

Table 6 present the analysis for the rating of preference tools for those with a concrete orientation.. The data in Table 4 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 6.009 (df = 9, 340), which is significant beyond the .01 level. Thus the data indicate that there are differences amongst the preferences among the various tools for those individuals who have a concrete orientation..

Table 5

SUMMARY **Preference of Method - Conceptual**

Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
PCausLoop	8	30	3.750	1.581
PTimeDelay	8	29	3.625	0.916
PBOT	8	23	2.875	0.835
PSysArch	8	26	3.250	1.282
PPolarities	8	30	3.750	1.488
PCauseEffect	8	34	4.250	1.165
PStckFlow	8	19	2.375	0.916
PMental	8	29	3.625	1.188
PDiscov	8	29	3.625	1.188
PKeepLog	8	32	4.000	1.195

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21.6125	9	2.401	1.675	0.112	2.017
Within Groups	100.375	70	1.434		Non-Signif.	
Total	121.9875	79				

Table 6

SUMMARY		**Preference - Concrete**		
Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
PCausLoop	35	145	4.143	1.004
PTimeDelay	35	152	4.343	0.684
PBOT	35	141	4.029	0.857
PSysArch	35	121	3.457	1.094
PPolarities	35	133	3.800	1.052
PCauseEffect	35	156	4.457	0.611
PStckFlow	35	111	3.171	1.071
PMental	35	133	3.800	1.052
PDiscov	35	144	4.114	0.867
PKeepLog	35	134	3.829	1.014

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	48.228571	9	5.359	6.009	0.000	1.907
Within Groups	303.2	340	0.892		Signif	
Total	351.42857	349				

Part VII.

Table 7 present the analysis for the rating of frequency of use for the active orientation. The data in Table 7 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 3.002 (df = 9, 140), which is significant beyond the .01 level. Thus the data indicate there are differences amongst the various tools based on the rating of the frequency of use of the various tools within an active orientation.

Part VIII.

Table 8 present the analysis for the rating of frequency of use for the passive orientation. The data in Table 8 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 5.380 (df = 9, 297), which is significant beyond the .01 level. Thus the data indicate that there are differences amongst the various tools based on the rating of the frequency of use of the various tools for those individuals who have a passive orientation.

Table 7

SUMMARY		**Frequency of Use - Active**		
Groups	Count	Sum	Average	*Standard Deviation*
FCausLoop	15	58	3.867	1.356
FTimeDelay	15	62	4.133	0.640
FBOT	15	52	3.467	1.302
FSysArch	15	49	3.267	1.223
FPolarities	15	57	3.800	1.014
FCausEffec	15	63	4.200	0.941
FStckFlow	15	39	2.600	1.352
FMental	15	56	3.733	1.033
FDiscov	15	62	4.133	0.915
FKeepLog	15	60	4.000	1.069

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	33.04	9	3.671	3.002	0.003	1.947
Within Groups	171.2	140	1.223		Signif	
Total	204.24	149				

Table 8

SUMMARY		**Frequency of Use - Passive**		
Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
FCausLoop	28	107	3.821	1.124
FTimeDelay	28	111	3.964	0.999
FBOT	28	90	3.214	1.101
FSysArch	28	89	3.179	1.090
FPolarities	28	98	3.500	1.171
FCausEffec	28	122	4.357	0.621
FStckFlow	28	77	2.750	1.110
FMental	28	101	3.607	1.197
FDiscov	28	109	3.893	1.031
FKeepLog	28	102	3.643	0.911

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	59.96104	9	5.996	5.380	0.000	1.863
Within Groups	331.0357	297	1.115		Signif	
Total	390.9968	307				

<u>Part IX</u>
Table 9 present the analysis for the rating of preference of tools for an active orientation. The data in Table 9 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 3.226 (df = 9, 140), which is significant beyond the .01 level. Thus, the data indicate that there are differences amongst the various tools based on the rating of the preference amongst the various tools for those with an active orientation.

<u>Part X</u>
Table 10 present the analysis for the rating of preference of the method for those with a passive orientation. The data in Table 10 shows the average (mean) and standard deviation for each tool. The Analysis of Variance indicates an F = 3.886 (df = 9, 270), which is significant beyond the .01 level. Thus the data indicate that there are differences amongst the various tools based on the rating of the preferences amongst the various tools for those individuals who have a passive orientation.

Table 9

SUMMARY — Preference of use - Active

Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
PCausLoop	15.000	60.000	4.000	1.134
PTimeDelay	15.000	62.000	4.133	0.640
PBOT	15.000	59.000	3.933	0.961
PSysArch	15.000	51.000	3.400	1.298
PPolarities	15.000	59.000	3.933	1.100
PCauseEffect	15.000	70.000	4.667	0.617
PStckFlow	15.000	45.000	3.000	1.069
PMental	15.000	60.000	4.000	1.069
PDiscov	15.000	65.000	4.333	0.724
PKeepLog	15.000	60.000	4.000	1.069

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	28.593	9.000	3.177	3.226	0.001	1.947
Within Groups	137.867	140.000	0.985		Sig.	
Total	166.460	149.000				

Table 10

SUMMARY		Preference of Use - Passive		
Groups	*Count*	*Sum*	*Average*	*Standard Deviation*
PCausLoop	28.000	115.000	4.107	1.133
PTimeDelay	28.000	119.000	4.250	0.844
PBOT	28.000	105.000	3.750	0.967
PSysArch	28.000	96.000	3.429	1.034
PPolarities	28.000	104.000	3.714	1.150
PCauseEffect	28.000	120.000	4.286	0.763
PStckFlow	28.000	85.000	3.036	1.105
PMental	28.000	102.000	3.643	1.062
PDiscov	28.000	108.000	3.857	1.008
PKeepLog	28.000	106.000	3.786	1.031

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	36.143	9.000	4.016	3.886	0.000	1.915
Within Groups	279.000	270.000	1.033		Sig.	
Total	315.143	279.000				

Analysis

This preliminary evaluation revealed that there was no apparent relationship between action learning styles, as defined by the KLSI, such as D*iverger*, *Acccomodator*, *Converger* or *Assimilator* and preference for certain systems thinking tools. To confirm that no relationships might have been missed, the participant groups were disaggregated into the four major orientations such as; “concrete-experience”, “active-experimenter,” “reflective- observer”, and “abstract –conceptualizer”. A second statistical analysis was then carried out for these groupings. The subsequent evaluation of this data revealed that the following findings:

1. There is evidence of significant differences in the rating of the frequency and preferences of use of a given tool amongst an individual’s orientation within the Kolb model.
2. Within orientation groupings, there are significant relationships among the group orientation and both preference and frequency of use of systems thinking tools
3. Differences within groups existed for all groups except the abstract conceptualizers.

Discussion

The evaluation of action learning styles indicated differences among the Kolb Learning orientations and the systems thinking tools of choice. Before the exact nature of this relationship can be discerned, it is recommended that further research be conducted in this area. In addition, the nature of any relationships should be analyzed in order to determine the relationship between stylistic groupings. Further, an analysis of the relationship between frequency of use and preferences for the various tools is warranted. The study revealed significant differences in preference for use of the ten various systems thinking tools among participants. However, there was no significant relationship found between use of preferred systems thinking tools and flight simulator performance. (as measured by cumulative profit)

If an analysis reveals a relationship between group orientations and systems thinking tools, the final results could lead to some more solid conclusions that might suggest a more definitive relationship between learning orientations and preference for using certain systems thinking tools over others. The existence of such a well-defined relationship would be significant to the practice of system dynamics because it would enable instructors or course designers to develop methods capable of “hooking”, the understandings of the various groups by aligning tool use with their natural action learning orientation. This would be a similar approach to the use of language as a means of interacting with Myers-Briggs types. Groups could also be clustered according to systems thinking tool preferences to simplify or expedite systems thinking instruction.

"Buckley and Caple (cited in Grace2007) have described the learning styles in their book *The Theory and Practice of Training* and made some observations on the validity of both models because of their reliance on the term 'experience' and the fact we lack a clear understanding of what an 'experience' is. From the viewpoint of training the real relevance must surely be that different people do seem to learn more effectively in different ways. For some the concept of learning by activity (activist) is by far the most attractive, while others are much more reflective (reflectors) by nature and prefer to be given information and allowed time to think about it before doing anything" (Grace, 2007). In his paper Grace goes on to describe both favorable and unfavorable activities for each learning style.

Finally, facilitators could choose which tools to select for presenting the ideas of system dynamics to groups. The core of the proposed concept is that by selecting systems thinking tools that homogeneous groups both prefer and use freely, participants would be more likely to accept the ideas of system thinking and system dynamics as tools for use in problem applications.

References

1. Cavaleri, S. (2002). "Evaluating the Performance Efficacy of Systems Thinking Tools", Proceedings of the 20th International Conference of the Systems Dynamics Society. 2002. Palermo, Italy. 57.

2. Cavaleri, S. and Sterman, J. (1997). "Towards evaluation of systems thinking interventions: a case study", *Systems Dynamics Review*. Vol.13. No.2, Summer 171-186.

3. Cavaleri, S and Friedman, S. (2003). "Evaluating Changes in System Thinking Capacity: A Methodology Based on Alpha, Beta, Gamma Analysis", *Proceedings of the 21st International Conference of the Systems Dynamics Society*, New York, New York.

4. Cavaleri, S. and Seivert, S. (2005). *Knowledge Leadership*, Boston, Butterworth-Heinemann.

5. Dechant, K. and Marsick, V. (1993). “The Team Learning Survey”. King of Prussia, PA. *The HRD Quarterly*.

6. Doerner, D. (1980). “On the Difficulty people have in Dealing with complexity”. Simulation and Games. Vol.11. No.1. March.

7. Doyle, J. (1997). “The Cognitive Psychology of Systems Thinking”, *System Dynamics Review*. Vol. 13. No. 3, Fall, 253-265.

8. Durham, J.I.R. (2002). “Balanced Scorecards, Mental Models and Organizational Performance. A Simulation Experiment”, Ph.D. Dissertation, University of Texas at Austin.

9. Durham, J.I.R. (2003). “The Systematic Influence of Scorecards on Mental Models and Organizational Performance”, *Proceedings of the System Dynamics Winter Camp*. 2003. The University of Texas. Austin Texas.

10. Edwards,W and Winterfeldt.D.Von. (1986). “On cognitive illusions and their implications.” (In *Judgment and Decision Making an Interdisciplinary Reader*. Ed. H. Arkes and K. Hammond, New York, Cambridge University Press).

11. Glacel, B.P. (2001).” A Survey for Team Learning”. The 2001 Annual: Volume 2. Consulting, Jossey Bass/Pfeiffer. P.117

12. Grace, M. Learning styles. British Dental Journal. London, England. http://www.nature.com/bdj/journal/v191/n3/full/4801116a.html.Retrieved May 22, 2007. (Note: Caple, J. and Buckley, R. (2007). The Theory and Practice of Training. New York. Kogan Pub.)

13. Graham A. and Senge, P. (1990). “Computer Based Case Study and Learning Laboratory Projects”, *System Dynamics Review*. Vol. 6, Winter, 100-105.

14. Honey , P. and Mumford, A. (1995). “Capitalizing on Your Learning Style”. King of Prussia, PA. *Organizational Design and Development*.

15. Huz, S, Anderson, D. F., Richardson, G.P. and Boothroyd, R. (1997). “A Framework for evaluating systems thinking interventions: an experimental approach to mental health systems change”, *Systems Dynamics Review*, Vol. 13. No.2, Summer, 149-169.
16. Kim, D. H. (1994). *Systems Thinking Tools*, Cambridge, MA, Pegasus Communications.

17. Koestler, A. (1945). *The Yogi and the Commissar*, London, Jonathan Cape Ltd.

18. Kolb,D.A., Rubin,I.M. and Osland, J. (1991). *Organizational Behavior*. Englewood Cliffs, N.J. Prentice Hall

19. Lawrence, G. (1995). “People types and tiger stripes”. Gainesville Florida.Center for Psychological Type.

20. Morecroft, J. and Sterman. J.(1994), *Modeling for Learning Organizations*,

Productivity Press.Portland Oregon. (Currently Pegasus Communications).

21. Murrel, K.L. (1987). "The Learning Model Instrument: An Instrument Based on The Learning Model for Managers". *The 1987 Annual: Developing Human Resources*. UA Associates.

22. Pugh, A. and Richardson, G. (1981). *Introduction to Systems Dynamics Modeling with Dynamo***,** Cambridge, Massachusetts. Productivity Press.

23. Radizicki, M. (1998). *Introduction to System Dynamics Modeling* (Draft). Worcester Polytechnic Institute.

24. Richmond, B. (1993). "Systems thinking: critical thinking skills for the 1990s and beyond*", System Dynamic Review,* Volume 9 Number 2 Summer. 113-133.

25. Saeed, K. (2003). Articulating developmental problems for policy intervention: A system dynamics modeling approach. *Simulation and Gaming*. 34(3): 409-436

26. Senge, P. (1990). *The Fifth Discipline*, New York, Doubleday/Currency.

27. Sterman, J. (1994). "Learning in and About Complex Systems". *MIT Paper D-4428.* Cambridge, Massachusetts, Massachusetts Institute of Technology.