Chapter 4
VAT-RUBARS: A Visualization and Analytical Tool for a Rule-Based Recommender System to Support Teachers in a Learner-Centered Learning Approach

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Abstract Smart learning environments are technology-enhanced educational systems that not only support learners' learning but also provide a learning environment to learners according to their learning needs. In our previous research, we proposed a rule-based recommender system that supports learners in a learner-centered approach (Imran et al. A rule-based recommender system to suggest learning tasks. Springer, Honolulu, 2014). In this chapter, we introduce a visualization and analytical tool for rule-based recommender system (VAT-RUBARS) to provide support to teachers in learner-centered courses. As a result, teachers no longer need to make assumptions about their learners (or courses) and can improve the learning environment to make it more smart and productive for their learners.

Keywords Smart learning environment · Learner-centered learning · Information visualization

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4.1 Introduction

Smart learning environments aim to assist, engage, and enrich the learning experience of learners by providing support to them [2]. In our previous work [1], we developed a rule-based recommender system for learner-centered learning that can be integrated into learning management systems which leads to a smart learning environment, where learners are given support by providing recommendations of learning tasks. Learner-centered pedagogy promotes learners' learning and motivation, and enhances learners' performance [3] by giving more power to the learners, making them independent in acquiring knowledge and, consequently, takes responsibility of their learning. However, there are two main concerns in such pedagogy. The first concern is about whether learners can make good decisions that are appropriate for them in their learning. The second concern is about the difficulty for teachers to plan and design a productive learner-centered learning environment as well as monitor and understand learners' behavior in such environment. The first concern was addressed by the recommender system that supports learners in a learner-centered environment, as reported in our previous research [1]. To address the second concern and to make learner-centered environments more productive, this chapter introduces the visualization and analytical tool for rule-based recommender system (VAT-RUBARS).

The remainder of the chapter is structured as follows: Sect. 4.2 presents related work. Section 4.3 discusses VAT-RUBARS and introduces its indicators in detail. Section 4.4 concludes the chapter by summarizing the main contributions of our work and presenting future directions.

4.2 Related Work

Learning management systems gather a lot of data related to learners' interactions with the system. These data are very important as it provides information about learners' behavior. Previously, the data tracked by learning management systems were mainly used to provide support to learners [4]. More recently, there is an emerging interest in using such data to support teachers with the goal of providing information about the course and learners through meaningful visualizations. In this section, we describe the previous research works related to analytical tools that provide support to teachers.

Mazza and Botturi [5] designed GISMO for Moodle to support teachers by displaying learners' tracking data through graphs based on log data. Teachers can look at graphs and examine learners' social, cognitive, and behavioral interactions in a course. The social interactions show how learners are participating in discussions while cognitive interactions focus on the learners' performance in quizzes and assignments. The behavioral interactions deal with the learners' access to the course. Likewise, Jovanovic et al. [6] presented a tool, LOCO-Analyst, to provide

feedback to teachers related to their learners' learning process in Web-based learning environments. The tool mainly shows three types of information: activities performed by the learners, usage of learning content, and social interactions among learners. Govaerts et al. [7] developed Student Activity Meter (SAM) to provide visualizations of learner actions. SAM can help teachers in identifying learners who are doing well or are at risk. The tool uses two metrics: time spent and resource use. Through time spent, teachers can see the time learners who are spending on activities in a course and can compare it with their expectations. Resource use can give information about how often particular resources are used by the learners.

Currently available tools, such as the examples above, mainly focus on visualizing learners' performance and interaction data, and identifying learners at risk. The tool proposed in this chapter, on the other hand, focuses on supporting teachers in a learner-centered setting, with focus on showing how learners perform and behave in such setting. Furthermore, teachers can use VAT-RUBARS to investigate the behavior of the learners with similar characteristics (such as learners with certain learning styles, prior knowledge level).

4.3 VAT-RUBARS

VAT-RUBARS uses graphs and tables for visualization. Along with these techniques, cues such as color and linking are used. For example, information is represented using three colors (red, yellow, and green) where red indicates that attention from a teacher is needed, yellow means attention might be needed, and green means that everything is going well. Figure 4.1 presents an interface of VAT-RUBARS. Different types of visualizations, called indicators, are shown in different tabs. Teachers can select the levels at which they want to see the information, distinguishing between an overall category where information about the whole class is presented, and an individual category where information about a single learner is presented. For each of these categories, a filter panel provides teachers with the functionality to set filters as needed. For the overall category, five filters (unit, difficulty level, expertise level, prior knowledge, and learning styles) are provided, while for individual learners, two filters (unit and difficulty level) are available. In the next subsections, each of the five indicators is discussed in further detail. While Fig. 4.1 shows the overall tool with the filter panel, subsequent figures will only show the visualizations displayed for each indicator, without the filter panel.

4.3.1 Unit-Related Performance

The first indicator is about unit-related performance (Fig. 4.2). For each unit, the performance of tasks is calculated as the average grades of a particular learner, a

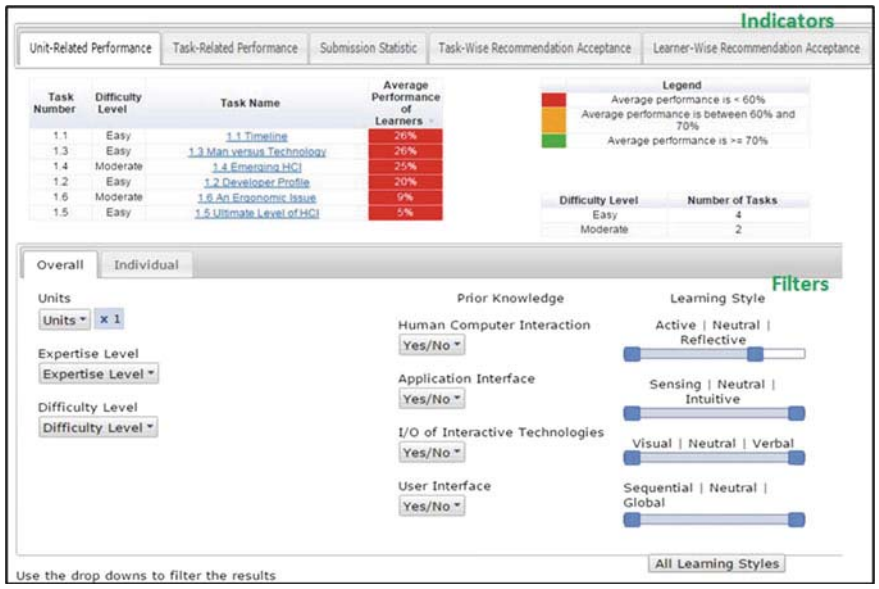


Fig. 4.1 General view of VAT-RUBARS

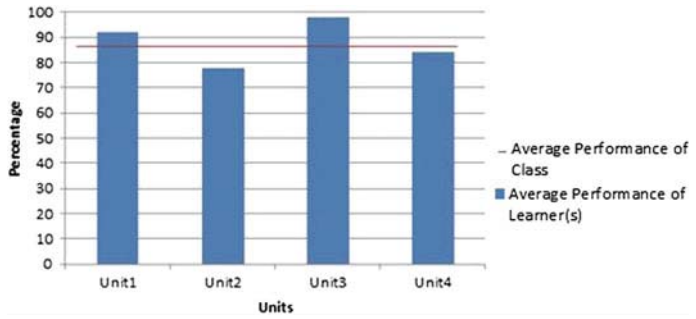
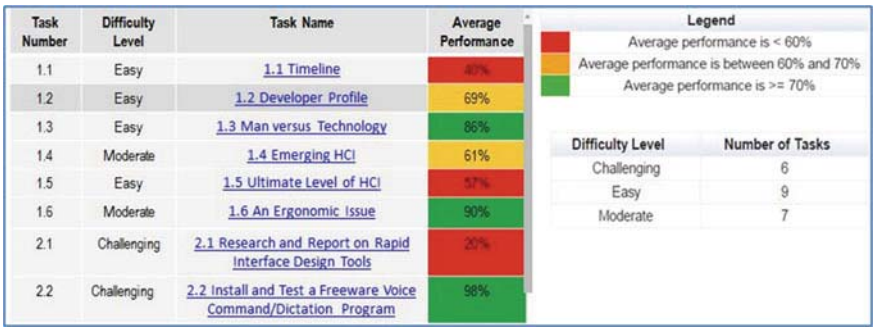


Fig. 4.2 Unit-related performance indicator

group of learners or all learners. The overall average performance of the whole class on all tasks is plotted on the graph as red line, so that teachers can see in which units the performance is higher/lower than the average performance of the whole class.

The indicator can help teachers in understanding in which unit the class, a particular learner or a group of learners, is not performing well. Accordingly, a teacher can further look into the tasks that are present in the respective unit.



Task Number	Difficulty Level	Task Name	Average Performance
1.1	Easy	1.1 Timeline	48%
1.2	Easy	1.2 Developer Profile	69%
1.3	Easy	1.3 Man versus Technology	86%
1.4	Moderate	1.4 Emerging HCI	61%
1.5	Easy	1.5 Ultimate Level of HCI	57%
1.6	Moderate	1.6 An Ergonomic Issue	90%
2.1	Challenging	2.1 Research and Report on Rapid Interface Design Tools	20%
2.2	Challenging	2.2 Install and Test a Freeware Voice Command/Dictation Program	98%

Legend
- Average performance is < 60%
- Average performance is between 60% and 70%
- Average performance is >= 70%

Difficulty Level	Number of Tasks
Challenging	6
Easy	9
Moderate	7

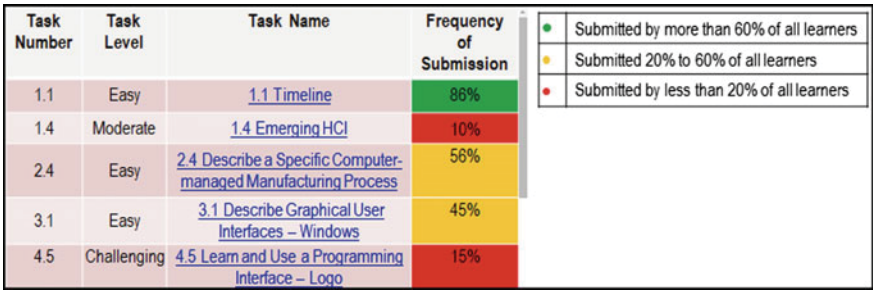
Fig. 4.3 Task-related performance indicator

4.3.2 Task-Related Performance

The "Task-Related Performance" indicator, shown in Fig. 4.3, supports teachers in getting information about how the overall class, a group of learners, or an individual learner performed in each task. The tasks are displayed in three colors (green, yellow, and red) based on the threshold values which can be set by a teacher. If these values are not set by a teacher, default values are used (i.e., 70 and 60 %). Different colors help teachers to see easily the tasks in which the learners are not performing well. Teachers can use this information to further investigate whether these tasks might need some revisions.

4.3.3 Submission Statistic

With the help of the "Submission Statistic" indicator, shown in Fig. 4.4, teachers can identify the frequency by which various tasks have been submitted by the learners. Again, how often tasks have been selected for being submitted by the



Task Number	Task Level	Task Name	Frequency of Submission
1.1	Easy	1.1 Timeline	86%
1.4	Moderate	1.4 Emerging HCI	10%
2.4	Easy	2.4 Describe a Specific Computer-managed Manufacturing Process	56%
3.1	Easy	3.1 Describe Graphical User Interfaces – Windows	45%
4.5	Challenging	4.5 Learn and Use a Programming Interface – Logo	15%

- Submitted by more than 60% of all learners
- Submitted 20% to 60% of all learners
- Submitted by less than 20% of all learners

Fig. 4.4 Submission statistic indicator

learners is visualized by using three colors (i.e., green, yellow, and red), where green means that a task has been submitted very often, yellow means that a task has been submitted sometimes, and red means that a task has been submitted rarely.

Similar to the "Task-Related Performance" indicator, default values are used (i.e., 20 and 60 %) for the thresholds on which to display a task in green, yellow, or red. This information provides teachers with insights into which tasks are often selected and which tasks are less or not at all selected.

4.3.4 Task-Wise Recommendation Acceptance

The "Task-Wise Recommendation Acceptance" indicator, shown in Fig. 4.5, gives an overview about the learners' behavior toward recommendations provided to them through the rule-based recommender system. This indicator provides information about (1) the number of learners who selected a particular task in their initial plan; (2) the number of learners to whom the particular task has been recommended; and (3) the number of learners who actually submitted that task. This indicator can help teachers in understanding why learners have selected a particular task and whether or not they followed the recommendations provided by the recommender system.

4.3.5 Learner-Wise Recommendation Acceptance

The "Learner-Wise Recommendation Acceptance" indicator, shown in Fig. 4.6, represents how often the learners accepted task recommendations by the recommender system, per learner and unit of the course. With this indicator, teachers can investigate the behavior of the learners toward the recommendations given by the

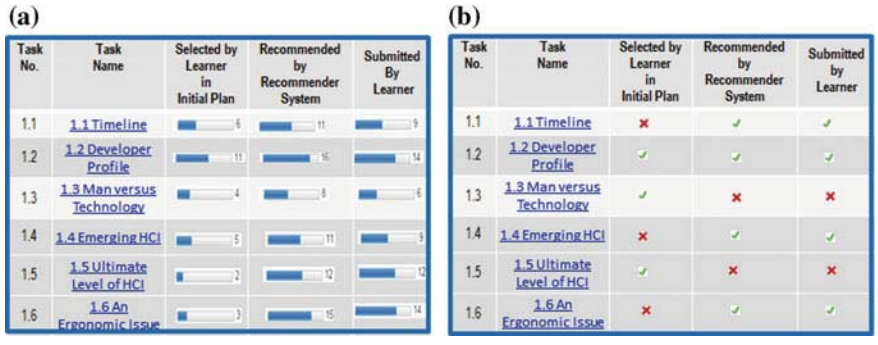


Fig. 4.5 Task-wise recommendation acceptance indicator. **a** Overall class. **b** Individual learner

Names	Acceptance Rate			
	Unit 1	*Unit 2*	*Unit 3*	*Unit 4*
Learner 1	80%	40%	60%	70%
Learner 2	50%	40%	80%	20%
Learner 3	10%	40%	80%	80%

Fig. 4.6 Learner-wise recommendation acceptance indicator

recommender system. This acceptance rate provides teachers with information on how well the recommender system is accepted by the learners.

4.4 Conclusion and Future Work

This chapter presented VAT-RUBARS, a visualization and analytical tool for rule-based recommender system. The main aim of this tool is to support teachers in smart learning environments by providing them with functionality to reflect on their teaching practices in courses that apply a learner-centered design, where learners can select learning tasks and are provided with recommendations of such learning tasks. VAT-RUBARS provides valuable information based on five indicators: unit-related performance, task-related performance, submission statistics, task-wise recommendation acceptance, and learner-wise recommendation acceptance.

In future work, we will extend VAT-RUBARS by adding a recommendation component for the teachers. This recommendation component will provide recommendations to teachers (e.g., tasks which should be revised) based on the information currently presented to them.

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