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Bridging Information Systems and Workplaces with Unified Systems Language (USL)

Yoichi Masuzawa
Shumei University, Japan, masuzawa@mailg.shumei-u.ac.jp

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masuzawa@mailg.shumei-u.ac.jp

ABSTRACT

To solve some problems in the current workplace, this study attempted to utilize unified systems language (USL) based on information science and linguistics. The USL method is applied to a job in one of the service industries in Japan and is proven to be valid motivating both employer and employee to achieve a harmonious relationship. This study also finds that efficiency rates are strongly correlated to the degree of environmental factors in the workplace. In other words, the degree of workplace efficiency can be measured and controlled by the environmental factors clarified by USL. It is concluded that the USL application to designing workplaces, i.e., bridging information systems with workplaces by unifying natural/ modeling/ systems/ non-verbal languages should be promising to further enhance the integrated workplace-management with an ecological approach (EA).

Keywords

Systems Analysis, Systems development, Unified Systems Language, Modeling Language, Ecological Approach

INTRODUCTION

In the last two decades, Japan has seen an increase in temporary employment, especially for younger workers (Ministry 2014, 2015, 2016, Institute 2008a,b, Cabinet 2005,2008). To address the problem, this study attempted to utilize the *unified systems language* (USL) based on an *ecological approach* (EA). As for the employment problem, the significant employment issues are stated below based on distinguished articles issued by both Japanese and overseas reliable/ influential media in 2006-2016. They are also supported by statistics issued by reliable official or public statistics agencies such as labor white books. Here, the term "*freeter*" (*free* part-*t*ime work*er*) is defined by the Japanese Ministry of Internal Affairs as part-timers aged between 15 and 34. Excluded are students and married women.

i. Deductive skill based on behaviorism: Hoping to reduce costs, companies often hire temporary, unskilled workers called *freeters*. This mechanical way of handling workers who cherish deductive (not creative) skills must be changed.

ii. Less-collaborative workplace: In order to alleviate the high turn over of new *freeter* employees, companies have been exerting communication training which has been neither successful nor effective. One reason of the failure might be the task process in actual workplaces, which do not support dynamic and/or synthetic teamwork.

iii. Static/analytic strategy: The countermeasures of government and industry (subsidies, job-card: personal data enlisting system, etc.) are not sufficient. Moreover, these countermeasures sometimes have severe side effects such as social costs, a heavy tax burden, privacy problems etc., because of the static/analytic strategies. The countermeasures, therefore, should instead be flexible, dynamic and synergetic.

ECOLOGICAL APPROACH (EA) TO WORKPLACE MANAGEMENT AND INFORMATION SYSTEMS

To solve some of these employment problems, this study attempted to utilize Ecological approach (EA) for human–machine systems with USL. As a practical methodology, EA is characterized by those interdisciplinary methods as job abstraction, closed-loop feedback, bottom-up decision making, self-realization, systems dynamics, intentionality and a knowledge database system in terms of designing not only business work places/environment but also human-machine interfaces including its data flow. This is mainly because both ecology and information systems aim to understand the transaction or exchange of data (information), i.e. *energy* between and among human and its environment. Therefore, many of ecological approach papers often point out that the efficiency of business should be supported by *synergetic* teamwork in workplaces (for details, refer Gibson 1979, Flach et al.1995, Kirlik 1995, Rusmussen & Pejtersen 1995, Saito 1998, Campion et al. 2005).

As a result, the present study formed the points which characterize EA method for solving work place problems as Table 1 below:

	Workplace Problem		Workplace Management
	Target	**Requirement**	**Ecological Approach(EA)**
1	Rationalization ability	*worker oriented environment*	jobs abstraction for within- and inter- sectional work analysis and integrated management system
2	Communication ability	*collaborative task process*	closed loop feedback system between workers and managers
3	Self-realization	*discretionary task performance*	bottom up decision making system for well-motivated workers (employees)
4	Incentives	*intentionality in performing tasks*	intentionality (*Intentionalität* /power of mind for performance: Husserl 1913) in performing tasks through all these processes 1,2,3,5
5	Flexible job design and performance	*dynamic analysis*	information and communication technology based knowledge sharing system

Table 1. Workplace Problem/ Management – Ecological Approach Relationship

REALIZATION OF EA THEORIES AS UNIFIED SYSTEMS LANGUAGE

The present study especially attempts to solve employment problems by realizing EA method as upper/lower stream of systems development and USL as core technology. USL is an interdisciplinary method of translating business languages (natural language) into modeling languages (ML) i.e. DFDs (Data Flow Diagrams), ERDs (Entity Relationship Diagrams), Mini-specs (Miniature specifications), universal modeling language UML and object constraints language OCL(OMG 2003). USL includes information systems development, software design, and/or programming language generation process. USL also includes non-verbal data for describing environmental factors such as audio-visual and numerical analysis data which can be used for business process innovation through bottom up decision making, closed-loop feedback system, job abstraction and knowledge database etc. USL also can bridge NL with other useful languages such as OWL, HTML, XML, and so on. Furthermore, USL connects verbal languages to non-verbal data such as audio-visually analyzed data. This section describes an example of EA implementation utilizing USL with a core database (Multi-Modal-Manual:M3, Masuzawa & Ikeda 2009) which consists of four areas as follows.

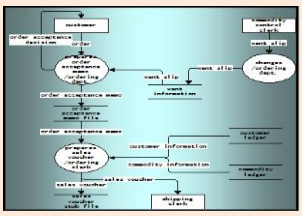
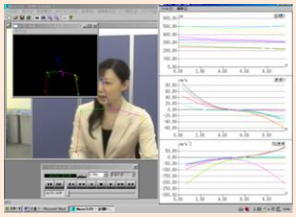
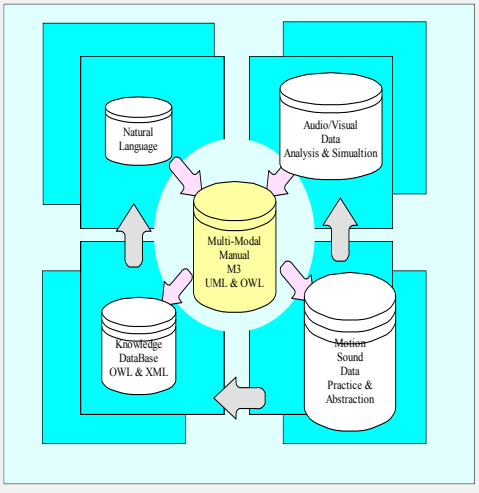
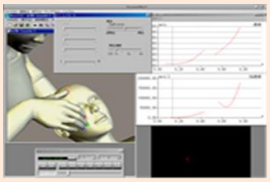
	Verbal system	**Non-verbal system**	**USL overview**
Practice Area	NL and ML manuals or other business materials 	Audio visual data and manual with analyzed data 	
Abstraction Area	Info-sys with Knowledge databases in NL, UML, OCL, OWL, XML etc. 	Audio visual database and/or graphical simulator with analyzed data 	

Table 2. Structure of USL Method

Verbal System - Practice Area

In this area, natural language processing and analysis can be performed utilizing written manuals, jobs descriptions, language processor (sentence parser, word tagger, etc.) in order to produce well-formed written procedure manuals and guidebooks. First, USL analyzes natural language, i.e., business manuals, in order to produce some important system modeling languages

– DFD, ERD, Mini-specs etc. A machine translation processes i.e., *analysis, transformation,* and *generation* (Jurafsky & Martin 2008) can be applied to USL, such as analysis, inter-language and systems language generation process. To carry out the above steps, basic technologies have been invented. They are *structured inter-language*, "***modified"*** *Case Theory*, and *authentification.* The basic theory of analysis and conversion utilizing the structured inter-language is the ***modified*** *Case Theory* based on cognitive linguists' work (Fillmore 1966, Fauconnier 1997,2003, Tomasello 2003, Masuzawa & Ohori 2005, Masuzawa & Ikeda 2007). Exchanging business procedures written in structured inter-languages both English and Japanese (deep structure) must be much more effective and precise than exchanging directly between the original natural language manuals (surface structure). All the processes are realized by algorithms (HMM: Jurafsky and Martin 2008) using toolkits as NLTK (Bird et al. 2010) etc. Followings are sample sentences (both natural and structured inter-language) and a systems modeling language representation (DFD diagram: Figure 1) which is translated directly from the inter-language.

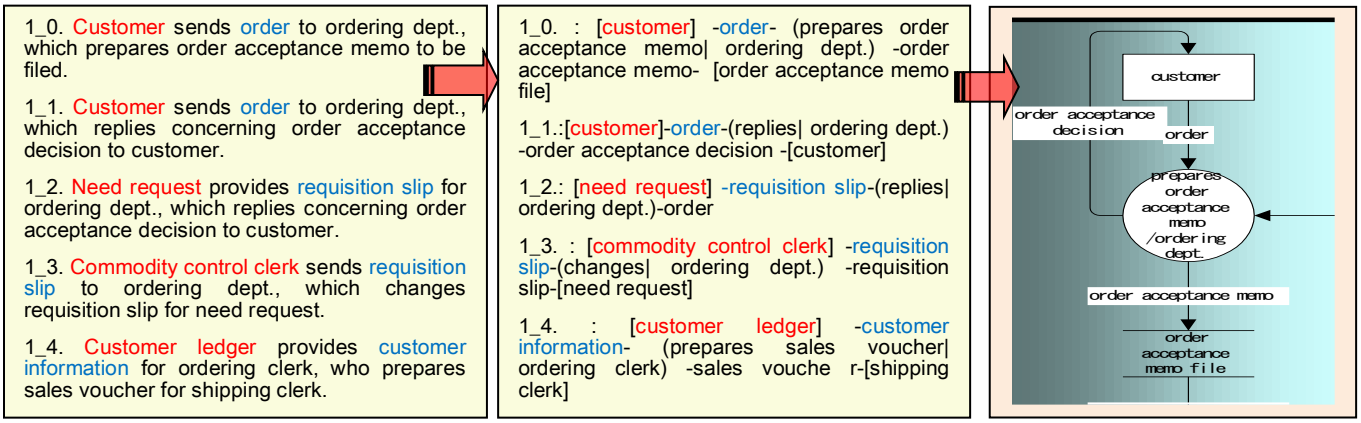


Figure 1. DFD generation (from NL to DFD via Structured inter-language)

Verbal System - Abstraction Area

First, USL's verbal area structures natural languages as modeling language, i.e., structured inter-language, DFD, ERD, etc. as stated above. Then USL's verbal abstraction area bridges structured natural language with all the other useful systems development and analysis languages such as Unified Modeling Language UML, Object Constraint Language OCL, XML and OWL. For accessing structured, analyzed, abstracted and organized written data and materials, USL main portal has been created utilizing Z, VDM and other formal method languages. The portal also connects USL to internet environment directly in order not only for the systems engineer but also for the worker to share the knowledge database with others within INTRA- / INTER-net. This means every worker can be both fully independent and interactive in the bottom-up closed feedback loop. The USL systems can also easily be extended to integrate other systems modeling tools. For example, USL can bridge natural language notation with powerful USE application (Bremen 2012), which is an OCL environment for UML.

Non-verbal (Visual) System- Practice Area

In this area, audio-visual data are analyzed using motion capture with analyzer, eye tracker, and sound analyzer in order to compile informative emotion-oriented systems development, visual manuals and guidebooks. All these sub-components are the integral part of USL system. This area analyzes "emotion-oriented" data utilizing emotional systems methodologies known as emotion-oriented methods which have recently been focused as an important field of software development (Petta et al. 2011). As for the software architecture of USL non-verbal area, the main platform is CLAN (MacWhinney 1995), which includes script, movie, sound synchronization tools and its viewer with syntax/sound analyzer. Motion capture with analyze, Sound analyzer, thermograph, EMG, and other emotion-oriented data analyzers are also integral parts of the USL system. Ontology editor and viewers are TM4L and Omnigator. For systems thinking simulation (Senge 1990), VenSim application has been utilized extensively.

Non-verbal (Visual) System- Abstraction Area

The final goal of the USL is to connect all the languages (i.e. verbal and others such as "emotion-oriented" languages) and convert them into a total system as an integrated knowledge database. Above stated areas also are coherently integrated as a multi-modal manual system. A *pilot* model of the system has successfully been implemented in a company and has been proven to be valid and efficient for daily business re-engineering (Masuzawa & Ikeda 2009). The efficiencies were measured by financial scales such as ROI, ROA, turnover ratios etc. Masuzawa & Ikeda (2009) also found USL is effectively applied through AHP and Conjoint Analyses.

CASE STUDY

In order to solve some of the employment problems described above, this study successfully utilized the EA theory and practice with USL for a solution that could satisfy the employers and employees. For evaluating USL efficiency, this study analyzed the data of 10 trainees of 5 skill (age) groups (**skill level 1**: novice, **skill level2**:junior (1-2 years of job experience), **skill level3**:senior (3-5 years), **skill level 4**: expert (more than 5 years), **skill level 5**:trainer) in the customer service department of a medium sized Japanese company. USL has been proven to be valid by **2-way ANOVA x 5 factors** (5 skill levels x 2 Manuals x 5 factors) analysis. The effects of the implemented USL can be categorized with their counterparts in legacy training systems as described in Table 3 below:

	USL	Legacy Training System
verbal analysis	verbal or language data analysis and structuring/ standardizing	plain (not analyzed or structured) written manual
non-verbal analysis	non-verbal (motion or voice, sound) or environmental data analysis and structuring / standardizing	photo (still) and tape-recorded non-verbal data with written manual without any analysis or structuring/ standardizing
multi-modal analysis	USL (Multi-Modal-Manual M3)	plain manual with photos and diagrams
functional abstraction	functional analysis (abstraction) by integrated USL	non-functional analysis with independent manual
feed-back loop analysis	bottom up feedback loop with mentor/trainee, worker /manager comparison	top down and non-feedback loop without mentor/trainee comparison
total analysis	integrated USL with interactive multi-modal manual	independent legacy manuals and job descriptions

Table 3. Comparison of USL with non-USL (Legacy) method

Five trainees experienced all the USL analysis levels above and were tested. Another five trainees (subjects) had tried conventional (legacy) training system with all the analysis level above and were also tested. In advance of the test trial, all trainees were interviewed and measured according to base skill level (L1-L5) in terms of F1-F5 factors (**F1**: RATIONALIZATION ability, **F2**: COMMUNICATION ability, **F3**:SELF-REALIZATION, **F4**: INCENTIVE, **F5**: FLEXIBILITY) respectively. The effects of both USL and legacy method based training were physically, psychologically and financially measured and analyzed in terms of above stated five **target factors (F1-F5) in 1-10 scale** and the results i.e., improvement rates are shown in Table 4 and 5 representing most of the factors are (significantly or marginally) effective in the case of USL comparing with legacy system.

	Rationalization	Communication	Realization	Incentives	Flexibility
USL vs. Legacy	0.053 +	0.124 +	0.111 +	0.117 +	0.045 *
Inter-skill level	0.068 *	0.102 +	0.346 ns	0.442 ns	0.017 **

+ marginally significant $p<0.20$, * $p<0.05$, ** $p<0.01$, n.s. not significant

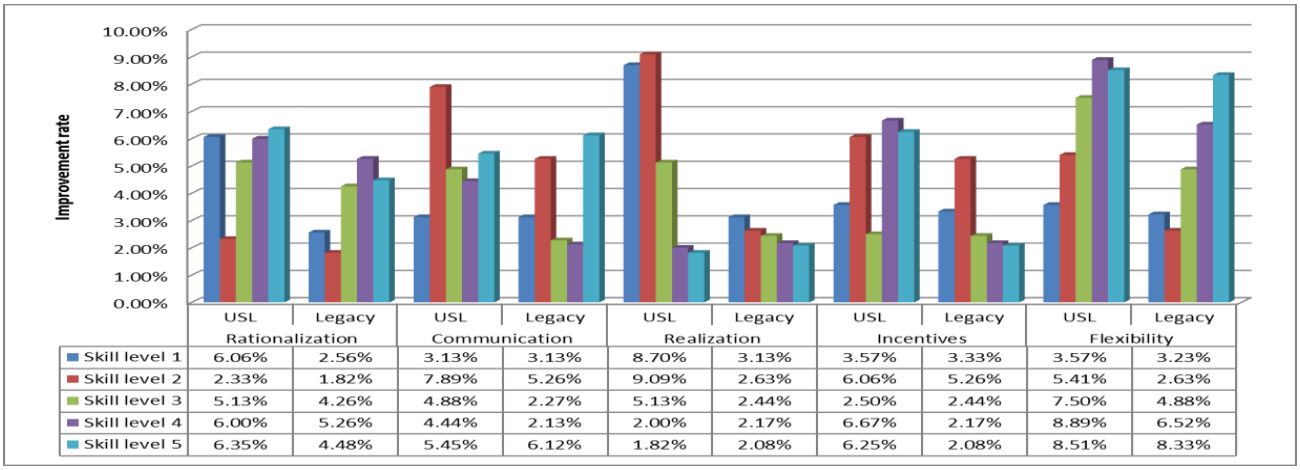
Table 4. Effects of USL Implementation: Results of ANOVA (p value)

DISCUSSION

As stated above, the improvement of working environment accomplished by EA/USL is statistically significant comparing with legacy system. The skill-level-wise analyses are shown below:

L1 Novice level: the rationalization and self-realization factor were improved considerably compared with legacy system because of bottom up decision making and abstraction by clarified job descriptions. This means converting weak manuals sentences into elaborately defined job requirement documents with ML or audio-visual data contributes greatly to establish bottom up closed loop feedback system with self-realization. This is also the case in junior level (L2) with the same reason.

L2 Junior level: realization and flexibility improved greatly owing to non-verbal, i.e., motion or sound data analysis (improved realization and flexibility by 6.46 and 2.78 points respectively comparing with legacy training) and reduced product cost (service cost) considerably. This is because task time has been re-estimated and revised by minute motion studies with USL by junior workers who were self-realized and well-motivated accordingly.



	USL Rationalization	Legacy Rationalization	USL Communication	Legacy Communication	USL Realization	Legacy Realization	USL Incentives	Legacy Incentives	USL Flexibility	Legacy Flexibility
Skill level 1	6.06%	2.56%	3.13%	3.13%	8.70%	3.13%	3.57%	3.33%	3.57%	3.23%
Skill level 2	2.33%	1.82%	7.89%	5.26%	9.09%	2.63%	6.06%	5.26%	5.41%	2.63%
Skill level 3	5.13%	4.26%	4.88%	2.27%	5.13%	2.44%	2.50%	2.44%	7.50%	4.88%
Skill level 4	6.00%	5.26%	4.44%	2.13%	2.00%	2.17%	6.67%	2.17%	8.89%	6.52%
Skill level 5	6.35%	4.48%	5.45%	6.12%	1.82%	2.08%	6.25%	2.08%	8.51%	8.33%

* *improvement rate* = (*improved skill – base skill*)/*base skill*

Table 5. Results of Improvement Rate Analysis

L3 Senior level: Well-balanced improvements are found in those factors such as realization, communication and rationalization. Flexibility (7.5%) improvement is significant. This is because the USL's efficient bottom up feedback loop and knowledge databases expedites the skill acquisition process of the senior workers.

L4 Expert level: All the factors except self-realization have been improved a lot in points, especially the flexibility factor. This is because the intersectional jobs are restructured and reduced through abstraction and feedback-loop processes in order to reduce the red tapes. This is a good example of the combination of abstraction and bottom-up decision making.

L5 Trainer level: Well balanced and significant improvements are found in all the factors except communication and realization, because of the strong impact of USL's multi-modal data on both workers and their supervisors. Trainers however, criticized some parts of USL because they preferred legacy system, which they were already used to. They were also embarrassed by the huge amount of USL data compared with the legacy system and felt redundancy.

As a result, the present study formed the points which characterize EA/USL method as follows:

1) EA/USL realized abstraction-practice-loop for 'self-realization in discretionary task performance' with USL through multi-modal integrated language methods.

2) EA/USL's closed loop feedback system between workers and systems (engineers)/managers realized collaborative task process for synergetic communication,

3) EA/USL's jobs abstraction for within- and inter- sectional work analysis and integrated language/management system realized straightforward rationalized systems analysis and design for both systems (engineers) and workers.

4) The integrated universal language (including audio-visually emotion-oriented data) based knowledge sharing system of EA/USL, especially *multi-modal knowledge database system* realized flexible job design and performance through dynamic information systems analysis.

5) 'Improving and upgrading incentives' is realized by intentionality in performing tasks through all these EA/ USL processes accordingly. These points with others improve the well-being of managers (employers) and workers (employees).

CONCLUSION

First, this study shows that the solution to current employment problems might be *rationalization ability, communication ability, self realization, incentives realized by intentionality and flexible job design*. Second, to solve some of these problems, this study attempted to utilize Ecological approach(EA) for human-machine systems utilized by unified systems language (USL) which has been integrated as information systems development, human resource management and practice for solutions that could satisfy the employers and employees. Finally, this study also describes an example of USL implementation in which the *frame work* i.e., bottom up decision making, closed loop feedback, job abstraction and knowledge database, was applied to an actual job in one of the service industries. The USL method was proven to be valid motivating both employer and employee to achieve a harmonious relationship. This study also finds that efficiencies are

strongly correlated to the degree of environmental factors in working places. In other words, the degree of workplace efficiency can be measured and controlled by the USL factors such as feedback loop, bottom up, knowledge sharing etc.

It is concluded that the USL application to designing workplaces, i.e., bridging information systems with workplaces by unifying natural /systems/ non-verbal languages should be promising to further enhance the integrated Workplace-management with an ecological approach (EA). However, further implementation of USL practitioners may require a sort of detailed tools whose development is beyond the author's efforts and to be presented elsewhere.

The author presented the first USL paper titled "Should Information Systems be Categorized ?" at the SAIS conference in 1999. After 18 years of research, the tentative answer is "it should be synergetic."

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