Task Execution Support in Research Activity using RAC System

Shigeki Ohira
Nagoya University
Furo-cho, Chikusa-ku, Nagoya, Japan
Email: ohira@nagoya-u.jp

Naoya Morita, Katashi Nagao
Nagoya University
Furo-cho, Chikusa-ku, Nagoya, Japan
Email: {morita,nagao}@nagao.nuie.nagoya-u.ac.jp

Abstract—**Research activities carried out daily in research laboratories, include conducting investigations, giving seminars on progress, performing experiments, analyzing results, and writing papers, but all of these research activities involve steady, methodical work that does not produce immediate, visible results. For this reason, a mechanism to maintain motivation when research is not going well or to help students get on track with research when they have just been assigned to a laboratory could be useful. Students that have just begun their research may not yet understand how to proceed. We previously developed a research activity concierge (RAC) system, which is a platform to encompass general research activities, and applied gamification to this system to keep user motivation high. However, even with the RAC, non-research-savvy students have difficulty handling challenges and executing tasks. In this research, we focused on discussions in seminars and introduced a mechanism to support task execution in students' research activities by implementing automatic extraction of task statements into the RAC.**

I. Introduction

RESEARCH consists of various activities. It begins with surveying related research and includes giving seminars on progress, discussing future plans, programming or constructing equipment, performing experiments, analyzing results, and writing papers. However, by looking carefully at these activities, it can be seen that the everyday activities are very mundane; sometimes they go well, and sometimes they do not. Scientists must often carry on without immediate visible results.

Motivation to research increases when everything is on track, and the everyday tasks become more interesting. However, when research does not go as expected or when students have just been assigned to a laboratory and do not know which way to turn, a high level of motivation can be difficult to maintain.

On the other hand, gamification—the use of game design elements in non-game contexts [1][2]—has attracted enormous interest across a range of different areas, including education [3][4]. Bodnar and Clark put game-based learning into practice in undergraduate engineering classrooms and obtained very positive results [5]. Ohira et al. incorporated gamification into seminars and found that students' motivation to speak better and debate was markedly improved [6]. González et al. presented an intelligent tutoring system including gamification

elements, which improved student achievement and enhanced learning [7].

We have developed a comprehensive gamification framework for general research activities [8][9]. Specifically, it provides a research activity concierge (RAC) system, which is a platform for recording and organizing everyday challenges and tasks arising in discussions and for visualizing the results when they are applied to real actions.

However, it is difficult for non-research-savvy students to accurately handle day-to-day challenges and completely execute day-to-day tasks. In this research, we focused on the discussions in seminars and introduced a mechanism to support task execution in students' research activities by implementing automatic extraction of task statements into RAC. The paper will report the results of supporting task execution and the improvement of the RAC system.

II. Research Activity

The IDC (interest driven creator) theory [10] has recently been attracting much attention, and learning and teaching methods have been changing from "examination-driven" to "interest-driven," that is, students study what interests them. Also, to fully engage in research activities, researches must be interested in them. However, students often do not know what kind of activity to carry out because they have not been shown a global image of research. Therefore, it is thought that research activities can be more smoothly executed by preparing guidelines of research activities for such students. We have classified all research activities into 11 main activities and 100 sub-activities [8]. We call this the research activity map and express it in the mind map format.

- Gaining expertise
- Deciding research themes
- Implementation
- Deciding evaluation methods
- Experimentation
- Project meetings
- Seminar presentation
- Discussion
- Conference participation
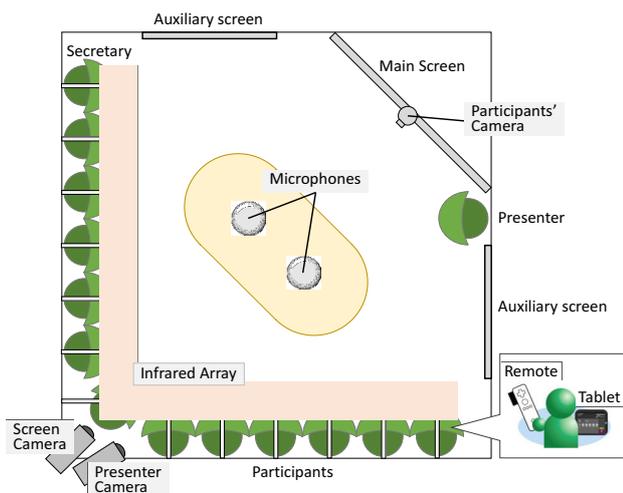- Conference presentation
- Writing papers

Fig. 1.   Discussion room.

Fig. 2.   Discussion Browser.

The main activities focus on the activities performed in every area of research. Moreover, the main activities cover activities from when a student is assigned to a laboratory until he/she graduates. We arranged activity nodes in a clock pattern on the research activity map in such a way as to be able to carry out activities in sequence. Each activity is subdivided into simple and practicable actions in accordance with the level of difficulty. In this research, we subdivide the main and sub-activities into about 500 actions. Thus, by seeing the specific actions to achieve a goal that should be performed in research activities, users can choose actions without omitting any necessary one. Furthermore, we prepared about 240 activity results that can acquire the achievement status of a target action automatically and can perform a statistical assessment.

Challenges and tasks also need to be clear for research activities to be smoothly executed. In particular, students just starting their research have difficulty setting appropriate challenges and tasks on their own, and discussion within the research group is extremely important in resolving this.

Our laboratory has been developing and operating a system to record seminar content [11]. Generally, proceedings of a seminar consist of an abstract and hand-outs, but seminar content can also include a summarized transcript, audio or video recordings of the seminar, or the slides used in the presentation. We have held seminars in the environment illustrated in Figure 1. After a seminar presentation, students use a Web application called Discussion Browser (Figure 2) for searching for and viewing seminar content to review and organize what was discussed.

The discussion during a seminar usually contains many useful opinions and much useful advice, so it is a good starting point in deciding future research directions. Thus, students should thoroughly review the seminar content as soon as possible after the seminar. However, reviewing a long seminar from beginning to end is not always practical. Discussions

contain statements that will not affect future research activities, so statements must be divided into those that are needed and those that are not when reviewing. Further, a transcript recorded by a secretary is presumed to be an incomplete summary that does not record all content, so it may be important to listen to the audio again to decide which parts are important. Later, after time passes, the discussion may be difficult to recall correctly, even if you remembered the content at some point. Thus, to avoid having to review the content over and over, summarizing notes should be left.

Reviewing seminar content in this way takes effort and is a significant hurdle for students, so a mechanism is needed for focusing on salutary opinions and advice for subsequent research activities and actively promoting the recording and organizing of challenges and tasks.

III. RESEARCH ACTIVITY CONCIERGE

Systems developed to support research activity include, Papits[12] for sharing information about "know-who" in a university laboratory, MIRASS[13] for improving usability of scientific search engines for medical informatics through data mashup, and systems for managing repositories of resources accumulated through research activities in a laboratory [14][15].

The research activity concierge (RAC) [8][9] is a comprehensive support system for general research activities that introduces a gamification framework for organizing challenges and tasks and visualizing research activity.

As shown in Figure 3, the research activity concierge system consists of three basic tools: the research activity organizer (RAO), the research activity visualizer (RAV), and the research activity watch-dog (RAW). RAO organizes challenges and tasks on the basis of seminar content, and RAV visualizes research activity on the basis of the performance and tasks. RAW is a tool that constantly monitors the information input and output from RAO and RAV, describes the current status of activity to the user, and recommends actions. RAO and RAV are applications that run on a web browser. In this research, since we carried out experiments and analysis using enhanced RAO and RAV, we will explain them both briefly.
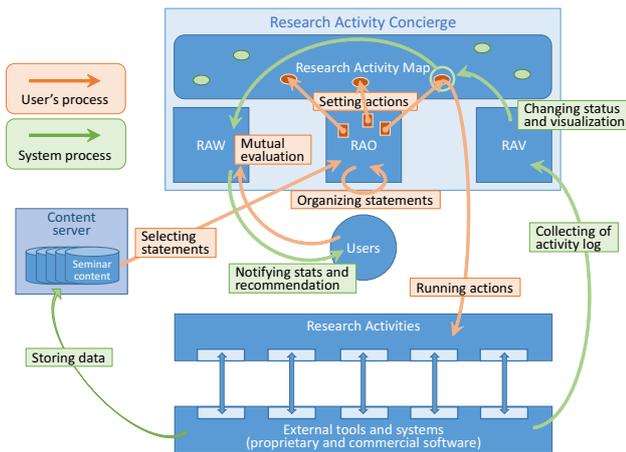
Fig. 3.   Research Activity Concierge system overview.

A. Research Activity Organizer (RAO)

A screen shot of RAO is shown in Figure 4. The right side is the statement view for browsing the content of a discussion in a seminar, and the left side is the note view for organizing challenges and tasks. Users organize the statements in note view while viewing them in statement view. Users can create notes for various research activities (such as surveys, implementations, or paper writing) and record detailed information in memos. Users can also create a note on a research activity map displayed by RAV, which we will describe later. When users choose an activity on a research activity map and click on the icon of "creating a note," a screen on the browser transitions to RAO, and the created note is displayed.

B. Research Activity Visualizer (RAV)

RAV can visualize challenges, tasks, and relationships that result from related research activities organized by RAO on a research activity map (Figure 5). RAV can also show the state of processing for such items quantitatively.

For this research, we used external tools and systems as much as possible for recording digital data so that the results for practically dealing with challenges and tasks could be handled quantitatively. In our laboratory, we use both commercial and independently developed software. These software packages enable the recording of the number of statements in discussions, times users view seminar content, items committed to in repositories, and words users input when writing papers, together with their dates and times. An application programming interface (API) or plug-in is used to retrieve information from each external tool or system, and when the user performs a research activity on the basis of a challenge or task, an outline of the action is retrieved by RAV.

IV. TASK EXECUTION SUPPORT

A. Goal Setting based on Challenges and Tasks

Although looking again at seminar content including useful discussions for research activities is important, it also requires time and effort. Thus, task statements have been automatically extracted by using a machine learning model that has metadata in a seminar content and linguistic information of the utterance as features [16][17]. The extracted task statement list is shown in the statement view of RAO (Figure 4, 6).

A user judges whether or not the statement extracted automatically is really a task statement and clicks the appropriate button on a statement list. The fixed task statement information is fed back as a teacher signal that a system uses for learning a task statement extraction model and is used for active learning [18] that updates a model. After judging a task statement, a user quotes the fixed task statement to a note view and creates a memo. Four types of progress tags can be attached to a created memo: not-started, in-progress, completed, or pending. Moreover, target actions can also be selected from elements included in a research activity map and attached to memos in the form of tags (Figure 7). Thus, created memos can record the research activity to which they are related.

A student with little experience of research activities often feels uncertain about how long to spend executing one of several tasks. Therefore, the time spent on each task should be managed. In this research, we introduced a scheduler for task execution as a function of RAV (Figure 8). In the upper part of the screen, graphs and a calendar are arranged, and users can see the approximate ratio and achievement status of tasks. In the lower part of the screen, users can schedule task executions on a timetable.

Four types of tasks can be added to the task scheduler.

- Event for the whole laboratory
  (ex. seminar).
- Research task
  (ex. computer experiment).
- Tasks other than research
  (ex. instruction to a lower-grade student).
- Other than these
  (ex. classes).

Each task on a timetable is colored in accordance with its type, and the ratio for all types of tasks is displayed as a pie chart. The free time in a pie chart is calculated by subtracting the scheduled time of all the tasks from the maximum activity time set beforehand. Users can plan a reasonable task execution schedule by checking their free time.

Since RAV sets a rule-of-thumb achievement time of a target action on the basis of results of a questionnaire to students, the simple automatic scheduling function is also implemented in the task scheduler.

B. Recording and Evaluation of Task Achievements

After task execution, users record details, such as the contents of execution, on the memo that quotes the task statement and change the progress tag of a memo to "completed." Furthermore, users evaluate the contents of task execution. The present RAC already has self-assessment and mutual evaluation functions. However, since the memos about research activities were private, we had not previously touched upon the assessment of the contents. In this research, we enabled the RAC to unfold the memo about a task that was clarified at
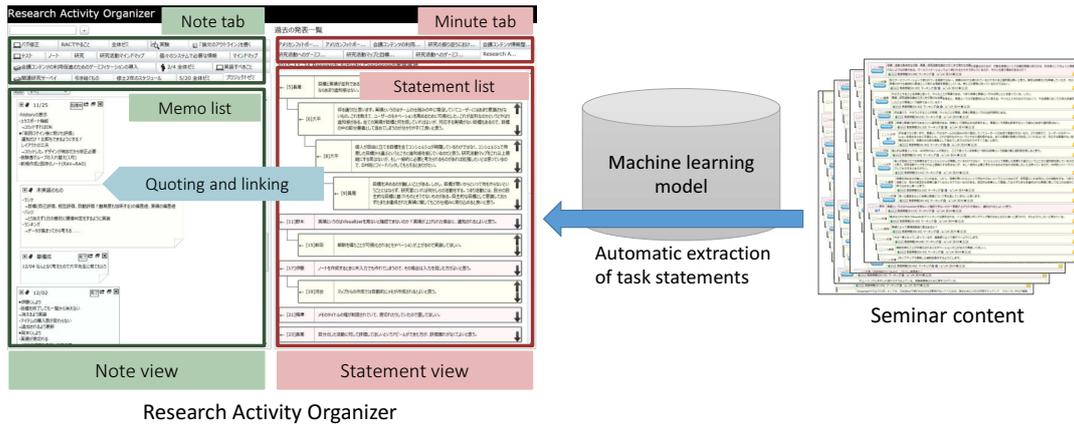
Fig. 4. Process of task statement extraction and Research Activity Organizer.
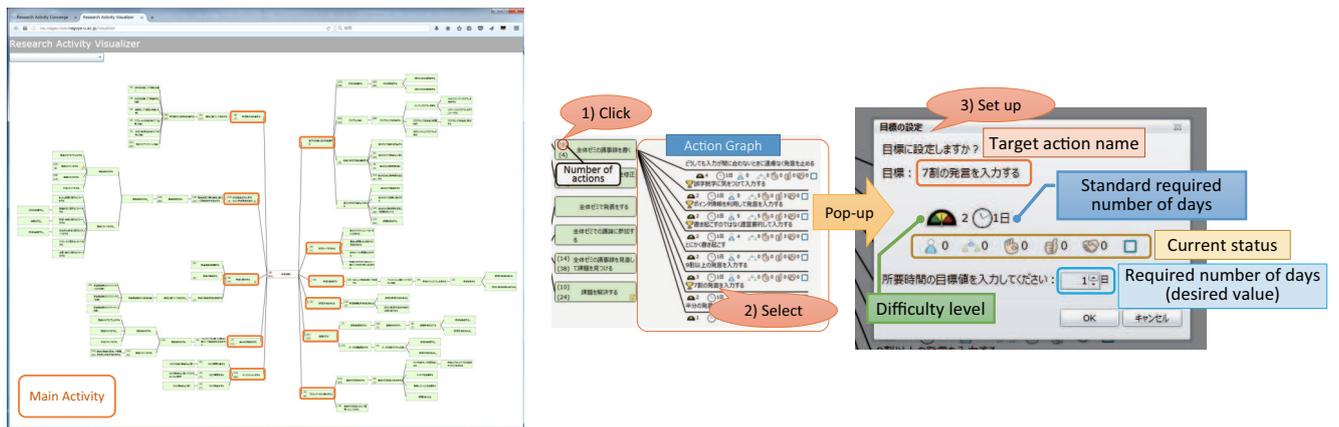

Fig. 5. Research activity map and goal setting on RAV.
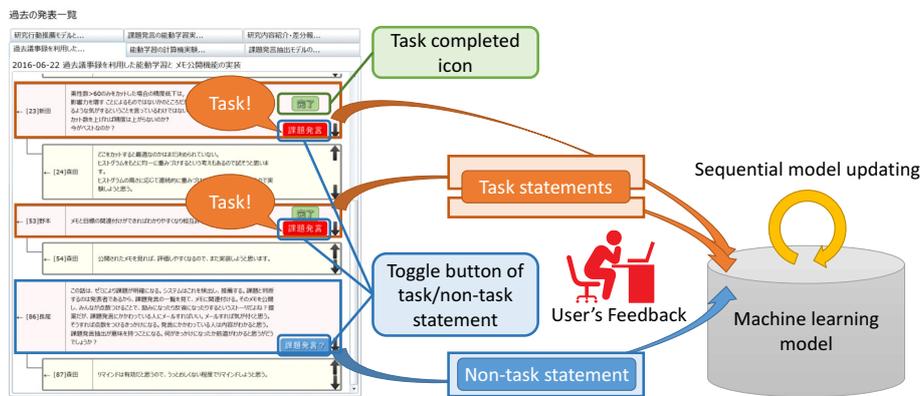

Fig. 6. Task statement list in statement view of RAO and extraction model updating.
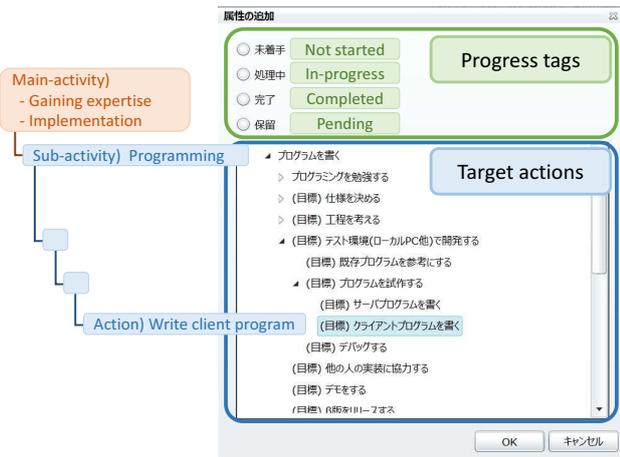
Fig. 7. Attachment of progress tags and target actions to memo.

Fig. 8. Task scheduler.

Fig. 9. Self-assessment dialog.

Fig. 10. Mutual evaluation dialog.

a seminar before laboratory members. Then, we enabled it to receive a sensitive assessment in accordance with the contents of execution of the task.

After completing a task, users can associate the memo about their own activity with the target action and can perform self-assessment in a self-assessment dialog (Figure 9). In self-assessment, the user evaluates his/her own actions on a five-point scale. When mutual evaluation from other users is received, the memos associated with the target action during self-assessment are displayed on the right-hand side of a mutual evaluation dialog (Figure 10), and users can use them as judgment material for evaluating the contents of execution of a task. In mutual evaluation, other users evaluate a user's action. Mutual evaluation consists of two indicators. One is a stamp assessment. This is concerned with evaluating not the content of the activity but the activity itself. There are three types of stamp: "Like!", "Great!", and "Thanks!" The other indicator is a five-point scale assessment. The stamp assessment evaluates the activity itself, and a five-point scale assessment is used to evaluate the content of the activity.

V. EXPERIMENTS AND ANALYSIS

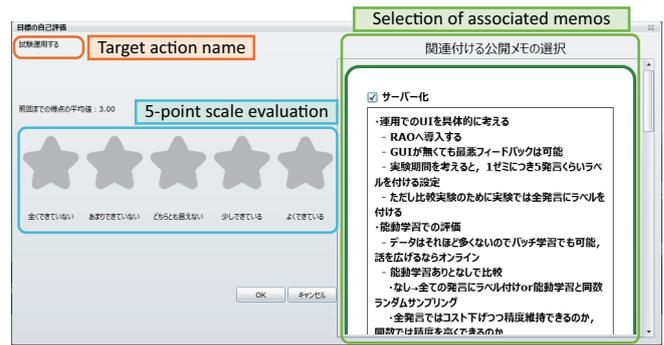We conducted experiments to quantitatively evaluate the effect on research activities of the proposed RAC and a qualitative assessment by a qu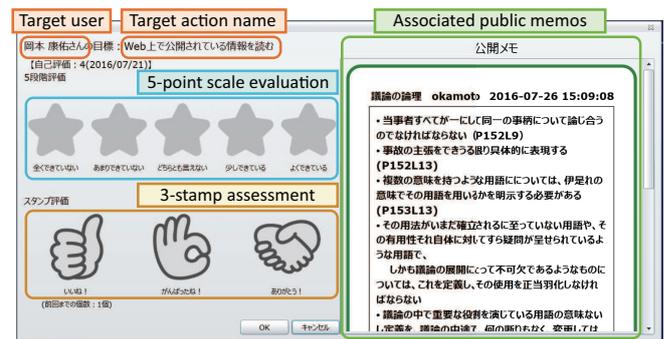estionnaire. The subjects that participated in the experiments ranged from undergraduate seniors (B4) to second-year graduate students (M2). There were eight students (B4: three, M1: three, and M2: two) in our laboratory. We randomly divided each grade into the intervention group (proposed system) and the control group (conventional system) and carried out crossover comparison tests in the first semester (April to July) and the second semester (October to December) of fiscal year 2016.

A. Quantitative Evaluation of Effect on Research Activities

The evaluation criteria of the system in quantitative evaluation are as follows.

- Task awareness rate
- Goal attainment level
- Self-assessment and mutual evaluation score

The task awareness rate is the proportion of task statements collected while using the RAC from the true task statements selected by reviewing all the seminar contents at the end of a semester. The goal attainment level expresses the number of goals achieved per day. The comparison results for the proposed system (P) and the conventional system (C) are shown in Table I.

As a result of performing a t-test of the task awareness rates between the proposed and conventional RACs, a difference was found that had the significance level of .05 ($p\text{-}value$ = 0.0481). Moreover, when two students used the conventional

TABLE I
EVALUATION OF PROPOSED (P) AND CONVENTIONAL (C) RACs.

Evaluation criteria	System	Ave.	SD	S.D.	Effective # of students
Task awareness rate (%)	P	61.4	23.3	*	6
	C	36.2	32.1		2
Goal attainment level	P	0.23	0.10	n.s.	5
	C	0.27	0.33		3
Self-assessment score (max. 5)	P	4.24	0.47	n.s.	5
	C	4.09	0.58		3
Mutual evaluation score (max. 5)	P	4.76	0.18	n.s.	2
	C	4.79	0.27		4

$*: p < 0.05$

$n.s.$: not significant

system, their task awareness rates became high, but the difference between systems was several percent and thus not very large. Thus, the function for automatically extracting the task statement in the proposed system effectively distinguishes between tasks.

The goal attainment level, self-assessment score, and mutual evaluation score do not significantly differ between systems as shown in Table I. However, the goal attainment level and the self-assessment score showed higher values when five out of eight students used the proposed RAC. Thus, this suggests that we need to increase the amount of data after this and to analyze them carefully. Since the quality of an execution result also changes a lot depending on the difficulty of a task, raising the proposed RAC's sensitivity to tasks and the goal attainment level or assessment scores may not necessarily be related.

B. Qualitative Assessment using Questionnaire

The results of a questionnaire given to users after they had used the proposed RAC are shown in Figure 11.

Seven out of eight students answered "strongly agree" to the statement "Tasks I forgot were extracted." Moreover, seven out of eight students responded positively to "RAC positively affected research activities," "I was more motivated to organize tasks," and "RAC is useful." In their free descriptions, users who answered "undecided" to these three statements said they had "not acquired the habit of using the system," so we can consider using push messages to urge use of the system.

On the other hand, only four students agreed that the proposed "RAC is easy to use." Since half the users did not think it was easy-to-use, the challenge is preparing an interface that raises use volition.

The task execution using RAC system mainly contains five behaviors: 1) selection of task statements, 2) organizing of the content of tasks, 3) goal setting based on tasks, 4) scheduling of tasks, and 5) recording of task execution results. To assess the usability of RAC about each behavior, we conducted a questionnaire using System Usability Scale (SUS) [19]. The

score of SUS and the related scales [20][21], and use/non-use of RAO/RAV in each behavior are shown in Table II. The result shows that it is necessary to greatly improve the usability of RAV.

As mentioned above, although the proposed RAC was useful in many users' research activities on the whole and was especially useful for arranging tasks, problems such as usability and routinization of use are left to be solved.

VI. CONCLUSIONS

In this research, to smoothly promote a student's research activities in a university laboratory, we added a task execution support function to a research activity concierge (RAC), which is our present research-activities support system. As a result of conducting a practical use experiment of the system for students engaged in undergraduate and postgraduate research, we found that the proposed RAC was able to grasp the existence of tasks more correctly than the present RAC.

In the present RAC, the user him/herself needs to set goals. However, since all research activities are large scale and many target actions are prepared by the RAC, it is difficult for the students unfamiliar with research activities to select target actions. Therefore, it is thought that an RAC that recommends a target action in accordance with a student's progress will be effective. For a recommendation system, many algorithms of user-based collaborative filtering will need to be adopted. By using collaborative filtering for a user's activity log obtained by long-term practical use of the proposed RAC, more suitable target actions for students should be able to be recommended and more advanced task execution support achieved.

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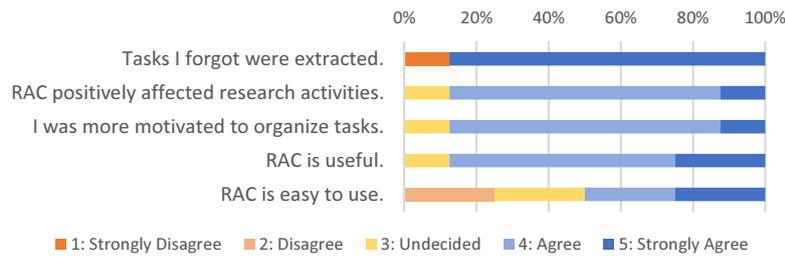
Fig. 11.   Results of questionnaire.

TABLE II
SUS SCORE AND RELATED SCALES OF TASK EXECUTION WITH RAC.

	RAO	RAV	SUS score [19]	Acceptability ranges [20]	Adjective ratings [20]	Grade [21]
1) Selection of task statements	+	-	86.9	Acceptable	Excellent	A+
2) Organizing the content of tasks	+	-	77.5	Acceptable	Good	B+
3) Goal setting based on tasks	-	+	51.3	Marginal low	OK	F
4) Scheduling of tasks	-	+	57.5	Marginal low	OK	D
5) Recording of task execution results	+	+	62.5	Marginal high	OK	D

+ : Use, - : Non-use

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