Task Design and Skill Measurement of Data Analysis Phase in GOAL System

YUANYUAN YANG[†1] RWITAJIT MAJUMDAR[†] HUIYONG LI[†]
HIROAKI OGATA[†]

Abstract: Self-direction has been proved its significant value in learning. Data analysis is one of important phase in self-direction which impacts a goal can be achieved or not. In previous research, scholars mentioned it more or less including in other phases of self-direction. Our previous research proposed DAPER (Data-Analyze-Plan-Execution monitoring-Reflect) as the process model for acquisition of SDS (self-directed skill). Data Analysis is treated as an independent phase in that model, where learners analyze their collected dataset to identify whether they have any problem in a chosen context. We built the GOAL (Goal Oriented Active Learner) system by implementing the DAPER process model in the context of learning and health data. In this paper, we introduce details of task design in the Data Analysis phase. Then, we classify 5 levels of analysis skill in SDL(self-directed learning), and introduce indicators for measuring analysis skill, which based on the interaction log collected in the GOAL system.

Keywords: Data analysis, Quantified-self, Self-directed learning, Self-direction skills, GOAL system

1. Introduction

Self-directedness plays a great important role in our life that has been proved by many scholars. As development of digital equipment and learning system, learning behavior is able to be collected and saved in digital way. It provides us chance searching for data-driven way to support learner's self-direction skill. In previous research, we proposed a process model called DAPER (Data-Analyze-Plan-Execution monitoring-Reflect) model [7]. And, we developed the GOAL (Goal Oriented Active Learner) system that allows learners proceed practice of self-direction following DAPER model.

Many scholars described analysis in other phases of self-direction. The common thing is that analysis is treated as a crucial precondition of setting meaningful goals and feasible plans. Data analysis, as one independent phase in DAPER model, is separated from other phases considering its great value in self-direction. In this paper, we explore in detail what data analysis is in the field of SDS and what actions in the system represent their data analysis skill. Furthermore, we overview past methods of measurement of SDS, and give a new method to measure this sub-skill of the learner's.

This paper, elaborates our notion of data analysis as a sub-skill of self-directedness. Based on that we answer the following research questions: *How to rate data analysis skill in the context of the GOAL system?*

2. Related Works

2.1 Self-directed Learning (SDL)

Scholars have recognized the importance of self-direction in the learning context. Practices of Self-Directed Learning (SDL) present as initiating challenging activities and developing personal knowledge and skills to pursue these challenges successfully [3]. According to Knowles(1975), SDL is described as "a process in which individuals take the initiative, with or without the help from others, in diagnosing their learning needs, formulating goals, identifying human and material resources, choosing and implementing appropriate learning strategies, and evaluating learning outcomes"[1]. In past researches of the process, different models of SDL have been proposed by scholars. Candy (1991)'s model comprises personal autonomy, self-management, learner-control, and autodidaxy [4]. Grrison (1997)'s model contains self-management, self-monitoring, and motivation [2]. Loyens, Magda, & Rikers (2008) point out that it generally entails goal setting and task analysis, implementation of the constructed plan and self-evaluation of the learning process [6].

In our previous research, we proposed DAPER (Data-Analyze-Plan-Execution monitoring-Reflect) model to describe the process in exploring SDL with technologies [7]. We developed GOAL (Goal Oriented Active Learner) system based on DAPER model, which contributes to technology solutions of promoting learner's SDS (Self-Direction Skill). Overall, DAPER model is consistent with other models. However, we adjusted our model to search for a data-driven way of improving SDS.

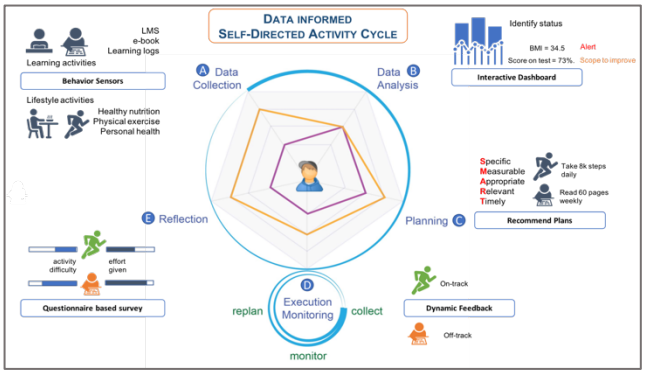

Figure 1. DAPER model of self-direction skill execution and acquisition

2.2 Analysis in SDL

In past researches, scholars mentioned that analysis takes a place in SDL. Some scholars describe it in goal setting and planning phase, and some scholars contain it in reflection phase. Loyens, Magda, & Rikers (2008) say that analyze happens in the starting point of SDL [6]. They state that analysis in the practice

†1 Kyoto University

of SDL is to analyze the task at hand and to determine the task (e.g., what is the task about?) and personal features (e.g., what knowledge can I apply? Do I find the task interesting?). In Thornton (2010)'s research, he mentioned analyzing needs and analyzing current skill in planning phase which is one phase in four phases of a self-directed learning cycle [8].

Furthermore, some scholar defined what analysis skill is in the context of SDL. Noguchi (2014) states that analytical skills is the ability to examine what happened in their learning process in detail and discern the cause and effect relationship among various elements involved in the process [10]. Throughout all those explorations of SDL, the common of their statements is that analysis is about examining learners' propensity and actual situation which leads to successfully pursue challenges.

Similarly, analysis is considered as a crucial element in DAPER model, except that it is as a separated main phase in SDL. It requests learner to get aware of their own situation, trend and current skill level by checking and comparing the collected data. It is an observable action while learner is checking and comparing the collected data though GOAL system.

2.3 Measuring Data-analysis skill in SDL

In the measurement of SDL, interview and questionnaire were widely used in past research. In Williamson's research, SRSSDL (the self-rating scale of self-directed learning), as a self-report way, has been developed for measuring the level of self-directedness in learner's learning process. It covers five areas for scoring, which are awareness, learning strategies, learning activities, evaluation and interpersonal skills. Stockdale & Brockett (2010) designed PRO-SDLS (Personal Responsibility Orientation to Self-Direction in Learning Scale) for measuring self-direction which also belongs to self-report way of measuring SDS [12]. As another method, Noguchi (2014) asked learner advisors speak their thinking process out while they are evaluating and deciding final grades for the submitted module work of their students and he recorded the think-aloud sessions [10]. A list of the criteria of grading has been made based on that record in this research.

Measurement of analysis skill in the context of SDL represents as several questions in the instrument of measuring SDS in past researches. For example, Thornton (2010) designed questions related to analysis in questionnaire. In the context of English learning, learner is asked to answer questions such as "What are your English Wants, Interests, Needs?", "What kind of English do you need for these situations?", "Which of these are the most important for you to improve? (Think about your own strong / weak areas, how important each aspect is, how much work you think you need to do to improve.) ", etc [8]. In another research, Noguchi (2014) introduces two key words "details" and "reason(ing)" -which are considered as two significant aspects that reflect analytical skills-while evaluating learners' analysis skill [10].

However, results getting from these methods significantly rely on subjectivity of learner. On the other hand, a realtime track of SDS's changing is hard to implement since it requires lots of time to evaluate SDS through these ways. We explore the possibility of the way evaluating learners' SDS from their actual performance. We observe their interactions while they are doing analysis, to measure their analysis skill for instead.

3. Designing analysis tasks in GOAL system

Analysis plays a significant role in SDL. In the practice of SDL, learner should know that promoting what kinds of activity is valuable to him. For example, if reading time he spent is below average, it might be rational for him to set a goal for reading. In contrast, if reading time he spent is higher than average, a goal for reading seems to be not so crucial for him. In addition, while learner is planning for his decided goal, the value he set in plan is better to be taken from the result of analysis, since an overload plan leads to fail of execution. So, in order to understand what kind of goal should be set, what a feasible plan should be, it is necessary for learners to know their current situation and current skill. Hence, analysis is essential in SDL. In this section, we design tasks to explain what kinds of actions represent learners' analysis behavior.

In this context, we developed Data Analysis functions in GOAL system, which allow learner to do analyze through system. The collected data shows as bar chart in Data Analysis Page. x axle is time line, and y axle displays data value. Learner is able to choose different periods above the chart. Additionally, maximum, minimum and average value of all users and recommend value exhibit in the chart if learner checked the corresponding items in the bottom of chart. These interactions

No.	Task	Steps	Importance
Task 1	Choose an activity to analyze	1. Open the first page of analysis (figure 2) 2. Click an item in it	It is the starting point of analysis.
Task 2	Check own trend	Select a period in the second page of analysis (figure 3)	Checking trend helps to understand one's situation.
Task 3	Compare with other values	Check option (show max/average/min/recommend) in the second page of analysis (figure 3)	Comparing with other values helps to understand one's position in a group.
Task 4	Check data in detail	Click chart in the second page of analysis(figure 3)	Precise information leads to deeper understanding of one's status.

Table 1: analysis task list

present learner's analysis behavior, such as checking data trend, comparing with other learners. Here we define analysis tasks as interactions of using analysis functions in the GOAL system. Task list shows in table 1.

Figure 2 shows the first analysis page in GOAL system, various activities learner can choose. Figure 3 exhibit the next page after learner choose an activity in the first analysis page. All of the tasks are indicated in Figure 2 and Figure 3.

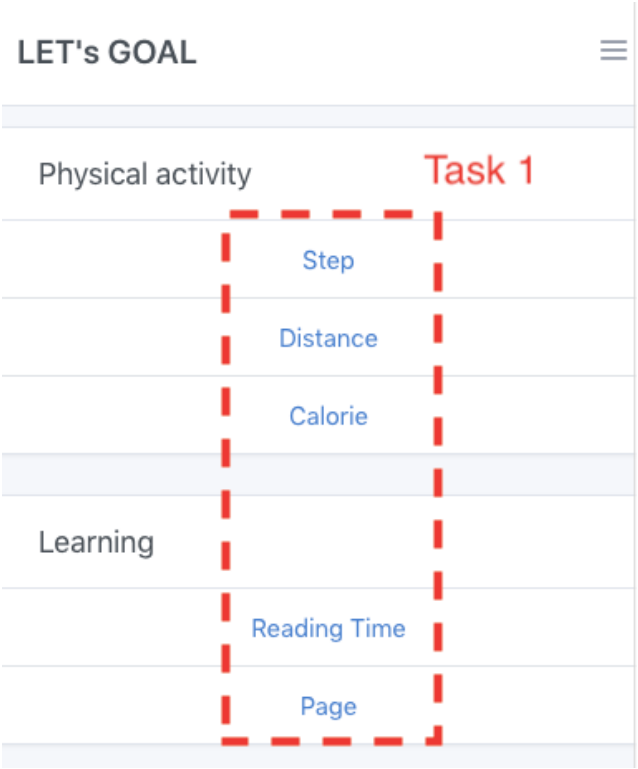

Figure 2: the first analysis page

4. Measuring analysis skill in GOAL system

4.1 Define levels of analysis skill

Firstly, in SRSSDL [11], awareness of self-directedness in learning is considered as one of the important elements in evaluating. In our context, awareness of analysis, means that learner understands doing analysis is a necessary phase and he should take action of it. It presents as the frequency of using analysis functions in the system. More frequently doing using analysis functions shows higher awareness of analysis.

Secondly, in Williamson's, strategy is another important element in scoring. In our context, strategy of analysis means using various analysis tools provided by GOAL system to understand self's status [11]. Whether learner is good at using strategy of analysis also reflects level of their analysis skill.

Thirdly, Noguchi (2014) mentioned that key word "details" reflects learner's analysis skills [10]. Details mean how deep learner understand data. In our paper, interaction in task 4 overlap with this statement. Checking detail data helps learner know the exact gap which relates to setting an effective plan.

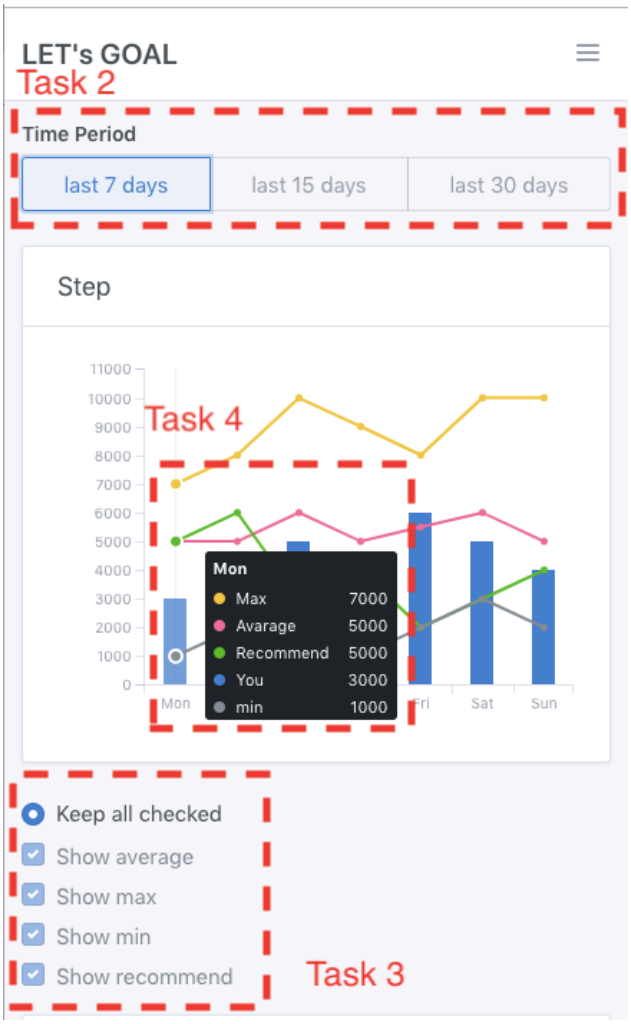

Figure 3: the second analysis page

To summarize, we measure analysis skill based on three perspectives: awareness, strategies and details. Through tasks in GOAL system, what can be observed and relate to these three keywords are frequency of learner do analyze, whether learner checks options and detail data. As we can see, more frequently doing analysis represents learner has higher awareness of analysis. Checking options, in another word, comparing with reference value, shows learner is good at using strategies of analysis. And, checking detail data reflects learner's concern on precise information.

Furthermore, it is noticeable that priority exists among these three aspects. Strategies and details appear to be powerless if learner barely do analysis. On the other hand, even learner checks detail data very often, information he acquired tends to be insufficient if he checked few reference data. Therefore, we can see four different levels of analysis skill, which show in Table 2. This follows criterion stated by Moskal (2000), which says categories should be created only if meaningful distinctions exist among them [13]. In each category, it provides learner an indication as to how to improve their analysis skill.

Level	Description	Performance in related task	Suggestion
4	Possess high awareness of analysis, use strategies to analyze, and care about specific data.	Do analysis (task 1) regularly, check reference values (task 2 and task3) and detail data (task 4).	None
3	Possess high awareness of analysis, use strategies to analyze, but never or barely learn specific data	Do analysis (task 1) regularly, check reference values (task 2 and 3), but never/seldom check detail data (task 4).	Check detail data
2	Possess awareness of analysis, but never or barely use strategies to analyze	Do analysis (task 1) regularly, but never/seldom check reference values (task 2 and task 3).	Check reference values
1	Low awareness of analysis	Seldom do analysis (task 1).	Do analysis at least regularly
0	Be lack of awareness of analysis	Never do analysis (task 1)	Start to do analysis

Table 2: levels of analysis skill

4.2 Quantified analysis behavior

Learner's analysis behavior represents as interactions in GOAL system. Here, we define interactions as "action" entity, and collected data as "activity" entity in database. Attributes of action is explained in Table 3.

Attributes	Description
id	Unique identifier of action
task_id	Which task action belongs to
time	When action is done
activity	Which activity does
uuid	Who did this action

Table 3: attributes of action entity

Sample of action: student 1001 clicks 'Reading' in analysis page at 2019/1/20 15:21:11, can be expressed as action(1, 1, '2019/1/20 15:21:11', 'reading', 1001).

Regarding to the first aspect, awareness, we calculate time interval between adjacent actions which belong to task 1. Less the mean of time interval is, higher score learner should obtain. To the second and third aspect, we count actions in one analysis behavior, which means after learner did task 1, how many options he checked and how many times he checked detail data. More reference values learner checked, the score becomes higher. And more count of actions that belong to task 4 is, score is higher. However, boundaries of these indicators need further experiment to determine. In this paper, we propose our method only.

5. Conclusion

In conclusion, analysis skill is crucial for learner achieving his goal. Analysis tasks in our context represents as interactions in GOAL system executed by learner. From three aspects, which are awareness of analysis, analysis strategies and details, we measure learner's analysis skill. In addition, we proposed three indicators from these three aspects for automatically scoring analysis skill.

From past researches, we can see that analysis acts an important role in self-direction, which requires learner find out what happened in their learning process in detail and the cause and effect relationship among various elements involved in the process [10]. However, none of them treat it as an independent phase. This paper discussed why and how to observe learner's analysis behavior on the basis of technology. Moreover, this paper gave a new method to measure sub-skill of SDS instead of self-report method which commonly used in past researches. Comparing with self-report, the first advantage of this method is that the result is more objective since score comes from learner's actual performance in the analysis task tracked by GOAL system. The second advantage of this method is that it is measured by GOAL system automatically. That allows learners to observe their continuing behavior and the change of their skill.

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