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A Mathematical Approach in Evaluating Biotechnology Attitude Scale: Rough Set Data Analysis

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Abstract

Individuals' thoughts and attitudes towards biotechnology have been investigated in many countries. A Likert-type scale is the most commonly used scale to measure attitude. However, the weak side of a likert-type scale is that different responses may produce the same score. The Rough set method has been regarded to address this shortcoming. A likert-type attitude scale was evaluated using the rough set method. Randomly selected 60 participants were given a biotechnology attitude scale and their responses to the scale items were examined using the method mentioned above. Participants belonging to a specific group were examined if they might also belong to another group in light of this method. Mathematical values of each sub-dimension and the extent to which a specific group accounts for the total variance in the overall dimension were calculated. Finally, the accuarcy of approximation for the high, moderate, low and very low sets are calculated as α_R(Y)=1, α_R(O)=0,8, α_R(D)=0,778, α_R(ÇD)=1 It means that the moderate and low sets are rough sets. Through reduction of attributes, "Public awareness of GMO, Ethics of genetic modifications, Ecological impact of genetic engineering and Use of genetic engineering in human medicine" sub-dimensions were found to be the indispensable sub-dimensions.

Key Words

Rough Sets, Attitude Scales, Biotechnology, Data Analysis.

Attitude, which is attributed to a certain individual, can be defined as emotional, behavioral tendency that a individual reacts to an abstract or concrete object (Baron & Byrne, 1977). As can be understood from this definition, attitude is a tendency rather than a behavior itself (Bogardus, 1947; Caine & Caine, 1994; Lackney, 1998). Attitude is a preparation situation when facing various stimuli. In other words, it is a response tendency. An individual do not realize his/her attitudes towards a particular object until he/she must respond to it.

As reported by Allport [1956] the first study on attitude was carried out by Thurstone [1929] and subsequent research followed. The assessment of attitude has always been important, because knowledge of attitude allows one to predict and control behaviour (Eren, 2001; Krech & Cructhfield, 1980). However, as attitudes do not have a physical dimension, it is very difficult to scale them. Therefore, attitudes cannot be directly assessed. Information on individual thoughts, emotions, and reaction tendencies are gathered instead (Thurstone, 1967).

Observation, list of questions, completion of incomplete sentences, narrations, method of wrong selection, and content analysis are some of the methods used in measuring attitudes (Anderson, 1988; Arul, 2002). The most commonly used method among these methods is the implementation of attitude scales (Tavşancıl, 2006). The attitude scale developed by Renis Likert (1932) is the most commonly used attitude scale. The ease of the implementation of this scale is what makes it popular.

The weak side of a likert-type scale is that different responses may produce the same total score (Tavşancıl, 2006). Take a likert-type scale which has a number of sub-dimensions as an example.

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Some of the sub-dimension scores may be low; some of them may be high. Two students having the same total score may have different sub-dimension scores. The rough set method developed by Pawlak (1982) may provide an alternative way to examine attitude scales in this way.

Vague concepts which we may also call uncertain knowledge, have occupied human mind for centuries. According to Frege (1904), uncertain concepts are those that are related to boundary-line view. That is, an uncertain concept is the one that has some objects not only outside or inside of it but also on its boundary. Philosophers, psychologists, current computing engineers, and mathematicians have shown interest in this topic. Now we face with such questions as "How can we understand uncertain knowledge?" or "How can we formulate uncertain knowledge?"

The first successful application of uncertainty approaches is the fuzzy sets was defined by Zadeh in 1965. In this approach, membership of an element in a set is defined via a membership function. In other words, in fuzzy sets, one cannot say whether an element certainly belongs to a set or not, one can only say that an element belongs to a set at a certain degree.

Another successful uncertainty approach is the rough sets defined by Pawlak in 1982. The basic tool in Pawlak's rough sets is an equivalence relation. The lower and upper approximations are built through equivalence classes (Aktaş & Çağman, 2005). Following Pawlak's definition, other rough set theories using different algebraic structures instead of an equivalence relation are suggested (Bonikowaski, 1995; Jiashang, Congxin, & Degang, 2005; Kumar, 1993; Kuroki, 1997; Narli & Ozcelik, 2008; Pomykala & Pomykala, 1998).

After being introduced, these sets were used as a mathematical tool to extract information from incomplete or uncertain data (Pawlak, 1983, 1991, 1995). Rough set theory can be used in data reduction, detection of dependences, estimation of the importance of data, forming control algorithms from data, approximate classification of data, detection of similarities and differences within data, detection of patterns in data, and detection of cause-effect relationships (Aydoğan & Gencer 2007; Pawlak & Slowinski, 1994). Rough sets are used for these purposes as illustrated in the literature (Ananthanarayana, Murty, & Subramanian, 2002; Breault, 2001; Chan, 1998; Felix & Ushio, 1999; Hassan & Tazaki, 2003; Hassan, Tazaki, Egava, & Suyama, 2002 ;Hassanien, 2003; Kent, 1994; Jerzy, Busse, & Siddhaye, 2004; Kuasik, Kern, Kernstine, & Tseng, 2000; Li & Wang, 2003; Lin & Cercone, 1997; Narli & Ozcelik, 2010; Narli, Yorek, Sahin, & Uşak, 2010; Nings, Ziarko, Hamilton & Cercone, 1995; Pawlak, Grzymala, Slowinski, & Ziarko, 1995; Pawlak, 2000; Polkowski & Skowron, 1998a, 1998b; Yorek & Narli, 2009; Zhong & Skowron, 2000, 2001).

Biotechnology is a field which covers other fields such as biochemistry, molecular biology, genetic engineering, and microbiology (Saez, Nino, & Carretero, 2008). Biotechnology influences individuals' lives directly and indirectly (Lamanauskas & Makarskaitė-Petkevičienė, 2008). There has been discussion about the consumption of foods produced from genetics transfers among beings (Pardo, Midden, & Miller, 2002). It has become important to measure and evaluate corretly people's attitudes that determine behavior regarding issues such as application of biotechnology including organisms whose genetics were changed (Erdogan, Özel, Uşak, & Prokop, 2009). A number of researchers have conducted studies to measure different students' attitudes towards biotechnology (Chen & Raffan, 1999; Dawson & Schibeci, 2003; Lamanauskas & Makarskaitė-Petkevičienė, 2008; Özden, Uşak, Prokop, Türkoglu, & Bahar, 2008; Prokop, Lešková, Kubiatko, & Diran, 2007; Usak, Erdogan, Prokop, & Ozel, 2009).

Prokop and et al. (2007) investigated Slovakian students' knowledge about biotechnology and their attitudes towards it. They found a significantly positive correlation between attitudes and the level of knowledge, besides the students had low levels of knowledge and numerous misunderstandings. Lysaght, Rosenberger III, and Kerridge (2006) investigated 375 Australian students' attitudes towards biotechnology and pointed out the importance of placing ethics education in curriculum. Using 1116 secondary education students, Dawson and Schibeci (2003) investigated Australian students' misunderstandings regarding developments in modern biotechnology and they found that one-third of students did not understand microbiology at all or understood little.

Although biotechnology has important influences on economic and social life, there has been little research on Turkish students' knowledge and attitudes towards biotechnology (Darçın & Güven, 2008; Özden et al., 2008, Usak et al., 2009). Darçın and Güven, (2008) developed a scale to measure science pre-service teachers' attitudes towards biotechnology. Özel, Erdoğan, Uşak, and Prokop

(2009) conducted a study to measure 352 high school students' knowledge and attitude towards biotechnology and it was found out that male and older students' attitudes toward biotechnology were more positive than those of female and younger students. When Usak and et al. (2009) compared attitudes of high school with attitudes of university students towards biotechnology and knowledge, it was found out that there was no difference between two groups in terms of knowledge, but there was a significant difference in terms of attitude (attitudes of university students were more positive) Erdogan and et al. (2009) argued that previously developed scales were not appropriate for university students. Thus, they developed a new scale which consisted of sub-dimensions.

In the classic set concept, the elements of a set are definitive. In other words, an element is a member of a set or not. For example, a set consisting of odd numbers is of this type. Because a number is either or even. In our daily lives, however, we can not separate things with certain lines.

When we think of a set of young people, this set cannot be identified with certain lines as in the odd-number example. The concepts we use in our speeches are concepts whose borders cannot be easily separated. This situation forced researches to investigate alternative set concepts. Rough set theory is the expansion of classic set theory.

Data are organized in a way that each row represents an object and each column represents a feature-value table showing a specific feature (Munakata, 1998). This table is called information table or decision table. Table 1 is an example of information table. An important point in data analysis is the investigation of relationships among features. By sense, if Q decision features set is defined by P situation features set, we can say that Q is dependent upon P (Pawlak, 1997, 1998).

Biotechnology Attitude Scale and Rough Set Analysis

One of the most important scientific and technological developments in recent times has been biotechnology and its applications in several areas (Pardo et al., 2002). Developments in biotechnology have affected social life and resulted in many discussions (Lamanauskas & Makarskaitė-Petkevičienė, 2008). For instance, discussions on genetically modified organisms' products have continued in numerous areas. (Pardo et al., 2002, Sturgis, Cooper, & Fife-Schaw, 2005). Biotechnology raises various issues with regard to ethics, the level of acceptable risk, and usefulness of the new products (Reiss & Straughan, 1996). Therefore, people want to be informed about science and technology to make better personal and social choices as members of the society (Usak et al., 2009).

The most effective way to inform people about biotechnology and its applications is formal education conducted in schools. As it is well known, one of the essential elements of science education is scientific literacy (Goodrum, Hackling, & Rennie, 2001). An important reason why people have anxiety is related to their lack of knowledge about biotechnology (Gunter, Kinderlerer, & Beyleveld, 1998). Thus, determining people's knowledge level and their attitudes towards biotechnology might play an important role in solving anxiety problems. This resulted in many research studies regarding this issue (Prokop et al., 2007; Lamanauskas & Makarskaitė-Petkevičienė, 2008; Usak et al., 2009).

Of all these studies, one study focused on developing a new attitude scale aimed at measuring students' attitudes towards biotechnology (Erdogan et al., 2009). The current study used this five-point likert type scale which is made up of 7 factors and 28 items. This study is a descriptive survey research. These studies are conducted in order to enlighten a given situation, to evaluate the standards and to reveal relationships between events (Çepni, 2009, p. 64). The model aims to describe a completed or continuing situation. The basis of the research is to define the event, the individual or the object, which is the issue of the research, as it is within its own context (Karasar, 2008, p. 77).

Students were classified into 5 groups ranging from very low to very high based on their sub-dimension and total attitude scores. Since the instrument was five point likert type scale, value of group extent was calculated by diving 4 by 5 4/5=0,8.

Study's Rough Set Analysis

When case features as a whole in the Table were taken into account 4, R equivalence relation (indiscernibility relation) separates IU students' set into equivalence class:

IU/R ={{x_1, x_2, x_3}, { x_4, x_5, x_6}, { x_7, x_8, x_9}, {x_{10}, x_{11}, x_{12}}, {x_{13}, x_{14}, x_{15}}, {x_{16}, x_{17}, x_{18}}, {$x_{19,}$ x_{20}, x_{21}, x_{22}, $x_{23,}$ x_{24}}, {$x_{25,}$ x_{26}, x_{27}}, {x_{28}, $x_{29,}$ x_{30}},{x_{31}, x_{32}, x_{33},x_{34}, x_{35}, x_{36}}, {x_{37}, x_{38}, x_{39}}, { x_{40}, x_{41}, x_{42}}, {x_{43}, x_{44}, x_{45}}, { x_{46}, x_{47}, x_{48}}, {x_{49}, x_{50}, x_{51}}, {x_{52}, x_{53}, x_{54}}, {x_{55}, x_{56}, x_{57}}, {x_{58}, x_{59}, x_{60}}}.

Based on the total attitude scores, four groups existed in the current study: ranging from high, moderate, low, to very low. We failed to identify

any student with a very high attitude score. For the analysis, we identified students within each level who belong to or might belong to a certain group and calculated low and high approach sets as shown below. :

$\{x_1, x_2, x_3, x_4, x_5, x_6\}$is a set on which students' scores are high. This set's low and high approach was calculated as it was written below:

$R_{low}(H)= \bigcup_{a\in IU} \{ R(a) : R(a) \subset H\}=\{x_1, x_2, x_3\}$ $\{x_4, x_5, x_6\}=\{ x_1, x_2, x_3, x_4, x_5, x_6\}$.

$R^{up}(H)= \bigcup_{a\in IU} \{ R(a) : R(a)\cap H\neq\emptyset\}=\{x_1, x_2, x_3\}$ $\{x_4, x_5, x_6\}=\{ x_1, x_2, x_3, x_4, x_5, x_6\}$.

The set of students with moderate levels of attitudes and low and high approach set is as follows:

Moderate= $\{x_7, x_8, \dots, x_{33}\}$.

$R_{low}(M) = \bigcup_{a\in IU} \{ R(a) : R(a) \subset M\}=\{ x_7, x_8, x_9\}\cup\{x_{10}, x_{11}, x_{12}\}\cup\{x_{13}, x_{14}, x_{15}\}\cup\{x_{16}, x_{17}, x_{18}\} \cup\{x_{19,} x_{20}, x_{21}, x_{22}, x_{23,} x_{24}\}\cup\{x_{25,} x_{26}, x_{27}\}\cup\{x_{28}, x_{29,} x_{30}\}= \{x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}, x_{16}, x_{17}, x_{18}, x_{19,} x_{20}, x_{21}, x_{22}, x_{23,} x_{24}, x_{25,} x_{26}, x_{27}, x_{28}, x_{29,} x_{30}\}$.

$R^{up}(M) = \bigcup_{a\in IU} \{ R(a) : R(a)\cap M\neq\emptyset\}=\{ x_7, x_8, x_9\}\cup \{x_{10}, x_{11}, x_{12}\}\cup\{x_{13}, x_{14}, x_{15}\}\cup\{x_{16}, x_{17}, x_{18}\} \cup\{x_{19,} x_{20}, x_{21}, x_{22}, x_{23,} x_{24}\}\cup\{x_{25,} x_{26}, x_{27}\}\cup\{x_{28}, x_{29,} x_{30}\}\cup\{x_{31}, x_{32}, x_{33}, x_{34}, x_{35}, x_{36}\}$. $\{x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}, x_{16}, x_{17}, x_{18}, x_{19,} x_{20}, x_{21}, x_{22}, x_{23,} x_{24}, x_{25,} x_{26}, x_{27}, x_{28}, x_{29,} x_{30}, x_{31}, x_{32}, x_{33}, x_{34}, x_{35}, x_{36}\}$

The set $\{ x_{34}, x_{35}, \dots, x_{57}\}$of students with low levels of attitudes and low and high approach set are as follows:

$R_{low}(L) = \bigcup_{a\in IU} \{R(a) : R(a) \subset L\}=\{x_{37}, x_{38}, x_{39}\}\cup\{ x_{40}, x_{41}, x_{42}\}\cup \{x_{43}, x_{44}, x_{45}\}\cup\{ x_{46}, x_{47}, x_{48}\}\cup\{x_{49}, x_{50}, x_{51}\}\cup \{x_{52}, x_{53}, x_{54}\}\cup\{x_{55}, x_{56}, x_{57}\}= \{x_{37}, x_{38}, x_{39}, x_{40}, x_{41}, x_{42}, x_{43}, x_{44}, x_{45}, x_{46}, x_{47}, x_{48}, x_{49}, x_{50}, x_{51}, x_{52}, x_{53}, x_{54}, x_{55}, x_{56}, x_{57}\}$

$R^{up}(L) = \bigcup_{a\in IU} \{ R(a) : R(a)\cap L\neq\emptyset\}=\{x_{31}, x_{32}, x_{33}, x_{34}, x_{35}, x_{36}\}\cup\{x_{37}, x_{38}, x_{39}\}\cup\{ x_{40}, x_{41}, x_{42}\}\cup \{x_{43}, x_{44}, x_{45}\} \cup\{ x_{46}, x_{47}, x_{48}\}\cup\{x_{49}, x_{50}, x_{51}\}\cup\{x_{52}, x_{53}, x_{54}\}\cup\{x_{55}, x_{56}, x_{57}\}= \{ x_{31}, x_{32}, x_{33}, x_{34}, x_{35}, x_{36}, x_{37}, x_{38}, x_{39}, x_{40}, x_{41}, x_{42}, x_{43}, x_{44}, x_{45}, x_{46}, x_{47}, x_{48}, x_{49}, x_{50}, x_{51}, x_{52}, x_{53}, x_{54}, x_{55}, x_{56}, x_{57}\}$

The students who belong to a very low level attitude set are the elements of the $\{x_{58}, x_{59}, x_{60}\}$set. This set's low and high approach set is as follows:

$R_{low}(VL)= \bigcup_{a\in IU} \{ R(a) : R(a) \subset VL\}=\{x_{58}, x_{59}, x_{60}\}$.

$R^{up}(VL)= \bigcup_{a\in IU} \{ R(a) : R(a)\cap VL\neq\emptyset\}=\{x_{58}, x_{59}, x_{60}\}$.

In the current study, when considering P = {F1, F2, F3, F4, F5, F6, F7}, F4, F2, F1 sub-dimensions might be discarded. {F1, F2, F3, F5, F6, F7}, {F1, F3, F4, F5, F6, F7}, and { F2, F3, F4, F5, F6, F7} are P's reduced feature sets. Thus,

Red(P)={ {F1, F2, F3, F5, F6, F7}, {F1, F3, F4, F5, F6, F7}, {F2, F3, F4, F5, F6, F7}},

$$Core(P) = \bigcap \mathrm{Re}d(P) = \{F3, F5, F6, F7\}$$

is calculated.

As a result, F F3, F5, F6, and F7 sub-dimensions can be regarded as indispensable sub-dimensions of the instrument.

Discussion

Whether they are quantitative or qualitative, statistical methods such as descriptive statistics, t-test, ANOVA/MANOVA, correlation and regression are commonly used in educational research (Hsu, 2005). These methods aim at evaluating individuals' features in studies regarding education. By nature, individuals' behaviors are multidimensional and complicated (Loslever & Lepoutre, 2004). From this perspective, it can be argued that the individuals' behavior and their features can not be categorized with certain lines. Similarly, since attitude does not have a physical component, it is not easy to measure it.

The use of alternative concepts such as fuzzy set and rough set has increased dramatically in recent years in evaluating uncertain expressions. These concepts have received attention in education as well (Yorek & Narli, 2009). Rough sets are used in areas such as artificial intelligence, machine learning, pattern recognition, decision support systems, expert systems, data analysis, and data mining. Offering a new approach to evaluating towards a biotechnology attitude scale, the current study discussed rough set approach in evaluating quantitative data. The analysis of total attitude scores revealed four groups. Of all these groups, the students who had very high and very low attitudes indicated exact set; whereas those who had moderate and low attitudes indicated rough set. This suggests that those who have moderate attitudes might actually have low attitudes and those who have low attitudes have potentially moderate attitudes. Moreover, sub-dimensions (Public awareness of GMO-F3, Ecological impact of genetic engineering-F6, Ethics of genetic modifications-F5, Use of genetic engineering in human medicine-F7) collectively accounted for high variance in total score, thus they can be viewed as indispensible factors of the scale. There are a number of inconsistencies among attitudes, which may have resulted from a lack of knowledge. (Özel et al., 2009). Thus, it can be said

that students may face concepts under high subdimensions more frequently and be affected more by them. Even though people forget what they have learned about a topic, they do not forget their attitude and tendency (Stodolsky, Salk, & Glaessnes, 1991). Narli (2010) reported similar results in his study on evaluating a mathematics attitude scale of Fennema-Sherman using rough set method. The studies of Yorek and Narli (2009) and Narli et al. (2010) revealed more explanatory results about the use of rough set method in education. It seems impossible to find these results using other statistical methods. From this perspective, analysis of rough set possesses a number of advantages.

Since its introduction by Pawlak in 1982, the use of set rough has received a great deal of attention in different fields such as mathematical morphology, genetics algorithm, artificial intelligence, Petri web, decision tables, probability, pharmaceutical industry, industry, engineering, control systems, and social science. The use of this method may provide new insights into analysis of data regarding human behavior, attitude, performance, and beliefs.

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