used to evaluate research. Scientists can further find out who initiated a knowledge flow in an area, their roles in a flow, changes in their status, the effect of knowledge flows on different areas, and the evolution of a knowledge flow. The system can evaluate researchers, institutions, and disciplines.

- *Estimate the development stage of a discipline and its maturity.* Based on the evolution of relevant knowledge flow networks, this service enables scientists to simulate and estimate the development of a discipline, and thus helps them plan research.
- *Detect an emergent research area.* This service enables scientists to detect the emergence of a new area from the convergence of two areas, especially a mature area and a relevant new area.
- *Interact with scientists.*
  - Display the distribution of research communities and cooperation between institutions and between scientists by searching scientists' and their team's Web sites, and extracting co-authors, authors' affiliation and region, and sponsorship information from articles.
  - Inform scientists of the status and type of an interest or group of common interests as well as the evolution of a research area.
- Answer queries about the research situation, including the number and distribution of researchers, articles, and topics over time.
- Plan personal development, and make policies for the development of disciplines.

Current Web and text analysis techniques can automatically find the citation, co-author, and author-affiliation relations in scientific documents on the Web or in digital libraries. Extracting document fragments that contain authors, affiliations, and references, an escience knowledge grid environment can find useful semantic relationships between documents or document fragments. Analyzing the relationship between authors, articles, and their citation network, the environment can automatically discover knowledge flow networks and can distinguish the type of knowledge nodes using ranking algorithms and trace their evolution. By extracting comments and comparisons of the cited articles and then organizing them according to the time of publication, discovers and displays how the area has developed as a research literature.

Figure 2(a) shows the interface of the personalization function that shows the evolution of the user's interests and knowledge. The top portion is a list of operational functions, the left portion displays the citation network of the user's publications, and the right portion displays the list of publications of any network node that the user clicks. Figure 2(b) shows the interface of the other personalization function. The left portion displays the distribution over areas of the number of publications and of citations using color-coded curves. The user can click any point to display relevant publications in the right portion.

Knowledge also flows in scientific activities such as communication between collaborators. The environment records information flow such as email within a research team, extracts useful information flows, analyzes common interests and cooperation relations, and displays the evolution of the flows to help assess the teamwork's effectiveness, for example, whether team members' changing interests match their tasks.

Knowledge Flows through Semantic Link Networks

Semantic links exist between scientists, scientific activities, and scientific entities such as journals and research institutions. These semantic links constitute a scientific semantic map [10]. Figure 3 shows a tool for visualizing the semantic map where the center nodes can trace the user's interest. Knowledge flows along semantic links such as "co-author" and "supervise" prior to other links to constitute a knowledge map. Such a knowledge map is dynamic, and it could be discovered by analysis of these links.

Research has shown the contact network and the virus spread model determine the spread of epidemics [11], so the evolution of the contact network influences an epidemic. Appropriately changing the contact network can control an epidemic. Knowledge

Coordinating and fusing knowledge flows, data flows, and control flows, and integrating knowledge flows and workflows, are POWERFUL MEANS FOR MAKING TEAMWORK EFFECTIVE.