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ABSTRACT

This paper discusses the assessment of learner strategies in the computer-assisted language learning context. It first reviews empirical studies, including two recent projects that have used the computer to record the interactive process where second language learners demonstrate different on-line language learning behavior, operationalized as types of learner strategies. Types of strategies included cognitive and metcognitive strategies such as resourcing, monitoring, practicing, or self-evaluation. The paper then illustrates the detailed process of data gathering, unitization, and interpretation. The findings and data collection techniques provide researchers in other fields with a new horizon where different sources of second-language learner data can be triangulated to help uncover the second language acquisition phenomena. Advantages of the powerful computer recording capacities lie in its accuracy, real-time immediacy, reliability, and compact storage space. It is argued that computer-based data collection methods are meant to complement other traditional methods, especially when the former are constrained. (Contains 28 references.) (NAV)

Assessing Learner Strategies Using Computers: New Insights and Limitations

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ABSTRACT

In computer-assisted language learning (CALL) environments, exchanges between (a) the input directly given in the material, or optional resources upon learner request, and (b) what the learner already knows become interesting as the electronic materials proliferate. This paper discusses the assessment of learner strategies in the CALL context, and the pros and cons. It first reviews the empirical studies, including two of the author's recent projects, which have used the computer to record the interactive process where L2 learners demonstrate different on-line language learning behavior, operationalized as types of learner strategies. The available literature has covered the areas of grammar learning, writing, reading process, and listening and viewing (video) comprehension. Types of strategies included cognitive and metacognitive strategies such as resourcing, monitoring, practicing, or self-evaluation. The data help applied linguists to better understand such situated learning, i. e., in CALL, by providing insights into the interaction between input and learners. The paper then illustrates the detailed process of data gathering, unitization, and interpretation. The findings and data collection techniques provide researchers in other fields a new horizon where different sources of L2 learner data can be triangulated to help uncover the SLA phenomena. Advantages of the powerful computer recording capacities lie in its accuracy, real-time immediacy, reliability, and compact storage space. However, the mechanical method has its limitations. It is argued that computer-based data collection

methods are meant to complement other traditional methods, especially when the former are constrained.

I. INTRODUCTION

The state of the art of the learner strategy research tell us that good learners are believed to be able to use effective strategies such as making inferences, using deduction, or seeking clarification (e. g., O'Malley & Chamot, 1990; Oxford, 1990; Weinstein, et al., 1988; Wenden & Rubin, 1987). Nevertheless, the field has been facing challenges in research methods. Namely, how to collect valid data that show what learners are rea'ly doing on language learning tasks. Rees-Miller (1993) raised the issue in a recent TESOL Quarterly article: "it is questionable whether they [cognitive learning strategies] can be specified in terms of observable, specific, universal behaviors that could be taught to or assessed in students ... in order to know whether teaching has been successful, teachers must be able to observe students performing the technique and how that the behavior observed indicates that students, from whatever culture, are practicing the target strategy" (p. 681). Indeed, both the language teachers and researchers need to observe learners in a way which is consistent, observable, specific, and universal so that the evidence can be easily cross-validated and thus disseminated.

O'Malley and Chamot (1990) have raised a framework for strategy data collection of which the elements and considerations are summarized in Table 1.

Table 1 Framework of Strategy Data Collection

Six Elements	Detailed Considerations
Objective of data collection	1. declarative/procedural knowledge of strategy 2. overt/covert strategies 3. types of strategy
Language task	1. L1/L2 2. modalities 3. specificity
Temporal relationship	1. simultaneous introspection 2. immediate retrospection 3. delayed retrospection 4. predicative introspection
Informant training	
Elicitation procedures	1. language 2. degree of structure 3. oral/written response
Individual/Group data collection	

In conducting strategy research, issues concerning validity and reliability of methods, more importantly, have been raised among common ways for assessing strategies. The classroom observation skill used in early good learner research can record only student's overt behavior. Teachers tend to focus on product than on process and need extra efforts to verify the observers' interpretations of learner strategies; thus, the approach may be tedious and unproductive. Further, Naiman et al. (1975) pointed out that very few learning techniques could be overtly displayed in the classroom. The class observation approach is limited to students who speak up, but says nothing about those who remain silent. Further, consistency of observation is hard to maintain. Such research may require two observers to ensure the reliability. A more difficult problem is that we do not know how typical a learner's observed behavior is. In other words, are the observational data consistent across day one and day n, or are they just idiosyncratic which happen in day n? The self-report methods--including introspective,

retrospective reporting, and think-aloud--rely heavily on student's ability to observe and report on their learning, although they can be done easily and usually obtain useful information about learner strategies. Among them, the common strategy questionnaire method further has the drawback of asking respondents to imagine a situation mostly using generalized statements and determine what they would do in it. The responses may be based on imagination when students probably idealize what they would be--labelling themselves. On the other hand, the questionnaire designers may have already had a theory in mind beforehand to design the questionnaire, or interview questions. Thus, the responses may not be elicited or interpreted objectively (Ericsson & Simon, 1984).

The think-aloud method, popular recently, can avoid some of the pitfalls mentioned above. In thinking aloud, the subjects actually perform a task and report what they are doing while they are doing it, or right after they have finished. It, however, has to be carried out with care because it itself has some inherent weaknesses. For instance, the think-aloud protocol would be poor when the reporting method is unsatisfactory: information not attended to, only part of the information actually reported, or only part of the information retained and thus retrievable.

Advantages of the powerful computer recording capacities lie in its accuracy, real-time immediacy, reliability, and compact storage space. Some scholars (to be enumerated shortly) have used the computer to record learning process while learners are using the computer software for language learning purposes. There are three advantages of computer log data. First, it can record learner behavior over different sessions systematically and consistently so it is easy to obtain average performance. Second, the data are not based on imagination; they are recorded while learners are actually using the learning materials. Last, the data show observable behavior, and thus, they can be universal as long as learners across countries or cultures can have access to the same CALL materials. Limitations of assessing strategies using computers will be discussed in the following section later.

Cohen (1987) used six factors to contrast common methods mentioned above. Comparing the think-aloud method and computer log tracking based on the six factors proposed by Cohen (1987), we can see the results in Table 2.

Table 2 Comparison of Think-aloud and Computer Tracking Methods

factors to be compared	think-aloud data	computer log data
# of participant	individual+investigator	large group w/o investigator
research context	other context	class or other with computer
recency of event	high	high
mode of elicitation&response	oral	oral or written
formality	low	flexible (determined by program design)
degree of intervention	low	almost none (controlled by program design)

For the number of participants involved, the computer tracking seems more efficient because it can allow many subjects at a time as long as the machines are available. Wherever the CALL materials for language classes are available, the computer tracking program can work inside or outside the class, whereas the think-aloud normally is conducted outside of the class because it is done one by one. Both of them have high recency of the language learning events. While the think-loud is elicited in oral mode, the computer tracking facilities allow both oral and written modes. The formality of the think-loud is low, but the computer program is flexible depending on how it is designed. Normally the think-loud has low degree of intervention, but the computer program can have none which is again controlled by the program designers.

II. ASSESSING STRATEGIES USING COMPUTERS

In this section, a review of literature which summarizes language learning research that has used computers as a tool is discussed. Then, the procedures of using

the computer tools to collect and interpret strategy data are illustrated through two of the author's recent research studies. Last, the limitations of the method are discussed with future perspectives.

Review of Literature on Strategy Research in CALL

In computer-assisted language learning (CALL), exchanges between (a) the input directly given in the material, or optional resources upon learner request, and (b) what the learner already knows become interesting as the electronic materials proliferate. Use of the optional resources, or on-line help can be operationalized as evidence of use of a kind of cognitive strategies, resourcing (Oxford, 1990; Chapelle & Mizuno, 1989). Resourcing is an important strategy investigated because this is an inherent advantage in CALL materials. As a desired feature in designing electronic instructional media, it immediately assists learners during the process. But whether on-line help is useful, how often learners tend to use it, what kind of help is crucial for a particular type of task, and how the help influences language learning remain unclear to computer-assisted language learning (CALL) researchers and developers. Several studies of on-line behavior and strategies have been conducted as summarized in Table 3. Back in PLATO IV period, Curtin et al. (1981) initiated such research. They recorded student users' log key presses, judged answers, requests for help, and working time per session. They suggested that the on-line data helped predict successful learners' performance, but for weak learners, further investigation is needed. Garrett (1982) asked subjects to work on PLATO courseware semester long and recorded their performance, believing that the computer tracking facilities make classroom observation convenient and precise through the simultaneous collection of data from several individual students. Additionally, she used methods that combined classroom observation, teacher hunches, and on-line data to study German interlanguage development of English native speakers. Last, she proposed a system that conducts ongoing classroom research that feeds directly and immediately back into classroom teaching and learning. Later, Jamieson and Chapelle (1987) inferred three types of on-line data as language learning strategies in an audio dictation lesson and a spelling computer lesson among the PLATO ESL courseware. The amount of time elapsed

between the end of the audio input and the time that the student pressed the first key to begin to answer was inferred as a strategy of advance preparation. At that time, they did not consider the time when subjects were idle without doing any learning. Monitoring output was inferred by the editing tasks subjects did in their answers. Monitoring input was the number of times subjects chose to have audio clues repeated. They found that two cognitive styles, impulsivity and field independence, were both independently related to fast response time. The field independent subject was a fast and accurate worker who edited his response; an impulsive subject worked quickly, but a reflective subject listened more to audio cues in the courseware and worked slowly.

Table 3 Summary of the Studies which Used Computer Tracking Method

studies	language skill or language+	*FOCUS or strategies investigated	
		cognitive	metacognitive
Curtin et al. 1981	+Russian	*error rate & time on task	
Garrett, 1982	+German	*interlanguage development	
Chapelle& Jamieson, 1987	spelling, dictation		advanced preparation, monitor input, monitor output
Chapelle& Mizuno, 1989	grammar	practice, resource (online help)	self-management self-evaluation self-monitor
Jamieson et al. 1992	reading	various (use questionnaire data)	various
Bland et al. 1990	writing	*language development	
Gildea et al. 1990	vocabulary	various resourcing strategies	
Chou, 1992	reading	skim organize macro-textual	
Hsu, 1994	listening	various resourcing strategies	
Liou, 1994a	reading	read local spots, post-read, pre-read	

Liou, 1994b	viewing	various resourcing strategies	

+ those not mentioned are for ESL/EFL learning and when language is mentioned, it targets at various skills.

* when strategy is not mentioned, the study is focused on other language learning issues.

Chapelle and Mizuno (1989) investigated how ESL students used strategies in a learner-controlled grammar lesson at a VAX system. Different students' on-line behaviors were again operationalized as strategies while using their grammar CALL lesson, based on language learning theories. For example, the self-management strategy was inferred by students' use of feedback messages to pursue plans. Results indicated that some students did use various on-line strategies but they did not always use the optimal strategies. No significant group differences were found among different learners of two proficiency levels. They suggest that the type of data collected in the study is essential for understanding second language acquisition and developing intelligent courseware which is sensitive to students' needs.

Jamieson et al. (1992) collected various types of student data in order to classify learners into successes, failures, and dropouts in CALL context. The data they used included notes subjects took, recall, and recognition test scores in an on-line reading lesson, and attitudes. In addition, they collected data of individual student characteristics (age, sex, first languages, second languages, field dependence/independence measures--a cognitive learning style), learning strategy use (by a questionnaire), and course information (various kinds of grades, and credits). They used the discriminant function analysis as the multivariate statistic to investigate all the data, and successfully differentiated the three groups of learners. They suggest that such research can help at-risk learners, and strategy training can be programmed into the computer courseware.

Hsu, Chapelle, and Thompson (1993) sought evidence for learner use of exploration strategy, experimenting and hypothesis-testing about the target language. Results indicated that learners explored the CALL environment in a routine way, but failed to creatively explore the morphosyntactic possibilities in their grammar courseware. As for learner group differences, routine exploration was correlated

positively with attitudes of intermediate learners, but negatively with the advanced group. On a French writing task, Bland, et al. (1990) analyzed subjects' request of glossary help and documented types of help employed as evidence of the learner language development. The types of on-line help request are classified as (a) token matching for complex morphological queries, phrase search, and search for lexical representation of grammatical concept, (b) type matching for base form and grammatical relationship searches, and (c) relexicalization -- using the first language or the second language (L2) paths -- for syntactic or semantic circumlocution.

Gildea, et al. (1990) launched a series of experiments to investigate how contextual enrichment in interactive videodisc material can help vocabulary learning for preschool children. They were not driven by perverse affection for modern technology but feeing that simpler instructional method was not enough. Important findings regarding types of enrichment in definitions, pictures, and illustrative sentences are:

1. Children did know when to initiate look-up, but did not know what information to ask for.
2. The children with help of illustrative sentences outperformed all others on multiple-choice tests. Definitions added very little, and actually detract from performance over time.
3. Pictures significantly improved sentence production for many words.
4. Helpful contexts for learning, i. e., effects for various kinds of help, were not additive. (p. 25)

In EFL context, Chou (1992) investigated the effects of four kinds of help in a hypertext reading program: text only (no help), text with on-line vocabulary help, text with on-line sentence structural analysis, and text with strategy help (strategies of skimming, organization, guidelines to each paragraph, and supplementary information). He then randomly divided 39 high schoolers into four groups to work on the four versions. He found that types of help did not make a difference on reading comprehension among groups of subjects. His questionnaire data show that subjects think the vocabulary help was the most useful, and was used the most frequently. Hsu (1994) in her dissertation project found that text reinforcement type modifications in a

CD-ROM English listening material were most effective for learner improvement in comprehension; the oral repetition help was the second effective. The dictionary help was found ineffective because the subjects were at very beginning level who could not make good use of such online help. Li (1994) investigated whether active or passive on-line help in an IVD unit was beneficial and found that active online help facilities were more frequently used; the other types of help were not used because subjects were not aware of their existence. He suggests that learners of French did need active guidance in using CALL material. Liou (1994a) and Liou (1994b) will be discussed in the following section.

Illustration of the Procedures: Examples

Twenty EFL college students participated in the study (for a detail report of the study on quantitative analyses, see Liou, 1994b). While subjects were viewing a video clip and answering questions posed in the program, their on-line history of help requests was recorded in a record using a database, dBASE format as shown in Table 4. The design was implemented in the courseware beforehand because the author had research agendas in mind.

Under BACKWARD, the numbers represent the record that a particular segment of the video was recalled and replayed upon request. The data in the record reflect quantity and quality of strategies use based on different help requests. Each record in our study has 13 fields as in Table 4.

Table 4 A Record in the Computer Log File

```
==========================================
ID NUMBER= 821201
NAME= Sherry
DATE= Thu Dec 02 1993
END_FRAME= 21688
PAUSE= 6789 12099
BACKWARD= (6824-6700)(11866-11798)(19339-18876) video frame range
CHINESE= (7890--ON)(12980--OFF)
ENGLISH= (5498--ON)(6588-OFF)(12390-ON)
GIST= 19058 19558
BACK_INFO= 19058
REPEAT= 19058 19058 19588 19588
REPEAT_P_SENT= 19058 19588
WORDS= (19058--ectoplasmic)
==========================================
```

We can re-construct the input processing process based on the record. Since the subject finished at the point of frame number 21688, we could check our data to know that she quit from the unit after she finished question item 28. She paused twice at frame numbers 6789 and 12099, replayed the video from frame numbers 6824-6700 and the other two ranges. At frame number 7890, she asked for the Chinese script help and turned the help off at 12980. She asked the English help at different points and left it on from 12390 till the end, 21688. She requested GIST help twice at 19058 and 19588 (a text summary for each video clip). Apparently she was stuck there by the word, "ectoplasmic" as indicated by the word checked, repetition of the sentence twice (REPEAT), and repetition of the previous utterance once (REPEAT_P_SENT). She used the two kinds of repetition help, Repeat and P_sent, at 19588 as well. She requested BACK_INFO help at 19058 (to get extra information for the setting other than explanation or content of the utterances in the video). Word and Idiom searches were saved under the field of WORDS.

It was found that the occasion when subjects looked up the unknown words happened only after they requested the English script help. This makes sense for if one does not know the meaning of an acoustic form, he or she rarely can spell the word out.

In the later data analysis, all the frame ranges in the data were standardized by numbers of comprehension question items covered within. Because each individual frame number is too small as a functional unit, whereas the laserdisk was not coded by the time such as minute or second unit. A logical unit is the frame range from one question to another one. That is, 54 units. Note the unit is categorical, not scalar because the frame ranges among question items vary in video length. This is one way to unitize the data because the video information subjects have accessed has seldom been studied and its units are hard to quantify. To fulfill language learning purpose, we devised such a way to unitize the data.

Concerning the levels of functions and linguistic or processing factors in the computer learning material, further analyses can be made based on the two variables, together with the actual help requests made by language learners.

In this specific computer program, on-line help has two function levels: the video control level, and the comprehension level. In the first level, video control, two functions may facilitate input processing: PAUSE and BACKWARD. The PAUSE retains visual information of the video, and provides a way to gain more processing time. On the other hand, the BACKWARD enables re-access of both visual and audio input in larger chunks (than repeating only one utterance), so it is used the most often among the nine functions. On the second level, similar comparisons can be made. It was found that both the Chinese and English script help functions have high frequency of use because they provide all audio, visual, and textual information. The English script gets higher frequency because our subjects are English majors--they perceive the English script more helpful, based on actual usage statistics, compared with that of the Chinese script. Gist, background information, and glossary (the smallest text unit) are used infrequently because they give only static textual information. The Gist, though with information for larger units than the other two, loses preference from users because the text style is very formal and thus difficult to understand. For background information, another factor to consider is whether the users can see the relevance of it to the video. This can be verified because we have collected perception data by a questionnaire instrument in Table 4. The data show that only 35% of the twenty subjects reported the background information help was useful; apparently it was not

deemed relevant nor helpful. Although REPEAT and REPEAT_P_SENT give audio and visual information, the input unit is much smaller compared with that of BACKWARD. The results are summarized in Table 5. The actual use statistics showed that they were used infrequently.

Table 5 Comparison of Various Kinds of On-Line Help

linguistic or processing factors

level of function	frequency of actual use	text/audio/ visual	unit size of process-ed input	freq. reporte d%@
1st Pause	low	visual/*more processing time	0	85%
1st Backw	highest	audio/visual	large	85%
2nd Chinese	3rd highest	L1text/audio/ visual	can be large	55%
2nd English	2nd highest	L2text/audio/ visual	can be large	80%
2nd Gist	low	text	large	50%
2nd Backg Info	low	text	irrelevant	35%
2nd Glossary	low	text	smallest	80%
2nd Repeat	low	audio/visual/ *reinforcement	small	70%
2nd Rep-P-sent	low	audio/visual/ *context	small	80%

@ the percentage here indicates the proportion of 20 subjects who reported useful for a particular kind of help in the questionnaire

The high usefulness frequency reported in the Backward function, 85%, is reasonable and can be validated in subjects' actual use of the facility. But the one in Pause is strange because it was not used often, nor were the glossary, Repeat, and repeat the previous sentence functions. The high frequency reported in English script request could also be validated in it actual use, but the low frequency in Chinese script

request again was again puzzling. There is discrepancy between how often subjects actually used the help and how useful they felt.

Functionally speaking, the first-level facilities are more convenient to use than the second-level ones, and the two functions received the highest reported usefulness rates. If we can equate what learners actually use with what they believe useful, then two tentative conclusions can be drawn in this study. First, input with more modes is preferred than that with less, and thus used more often. Second, re-access of input with larger units is preferred to that of smaller, and thus accessed more often.

In the second study (for detail, see Liou 1994a), 14 subjects with different English proficiency levels were reading an article in the same way as that in the paper version of Mosaic II except that all of the words displayed on the computer screen are linked to the entries of the Longman English-Chinese Dictionary of Contemporary English (Longman, 1978). All the words consulted are recorded by the computer which help infer reading strategies (see Table 6 for records of two subjects). One important strategy found in Liou (1994a) is the strategy of re-reading local spots. To unitize the strategy data is like what other researchers have done: operationalize, or infer the frequency of strategy use based what we know about what learners are doing in CALL context.

It is found that learners did use the glossary help to assist reading comprehension, but might not be able to use the optimal look-up strategies. She investigated three groups of EFL learners who read an article with the Longman bilingual English/Chinese dictionary entries linked to each of the words in the reading text. Examining the individual log files of words consulted by the computer, we could find the order of words looked up. Compatible to Hulstijn's data (1993), most of them were linear within paragraphs or even within the passage. There were some incidents that subjects went back to look up words in the previous sentences to reconfirm their initial hypothesis, which was then defined as the strategy of re-reading local spots. As readers' proficiency decreased, the frequency of use of the re-reading local spots strategy increased. Namely, the strategy of re-reading local text strategy was found to differentiate the three groups of learners of various proficiency levels, but those of re-reading globally and pre-reading did not tell various learner groups. Interestingly, two ineffective word consultation strategies (of the on-line Longman dictionary) were documented: ignoring key words, and choosing incorrect word senses in the multiple dictionary entries. The best learners were found to skip some key words and not look

them up in the dictionary.

Table 6 Consulted Words in the Computer Log File (based on Mosaic II: Reading)

	S3	S5
PRE-READING		
	irony	chill
		spine
		brevity
		#brevity
DURING-READING		
	archaeology	archaeology
	gaps	gaps
	divine	#gaps
	flung	flame
	fling	#flame
	strands	divine
	skeleton	#divine
	calcium	flung
	compound	fling
	titanium	#flung
	spares	#fling
	needle	skeleton
	cutoff	calcium
		titanium
		learnedly
		thermostat
		circuits
		kit
		#kit
		spares
		needle
		cutoff
POST-READING		
	downfall	moral
		downfall
Total words	16	29

#: word looked up the second time by the same subject

It is interesting to note the process data shown in Table 6. S5 clicked on "flung," the dictionary entry gives "the past tense of fling" so she clicked on "fling." It seems that she could not figure out the context and select a proper word sense, nor

retain it. So she went through the process again. Data of this type could be difficult to capture if without the use of the hypertext and the tracking programs.

Limitations and the Prospective Solutions/Research Directions

The major disadvantage of on-line hard data recorded by computing tools is that the learning materials are very much context-bound. The computer can record only particular kinds of data, constrained by the types of interaction designed in the courseware. Further, it is crucial to find a universal framework to describe learner-computer interaction such as the discourse framework proposed by Chapelle (1990; 1994), so the CALL profession can communicate and disseminate information. The state of the art for the taxonomies of CALL activities vary greatly from one to another. The third limitation is that traditionally, it does not, or cannot record student own spontaneous explanation of their process. But the modern technology has come to solutions recently which can record users' voice input as well as visual images.

Other Potential Research Agendas

Nowadays, the technology has new potentials in multimedia or hypermedia-type courseware where students have much freedom navigating in the environment. Student decision-making, which demonstrates higher-level cognitive skills, and other highly individualistic use of hypermedia systems become issues which can again be observed. Depending on how sophisticated the hardware and software support an institute has, a researcher can collect a huge range of on-line hard data as assessment of student strategy use.

Gay and Mazur (1993) summarize new multimedia tracking programs in five formats: customized tracking, records of written products, interaction histories, on-line recorder, and player piano. One possibility for such a range of on-line data is that users can view their previous steps in the program, plan future moves, and reflect upon work in progress if tracking data are made visible, namely, investigating learners' metacognitive moves. Meanwhile, since network use computing facilities become widespread, specific communication activities in the network system can be used as on-line hard data. For example, orientation, directives, clarification, social exchanges,

acknowledgements, and requests for information (Gay & Mazur, 1993) are important communicative acts in language learning settings (e. g., Liou 1995 studied such cooperative learning interaction). In an ambitious large-scale research project, Huang (1994) and his colleagues are trying to compute the degrees of concentration and willingness of learning in learners. To illustrate, the degree of concentration is obtained by dividing the effective session time (common session time minus ineffective session time, defined and examined by the talking protocols which contain few key words after the key-word matching procedure is examined) by the complete session time. He would use some fuzzy reasoning to figure out the parameters, together with others, to enable the network system with an intelligent computer manager which can provide adaptive teaching strategies.

In the near future, multimedia tracking programs would allow users to review and annotate real-time records of their use, a variation on the think-aloud protocol technique. Second, new tracking systems evolving into multimedia formats have their accompanying expressive potential, amenable to transformation into other useful computer formats which aid both qualitative and quantitative analysis, such as spreadsheets.

The tracking function can thus be expanded to fulfill applied linguists' research agendas. For example, in Liou (1994a) reading program which has the only simple capacity of recording glossary help, it can be complemented now by another facility in Liou's system (1995), reading time for each page in a hypertext program in addition to glossary use log. In Liou (1995), the IVD courseware is implemented to include training of strategies, and it can record the number of times when subjects access video material once or twice and time for each session, evidence of use of the advance organizer strategy.

III. CONCLUSION

The findings and data collection techniques in the paper provide researchers in other fields a new horizon where different sources of L2 learner data can be triangulated to help uncover the SLA phenomena. In the computer-assisted instruction (CAI) field, the techniques have been very commonly used. It is commonly believed

by CAI scholars that research using techniques that allow in-depth analysis of how students are constructing knowledge as they work proves fruitful, indicating a new research approach. In a survey article, Gay and Mazur (1993) discuss several kinds of data that computer tracking systems may record: keystrokes, content items seen by the user, navigation strategies, and paths constructed. They point out benefits of such data for learners and courseware developers. Learners may use the data as input of their metacognitive strategies: view their previous steps, plan future move, or reflect upon work in progress. These functions facilitate CALL environments to train learners in using metacognitive strategies such as planning, evaluating, or monitoring. The developers can also use the data to determine the effectiveness, usability, and comprehensibility of the system. This helps develop a functional understanding of how the technology is used. In their paper, Gay and Mazur call for triangulation of both the tracking data and the perception data from learner users. For language learning, the use of several methods, each with their strengths and limitations, allow for cross-validation and thus result in more accurate assessment of strategies and learning process. It is argued in this paper that computer-based data collection methods are meant to complement other traditional methods, especially when the former are constrained.

Computer tracking facilities have limitations: its value for research will be shaped by the breadth and depth of the research questions, namely, constrained only by human beings' intellectual inquiry. As well supported by Chapelle (1994) "technical capabilities for data collection in CALL environments far exceed our current theoretical and analytical capabilities for their description and interpretation" (p. 42). Why are we waiting and keeping from using such a powerful tool in our profession?

References

Bland, S. K., Noblitt, J. S., Armington, S., & Gay, G. (1990). The naive lexical hypothesis: Evidence from computer-assisted language learning. The Modern Language Journal, 74(4), 440-450.

Chapelle, C. (1994). CALL activities: Are they all the same? System, 22(1), 33-

45.

Chapelle, C., & Mizuno, S. (1989). Student's strategies with learner-controlled CALL. CALICO Journal, 7(2), 25-47.

Chou, C. T. (1992). Reading comprehension strategies and computer-assisted English language learning. Research Report (NSC 81-0301-H003-11) National Science Council. Taipei, Taiwan, ROC.

Cohen, A. D. (1987). Using verbal reports in research on language learning. In Faerch, C., & Kasper, G. (Eds.), Introspection in second language research (pp. 82-95). Multilingual Matters, Ltd.

Curtin, C., Avner, A., & Provenzano, N. (1981). Computer-based analysis of individual learning characteristics. Studies in Language learning, 3(1), 201-213. Language Learning Lab, University of Illinois Urbana-Champaign.

Ericsson, K. & Simon, H. (1984). Protocol analysis--Verbal reports as data. Cambridge, Massachusetts: The MIT Press.

Garrett, C. B. (1982). In search of interlanguage: A study of second language acquisition of German syntax. Ph. D. Dissertation, University of Illinois, Urbana-Champaign.

Gay, G., & Mazur, J. (1993, April). The utility of computer tracking tools for user-centered design. Educational Technology, 45-59.

Gildea, P. M., Miller, G. A., & Wurtenberg, C. L. (1990). Contextual enrichment by videodisc. In Nix, D. & Spiro, R. (Eds.), Cognition, education, and multimedia: Exploring ideas in high technology (pp. 1-29. Lawrence Erlbaum.

Hsu, J. (1994). Computer-assisted language learning: The effect of ESL students' use of interactional modifications on listening comprehension. Doctoral Dissertation, Iowa State University, Ames.

Huang, K. T. (1994). A study on an intelligent long distance cooperative learning environment. Ongoing research project of National Science Council, Taiwan, National Chiao-Tung University, Hsinchu.

Hulstijn, J. H. (1993). When do foreign-language learners look up the meaning of unfamiliar words? The influence of task and learner variables. The Modern Language Journal 77(2), 139-147.

Jamieson, J., & Chapelle, C. (1987). Working styles on computers as evidence of second language learning strategies. Language Learning, 37, 523-544.

Jamieson, J., Norfleet, L., Berbesada, N. (1993). Success, failures, and dropouts in computer-assisted language lessons. CÆLL Journal, 4(1), 12-20.

Li, R. (1994). How should online help be given in CALL -- Passively or actively? Paper presented at Computers in Applied Linguistics Conference, Ames, Iowa State University, U. S. A., July 9-13.

Liou, H. C. (1994a). A study on reading and word consultation strategies used

by EFL students with an on-line bilingual dictionary. Paper presented at Computers in Applied Linguistics Conference, Ames, Iowa State University, July 9-13.

Liou, H. C. (1994b). Strategy research for multimedia CALL evaluation. Paper presented at Japanese Association of Language Teachers '94, Matsuyama, October 7-10.

Liou, H. C. (1995). Evaluation of interactive videodisc courseware: A strategy perspective. Paper to be presented at TESOL '95 (Teachers of English to Speakers of Other Languages), Long Beach, March 28 - April 1.

Longman, Inc. 1978. Longman Dictionary of Contemporary English. London: Longman.

Naiman, N. M. Frohlich, H. H. Stern and **A. Todesco.** 1975. The Good Language Learner. Toronto: Modern Language Center, Ontario Institute for Studies in Education.

Norman, D. (1987). User centered design. In D. Norman (Eds). The psychology of everyday things. New York: Basic Books.

O'Malley, J. M., & Chamot, A. U. (1990). Learning strategies in second language acquisition. Cambridge University Press.

Oxford, R. L. (1990). Language learning strategies: What every teacher should know. Newbury House.

Rees-Miller, J. (1993). A critical appraisal of learner training: Theoretical bases and teaching implications. TESOL Quarterly, 27(4), 679-689.

Weinstein, C. W., Goetz, E. T. & Alexander, P. A. (1988). Learning and study strategies. San Diego: Academic Press.

Wenden, A., & Rubin, J. (Eds.). (1987). Learner strategies in language learning. Prentice Hall.