A preliminary proposed curriculum support system for information technology specialists based on the service science approach

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Abstract

Legacy curriculum support systems have simple functions for searching syllabi and course registration. However, students, who are educational service customers, have different characteristics. Nevertheless, students are in most cases provided fixed curricula designed solely by educational service providers.

In this paper, we propose a preliminary curriculum support system for information technology specialists based on a service science approach. The aim of this system is to support completion activities through which students can design a suitable curriculum to reach to their individual career goals. In the design step of the system, we gathered data from 30 students using the persona strategy method. We then, undertook a case study by redefining the education service of University A based on IEEE&ACM’s Computer Curricula 2005 report. We also applied knowledge space theory to the system interface for visualization of ideal, current and increased knowledge.

For evaluation, we selected 10 graduates of University A. We checked the correlations between the curriculum provided to these graduates and the curriculum recommended by the system. As a result, the system recorded a 57.66% correlation between the recommended courses and courses taken by graduates. We expect that this system can become an interactive support system between students and service providers for value co-creation with the role of designing suitable curriculum by students.

Keywords: Service science, Information technology, Curriculum support system, Knowledge space theory, Computing Curricula 2005

1 General Instructions

Recently, the information industry has become increasingly complicated with the rapid advance of information technologies; therefore, educational service providers of information science have to consider the question how to educate information technology specialists [1]. Multiple potentials such as communication ability; problem solving and project management skill are required for working. To meet these needs, the Computing Curricula was published by IEEE&ACM for guidance of graduate schools; many universities design education program based on these guidelines.

However, legacy curriculum support systems provide only simple functions for searching syllabi and course registration. These systems do not consider the characteristics (career goals, interests and potentials) of registrants [2]-[4]. Educational service providers design fixed curricula based on their roles on the education program, and provide them to students like consumer products. Thus, students cannot receive suitable curricula for accomplishing their career goal from legacy curriculum support systems.

In terms of the service science approach [5]-[7], legacy support systems are Goods Dominant Logic based. On the other hand, if curriculum support systems are designed in accordance with Service Dominant Logic [8], educational service providers can offer suitable processes of completion activities for value co-creation by offering a suitable curriculum designed by students in cooperation with educational institutions.

To test this idea, we designed a curriculum support system based on Service Dominant Logic concepts and persona strategy method [9]. This system aims at supporting completion activities based on the relationship between career goals and courses. We considered standards for display
of interactive activities processes and co-creation value evaluation. We then applied knowledge space theory to the interface of our system to display completion activity processes and the courses required to reach career goals for knowledge extension based on students’ current state of knowledge.

In addition, we had to devise mutual standards for the content and scope of knowledge and competencies required to reach career goals. For this purpose, we adapted the findings of the Computer Curricula 2005 report to the system.

In this paper, we introduce the prototype implementation case study conducted at the information science school of university A.

1.1 Computing Curricula 2005

IEEE&ACM Computer Society jointly sponsor the development of a Computing Curricula volume on Computer Science [10]. These volumes have helped to set international curricular guidelines for graduate programs in computing. Computing Curricula 2005(CC2005) presents five kinds of degree programs; CE (Computer Engineering), CS (Computer Science), SE (Software Engineering), IT (Information Technology), and IS (Information Service).

![Figure 1. Five degree programs of CC2005](image)

The CC2005 is guideline for curriculum with comparative weight (from 0 to 5 points) and relative performance capabilities (from 0 to 5 points) over 11 areas in not only computing courses but also non-computing courses for graduate degree programs. We applied the CC2005 report to proposed system for three reasons: it was published by the International Committee of IEEE and ACM Computer Society; it can be widely applied to other information science universities and colleges; it allows a relationship between information science industries and information science education programs to be mapped.

1.2 Service science approach

When educational service providers design education programs, CC2005 will be a guideline. According to CC2005, we can present standards to students of what knowledge required reaching career goals with the five degree programs. In addition, we can define knowledge level based on comparative weight and relative performance capabilities. Additionally, CC2005 provides a guideline about suitable curriculum to students with specific career goal. Given that information technology education is a service, the value of this service is important to both service providers and students.

![Figure 2. Definition of Service](image)

According to Figure 2, service providers have to provide service to customers based on professional techniques and gain compensation. Moreover, service providers have to consider customers, objects and satisfaction. That means service providers have to consider increasing service value and customers’ satisfaction [11]. In addition, service providers have to provide service based on the customers’ (students) objects (purposes) and characteristics. In the proposed system, we define service value as follows: students can take suitable courses and curriculum with individual characteristics for achieving their career goals. Under the proposed system, students can require the service providers to provide something these needs and attempt to meet them. As a result, students can acquire service value and feel satisfaction with the service provided from the educational institution [12]-[15].

1.3 Concept of Knowledge Space Theory

Actually, education service value can be defined differently according to situations, institutions
and targets. In this paper, the definition of value is that students accomplish career goals. For co-creation of value, basis for a mutual understanding of applicable standards is required among service stakeholders. We defined career goals with required knowledge and knowledge level for acquire process with expansion of knowledge [16]. Hence, we re-composed the curriculum of University A based on the integration CC 2005 with knowledge space theory as a user interface for supporting completion activities.

Knowledge space theory was proposed in 1985 by Jean-Paul Doignon and Jean-Claude Falmagne to explain the formation of a given province of knowledge. The formal concept is that a field of knowledge is specified by a finite set of items, i.e., problems or tasks a student may or may not be able to solve [17]. The set of all possible knowledge states is called a knowledge space. In this paper, we identify career goals a student may be able to achieve. Each student can attempt to reach them from his or her current knowledge state. Therefore, we can show a goal-related degree program and courses to students in a knowledge space when students select career goals (ideal knowledge A) and current knowledge level (current knowledge B) as axes. In addition, we can identify subjects that are required knowledge for reaching career goals (increased knowledge C) as expanding from current knowledge B to reach ideal knowledge A. Knowledge space B expands when students take a course, do research, or get credentials or degrees. We expect to stimulate students’ motivation for completion activities by visualization of goals, knowledge and potential. In addition, we anticipate gathering data about student’s activities and changed data about student’s activities and changed knowledge space with career goals for service innovation of information technology education. Service providers can support students’ career goals and provide new standard guidelines for completion activities based on analysis of gathered data. Students can design curricula and undertake completion activities. When students’ knowledge space expands, students can visualize information and impressions with service stakeholders based on the proposed system. As a result, we expect service value co-creation based on interaction between students and service providers using the proposed system.

2 Methods

In this chapter, we explain the curriculum design process and the method of creating a knowledge space with a case study of University A’s school of information science [18].

2.1 Curriculum re-composition

To create a curriculum structure in the knowledge space, we divided all of University A’s courses based on five degree programs and areas of the CC2005 guidelines. In addition, we mapped the relations among courses [19].

As a result, we drew a relationship diagram of courses based on CC2005, as shown in Figure 4. All subjects were reclassified based on CC2005. We extracted the subject areas need to reach career goals by applying the knowledge space of each axis as defined in Figure 6.

2.2 Design of knowledge space
2.2.1 Definition of career goals and knowledge axe

First, we have to develop a career goal list and a knowledge axis with subjects (major field) for knowledge space creation.

<table>
<thead>
<tr>
<th>Major Field</th>
<th>Subject</th>
<th>Major Field</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Algorithm</td>
<td>M6</td>
<td>Database</td>
</tr>
<tr>
<td>M2</td>
<td>Operating system</td>
<td>M7</td>
<td>Software Foundation</td>
</tr>
<tr>
<td>M3</td>
<td>System Development</td>
<td>M10</td>
<td>Network &amp; Communication</td>
</tr>
<tr>
<td>M4</td>
<td>Artificial Intelligence</td>
<td>M11</td>
<td>Computer Graphics</td>
</tr>
<tr>
<td>M5</td>
<td>Logic and Mathematics</td>
<td>M12</td>
<td>IT management</td>
</tr>
<tr>
<td>M6</td>
<td>Human Interface</td>
<td>M13</td>
<td>Embedded System</td>
</tr>
<tr>
<td>M7</td>
<td>Hardware and Device</td>
<td>M14</td>
<td>Security</td>
</tr>
</tbody>
</table>

Figure 5. List of subject fields based on CC2005 and A University program.

We identified the 16 career goals (G1, G2 …Gn) below based on a survey of 30 students from University A using the persona strategy method.

In addition, we added 2 specialist subject areas (embedded systems and security) that are provided by University A to the areas on the CC2005 list. 14 subject areas (Major Field, M1, M2 … Mn) were defined as axes of the knowledge space. (Figure 5)

We made the table shown in fig.6 considering University A’s information science school to define the knowledge space.

Then, to each career goal, 4 major fields were substituted as knowledge space axes (A1-A4) based on high comparative weight and relative performance capabilities as defined in the CC 2005 guidelines. (Figure 6.)

2.2.2 Definition of knowledge level

To define the knowledge level, we specified relative performance capabilities in subject fields from a minimum of 0 to a maximum of 8.

We suggested from a minimum of 0 to a maximum of 5 for M.S. candidates and from a minimum 5 to a maximum of 8 in a subject area for Ph.D. candidates. The A1 axis below shows the courses with the highest comparative weight in the CC 2005 guidelines.

<table>
<thead>
<tr>
<th>No.</th>
<th>Categories of Goal Career</th>
<th>CC Field</th>
<th>Knowledge Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>Development of hardware and Device</td>
<td>CE</td>
<td>A1* A2 A3 A4</td>
</tr>
<tr>
<td>G2</td>
<td>Design of human interface</td>
<td>CE</td>
<td>M7 M1 M2 M3</td>
</tr>
<tr>
<td>G3</td>
<td>Research about Operating system</td>
<td>CE</td>
<td>M2 M1 M9 M7</td>
</tr>
<tr>
<td>G4</td>
<td>Development of embedded system</td>
<td>CE</td>
<td>M13 M7 M3 M2</td>
</tr>
<tr>
<td>G5</td>
<td>Design an algorithm</td>
<td>CS</td>
<td>M1 M4 M5 M11</td>
</tr>
<tr>
<td>G6</td>
<td>Development of artificial intelligence</td>
<td>CS</td>
<td>M4 M1 M6 M5</td>
</tr>
<tr>
<td>G7</td>
<td>Research about Computer graphics</td>
<td>CS</td>
<td>M11 M1 M6 M5</td>
</tr>
<tr>
<td>G8</td>
<td>Design of logical model and mathematical theory</td>
<td>CS</td>
<td>M5 M1 M2 M9</td>
</tr>
<tr>
<td>G9</td>
<td>Software development</td>
<td>SE</td>
<td>M3 M8 M10 M2</td>
</tr>
<tr>
<td>G10</td>
<td>Research of software foundation</td>
<td>SE</td>
<td>M9 M3 M2 M5</td>
</tr>
<tr>
<td>G11</td>
<td>Management of development</td>
<td>SE</td>
<td>M12 M3 M8 M10</td>
</tr>
<tr>
<td>G12</td>
<td>Management of embedded system development</td>
<td>SE</td>
<td>M13 M3 M12 M7</td>
</tr>
<tr>
<td>G13</td>
<td>Research about network</td>
<td>IT</td>
<td>M10 M1 M5 M2</td>
</tr>
<tr>
<td>G14</td>
<td>Management of network</td>
<td>IT</td>
<td>M10 M12 M7 M2</td>
</tr>
<tr>
<td>G15</td>
<td>Research about security</td>
<td>IT</td>
<td>M14 M1 M7 M10</td>
</tr>
<tr>
<td>G16</td>
<td>Management of Information business or service</td>
<td>IS</td>
<td>M12 M3 M8 M10</td>
</tr>
</tbody>
</table>

Figure 6. Setting of knowledge axis
On the other axes (A2-A4), we will provide optional functions for students to adjust knowledge level by themselves. In the first step, current knowledge B is created by initial value (from 0 to 2) based on input data from students background, information science experience and licenses or credentials.

2.2.3 Knowledge space creation

Figure 7 shows a flow-chart that explains the knowledge space creation. Steps 1 and 2 are defined in figure 6. In step 3, students can choose a career goal from the categories of career goals on the proposed system. Next, in step 4, the system identifies 4 subject areas related to career goals based on figure 6. Then, in step 5, the system recommends the ideal knowledge space (as explained above) and creates the current knowledge space. In step 6, students can choose a curriculum from subject areas (shown in step 4) on the system. Students undertake completion activities based on a curriculum from step 6. As a result, professors give credits and comments to students. Finally, completion activities results and information are input into our system by professors, and the current knowledge space is updated automatically.

For example, to create a knowledge space for M.S students who want to engage in algorithm research, the following procedure applies: Students choose their career goals from G5 (including CS degree program shown in figure 6); the A1 axis is then set to the Algorithm (M1) subject area and ideal knowledge level 5 automatically. In addition, Artificial Intelligence (M4), Logic and Mathematics (M5) and Computer Graphics (M11) are selected as relative subject areas. If the student selects Artificial Intelligence (M4) as a sub research area in subject areas, M4 becomes the A2 axis.

Finally, the knowledge space is created as follows:

\[ \text{KS(MasterStudent, G5)} = \{A1*=M1(5), A2**=M4(4), A3=M5(3), A4=M11(3)\} \]

2.3 Method of increasing knowledge

The relationship diagram shows how students reach goal levels on the knowledge space (figure 8). On the A1 axis, the current knowledge level is 1 and the ideal knowledge level is 5, so increased knowledge variance between ideal and current knowledge level can be calculated. Figure 8 shows the completion process in the algorithm area based on the knowledge space. This student is recommended to take courses on level 2 and 3 layers.

Figure 7. Knowledge space creation flow chart

Figure 8. Interface of the knowledge space

The student then has to make a research proposal on the level 4 layer, and to write an M.S. thesis on the level 5 layer. Other axes can be represented through this method.
3 Implementation

In this chapter, the usage scenario is explained from the user’s viewpoint.

3.1 Usage Scenario

To utilize this system,
1) students input personal data (profile, education background, language ability) as basic data.
2) students create a new current knowledge space based on the input data.
3) students select a course (M.S. / Ph.D.) and career goal from 14 goal careers listed in the box.
4) the proposed system creates an ideal knowledge space with 4 axes.
5) the proposed system selects a main-research subject area axis automatically, and students
6) select a sub-research subject area from the 3 remaining subject areas axes.
7) students undertake completion activities following the curriculum on step 6; academic advisers input educational records with comments into the system.
8) during completion activities, the current knowledge space is updated with educational evaluation from academic advisers.

In this paper, we implemented a prototype system based on scenario from step 1 to step 6. Step 7 forward will be considered in future research.

Figure 9. Integration diagram of usage scenario
3.2 User Interface

We developed a prototype system with layer interface (figure 8) of the knowledge space. In figure 9, when student selects the name of the axis for a major field, the current knowledge layer (blue color) and ideal knowledge layer (red color) are displayed. On the layer structure, courses which are vertically related are “core” courses; these which are horizontally related are “elective” courses. Each lecture is selected by clicking. Moreover, course information (unit, lecturer, difficulty) can be shown on the interface. Additionally, required conditions for graduation can be checked automatically.

4 Evaluation

To evaluate this system, we select 10 graduates from university A who gave us feedback on this system. We are gathered personal information and data from the interviewees. In addition, we compared the graduates’ curricula and the system’s recommended curriculum for correlation. The results are shown in figure 10. The average correlation is 57.66%. The highest point recorded was 76.8%, in the Information Service area. The Computer Science area and the Software Engineering area also recorded over 60% correlation. Correlation in the Computer Engineering area was around 50% correlation and the Information Technology area recorded the lowest correlation, around 40%.

<table>
<thead>
<tr>
<th>ID</th>
<th>Goal/Career</th>
<th>Goal/Ability</th>
<th>Accured</th>
<th>Total</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>s100001</td>
<td>M Program Development of hardware and device</td>
<td>Development of hardware and device</td>
<td>5</td>
<td>9</td>
<td>55.5%</td>
</tr>
<tr>
<td>s100002</td>
<td>M Program Research about Operating system topic</td>
<td>Research about Operating system topic</td>
<td>6</td>
<td>12</td>
<td>93%</td>
</tr>
<tr>
<td>s100003</td>
<td>M Program Development of Software</td>
<td>Development of Software</td>
<td>4</td>
<td>7</td>
<td>57.1%</td>
</tr>
<tr>
<td>s100004</td>
<td>M Program Management of embedded system development</td>
<td>Management of embedded system development</td>
<td>7</td>
<td>11</td>
<td>63.0%</td>
</tr>
<tr>
<td>s100005</td>
<td>D Program Management of information and business processes</td>
<td>Management of information and business processes</td>
<td>10</td>
<td>15</td>
<td>70.8%</td>
</tr>
<tr>
<td>s100006</td>
<td>M Program Management of Network issues</td>
<td>Management of Network issues</td>
<td>5</td>
<td>10</td>
<td>50%</td>
</tr>
<tr>
<td>s100007</td>
<td>M Program Research about network security issues</td>
<td>Research about network security issues</td>
<td>6</td>
<td>11</td>
<td>54.5%</td>
</tr>
<tr>
<td>s100008</td>
<td>M Program Research about Network issues</td>
<td>Research about Network issues</td>
<td>4</td>
<td>10</td>
<td>49%</td>
</tr>
<tr>
<td>s100009</td>
<td>M Program Design of human interface</td>
<td>Design of human interface</td>
<td>5</td>
<td>8</td>
<td>62.5%</td>
</tr>
<tr>
<td>s100010</td>
<td>D Program Design of machine intelligence</td>
<td>Design of machine intelligence</td>
<td>6</td>
<td>9</td>
<td>66.6%</td>
</tr>
</tbody>
</table>

Total Probability 57.66%

The average correlations were lower than our initial predictions. Moreover, we discovered that “core” courses’ correlation was over 90% but “elective” courses’ correlation was only around 20%.

From interview with graduates, we learned that is students most graduates had selected courses to get credit easily or based on other students’ advice. However, the interviewees felt that the proposed system would have been helpful in choosing courses when they were students.

Figure 9. Curriculum design page interface
5 Discussion

According to interviews and feedback, students had positive reactions and comments about the knowledge space interface and curriculum visualization with student characteristics. In addition, additional functions that allowed them to check required conditions for graduating were also evaluated positively.

However, concerns exist about the major field, courses and knowledge level. Defining career goals and major fields at this point encounters a problem: how to generalize the career goals and the major field this system to the curricula at other institutions. In particular, freedom of selecting subject areas and axis was evaluated poorly.

Despite that, proposed system takes a service approach that considers not only service from provider to customer, but also customer to provider and creates service value through cooperation and co-creation. We have a plan for future work that how to provide a balanced curriculum which ‘core’ and ‘elective’ courses to student. We hope to that, after completion of development, this system becomes the interactive supporting system platform between students and service providers for value co-creation in not only information technology education but also other areas of education.

Acknowledgment

The authors would like to thank Professor K. Ochimizu, Ph.D. A. SEO and Professor Wm.R. Holden III for their valuable advices.

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