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Challenges of Teaching Information Quality: Demonstrating an Adaptation of a Popular Management Game in Teaching Information Quality

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ABSTRACT

Over the last years information quality has gained increasingly importance in practice as well as academia. Recently aspects of information quality are included in many Information Systems' curricula. However, teaching aspects of information quality to students is challenging and often emphasizes merely theoretical aspects. As a consequence many graduates have a limited understanding of information quality issues and management practice. In order to help to raise the awareness of information quality aspects, we developed a teaching tool that can demonstrate the impact of poor information quality and the importance of information quality management. The tool is based on a popular management game and can show the effects of information quality on organizational decision-making.

Keywords

Decision making, information quality education, effects of information quality

INTRODUCTION

In an age characterized by high information dependency, a critical concern for a wide range of organizations is information quality (IQ). More than ever before, many organizations focus their business on the provision of valuable information and thus are highly depended on high IQ. In order to assure that such information is of a high quality, organizations face the considerable challenge of controlling IQ. Therefore information quality management has become an essential component of organizational management. Over the last decade, the importance of IQ is ever more recognized among practitioners and academics. It has developed beyond the traditional view of IQ as a synonym for data accuracy. Wang and Strong (1996) note that in order to improve data quality in an organization, a multi-dimensional view of the concept must be taken.

Many researchers have examined IQ from various perspectives (Ge & Helfert 2008). The result of the plethora of publications is a multiplicity of descriptions, definitions, criteria lists, case studies and frameworks for various areas of applications (e.g. Wang, Storey & Firth 1995). In addition to these frameworks, literature on IQ indicates a number of technical, managerial, and organizational factors that are believed to improve IQ. However when reviewing recent IS study programs, these frameworks and approaches have rarely found its way into the IS curriculum. Indeed when reviewing some of most prominent reference curricula related to IS (Gorgone et al., 2002a; Gorgone et al., 2002b; Topi et al., 2007; Gorgone et al., 2000) we rarely found reference to IQ education. Over the last year, some IQ researchers have addressed this problem and provided a matching between the MSIS curriculum building blocks and IQ capabilities. The approach described in Lee et al. (2007) presents an integration of IQ into the MSIS curriculum. Also, Helfert (2007) describes how IQ skills can be taught in a Business Informatics Programme. However, from these positive examples of IQ oriented curricula and from discussions with practitioners only few professionals have received systematic training in managerial aspects to maintain and improve IQ.

Recognizing the importance of IQ, several academics have started to include aspects of Information Quality Management (IQM) into their teaching approach, however often with a theoretical lens to the subject. Modern information system education should not only include theoretical aspects, but should emphasize a problem based teaching approach (Macdonald 2005). One positive example on combining a problem-based and case study oriented approach with theoretical concepts on IQ is presented by Chaffey and Wood (2005), which formed the bases for a teaching approach in academia. In order to enrich the learning experience, we aimed to enhance the problem based approach with training and educational tools for IQ. However, at present there are only a few tools suitable for IQ training and education. Furthermore, there is no practical tool focusing on teaching IQ skills or competences. Due to the lack of a suitable training tool and in order to assist our teaching approach we developed a teaching tool. The tool is aimed to increase the awareness of IQ, to show practical application of IQ and to increase the awareness of the effects of poor IQ on decision making. This paper presents the details of the tool as well as experiences made.

The paper is organized as follows. Section 2 provides a review of IQ research to highlight the development of IQ. Followed by the review, section 3 proposes a teaching tool that can be used to show the effects of IQ in organizations. In order to evaluate the tool, section 4 presents the analysis results of our experiment and the comments received from users who used our tool. Finally, section 5 concludes this paper by summarizing our experiences and outlines the further developments.

RELATED WORK AND REQUIREMENTS OF IQ TRAINING

Over the last decades IQ became an important area both in research and practice. Recent job openings indicate that many organizations require professionals with expertise as IQ Manager, IQ Analyst, IQ Consultant, and IQ System Developer. Addressing the growing demands for qualified IQ professionals, taught courses and research programmes were initiated at some Universities. One example for such programmes is the IQ Program at the University of Arkansas at Little Rock (USA), which is presents a balanced approach between practice and theory (Lee at al. 2007). Professional training courses are offered from various organizations, such as the IQ Programme at the Massachusetts Institute of Technology, Training programmes from the International Association for Information and Data Quality or Information Impact International, Inc.

Content taught within these programmes can build on an extensive foundation of IQ research, which was established over several decades. In order to outline main contributions in the area, we reviewed the literature and structured the development of the IQ area in three main phases.

In the late 1960's, statisticians are the first to study IQ problems (Batini & Scannapieco 2006). They investigated data duplication issues in statistical datasets by mathematical theories. The following researchers are accounting professionals. For example, Yu and Neter (1973) developed a quantitative model to measure data errors in financial IS. The pioneering works have stated or implied the concept of IQ and investigated certain IQ dimensions.

From 1980's to early 1990's, IQ research is widespread but not yet systematic. Researchers begin to focus on exploring the IQ dimensions, assessment methodologies and improvement strategies. At this stage, different sets of IQ dimensions have been explored. For example, Brodie (1980) proposed that IQ contained three distinct components: information reliability, logical integrity and physical integrity. In addition, different assessment methodologies are proposed. For example, Paradice and Fuerst (1991) developed a quantitative measure to formulate the error rate of stored record in IS. In this phase, researchers have concluded that IQ is a key determinant for information system success (DeLone & McLean 1992).

From the middle 1990's to present, IQ research becomes intensive, systematic and empirical. This can be notices by the amount of IQ papers that have significantly increases in a wide range of journals and conferences. From 1995 to 2008, more than 15 IQ books are published. These books have addressed different aspects of IQ research. Three IQ journals have been launched so far: Data Quality Journal in 1995, International Journal of Information Quality in 2007 and ACM Journal of Data and Information Quality in 2008. Many leading database and information system conferences such as SIGMOD, VLDB and CAiSE have included IQ as one of the conference themes. Furthermore, since 1996, International Conference on Information Quality (ICIQ) is annually held to provide a forum for researchers and practitioners to present research findings and exchange IQ knowledge. Beyond the research development in academia, industry and government begin to pay attention to IQ issues. For example, Navesink Consulting Group was formed in 1996 and provided IQ solutions and services to other organizations. During this phase, the academic and professional training courses mentioned above were established.

Over the last few years large progress have been made to developed IQ curricula. For instance Lee et al. (2007) provides a curriculum for a Master of Science in IQ, which presents a balanced approach between theoretical rigor and practical relevance. The programme is currently offered by the University of Arkansas at Little Rock (UALR) and includes case studies, problem based teaching and focuses on student's learning experiences. Reviewing selected courses and programmes, we identified following main concept and key points that current IQ training programmes and courses contain or at least aim to achieve:

- Demonstrate a critical awareness of the importance and implications of IQ.
- Appraisal of various definitions for IQ and a thorough understanding of IQ as fitness for use in a particular application.
- A systematic understanding of concepts, principles, tools, and models essential in defining, measuring, analyzing, and improving the quality of information.
- A systematic understanding of Information Science theories and practices in the areas of database systems, systems analysis, and information visualization.

- A systematic understanding of interrelationships between IQ and other key IS concepts such as enterprise architecture, data warehousing, analytical IS, data integration, data modelling.
- The ability to develop IQ strategies, policies, and programs to support an organization's operational, tactical, and strategic needs.
- The ability to critically evaluate problems and alternative solutions in a variety of context, such as customer relationship management, logistics or Web environments.
- Awareness of ethical standards of the profession such as data privacy and protection which aims to ensure compliant use of the IQ expertise.

However, despite these positive examples and the increasing number of IQ training courses, only few IS professionals have received formal training or education to manage IQ (Khalil et al. 1999). Furthermore, apart from some positive examples like at UALR, many educational programmes of IQ focus on theoretical aspects. Recognizing the limitation of current efforts to teach IQ, we aimed to improve the learning in IQ and to provide a different learning experience for students.

Our approach was developed in the context of an undergraduate "Information System Strategy" Course using a problem-based teaching approach. As foundation we use the textbook from Chaffey and Wood (2005), which provides a problem and case study based approach to IS. In order to emphasize the concepts taught we include case studies and discussions throughout the course. Furthermore, in order to provide a practical experience for students, we developed a software tool in form of a game to help students understand the importance of IQ management.

A TOOL FOR IQ EDUCATION

The tool is based on a popular management game, the traditional Beer Game, which involves managing supply and demand in beer supply chain. The concept for the game was first developed at the Massachusetts Institute of Technology in 1960s. Since then, several extensions and modifications are proposed. Kaminsky and Simchi-Levi (1998) identified several weaknesses of this traditional game and extended to the computerized Beer Game.

We have extended the traditional Beer Game and included IQ aspects in form of various marketing and sales information to the students. The system is designed to provide information of different quality levels. Using the given information, students are asked to make inventory control decisions.

This supply chain in the game involves manufacturer, distributor and customer. The participants are asked to play the distributor. The two other roles are taken over by the computer. According to the inventory information and customer ordering history, participants will order products from the manufacturer and supply products to the customer. There are two sources of cost associated with the game: (1) If the distributor cannot fill customer's order, a cost will be occurred (1 euro per unfilled item). (2)When the items are stored in the inventory, a cost will be occurred (0.5 euro per stored item per week). The goal of the game is to minimize the cost in the distributor's inventory management.

The interface of our teaching tool is shown in Figure 1. In order to start the game, participants place an order in the input box and click the "OK" button. The order is sent to the manufacturer. The procurement delay from manufacturer takes 3 weeks. That means it takes 3 weeks from making the order and receiving the ordered items. Note that the manufacturer may not be able to fill the order if this order exceeds the inventory of the manufacturer. For example, in week 10, participants place an order to the manufacturer. This order will arrive at the manufacturer in the beginning of week 11. The manufacturer needs 1 week to process the order. In the beginning of week 12, the manufacturer ships the ordered items to the distributor. The shipment takes 1 week. Therefore if participants make an order in week 10, the order will arrive in week 13.

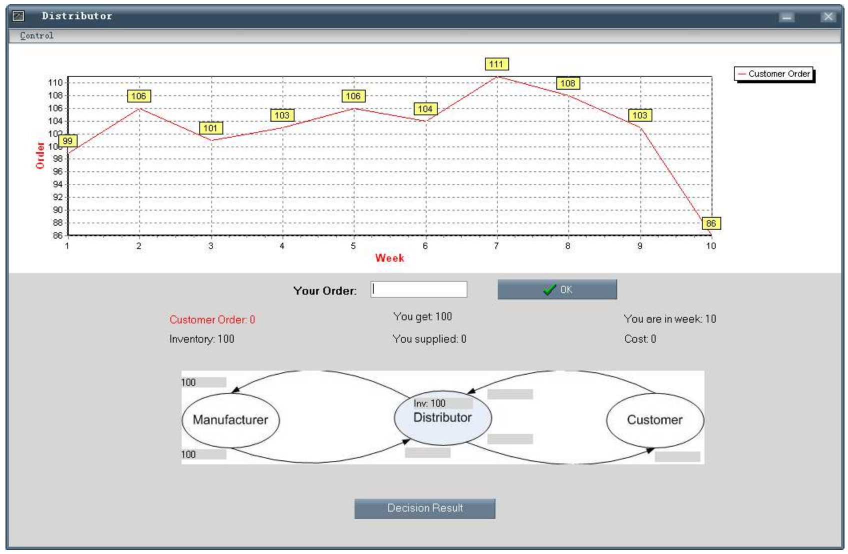

Figure 1: Initial interface of this teaching tool

When playing the game, participants could obtain the following information from the software interface: customer order, current inventory, how many ordered items are arrived, how many items are shipped to the customer, current week, and the total cost. Participants also could observe the delays between the manufacturer, the distributor and the customer. One round of the game contains 10 weeks. Figure 2 has shown snapshot of the software after one round of the game. After completing 10 weeks, the student can play another 10 weeks or finish the game. When the student finishes the game, he or she will receive the results.

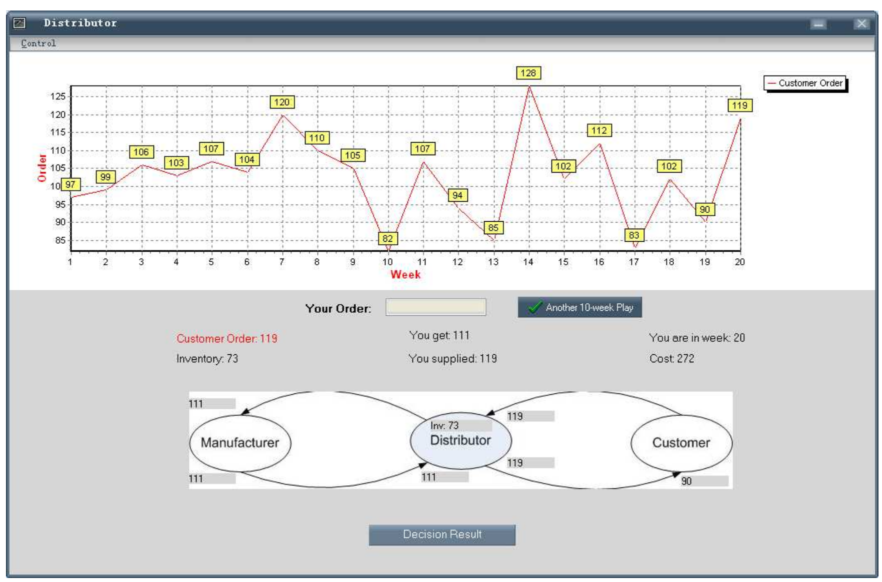

Figure 2: Snapshot of one round of the game

When participants click the decision result button, the decision results of last 10 weeks are showed as Figure 3.

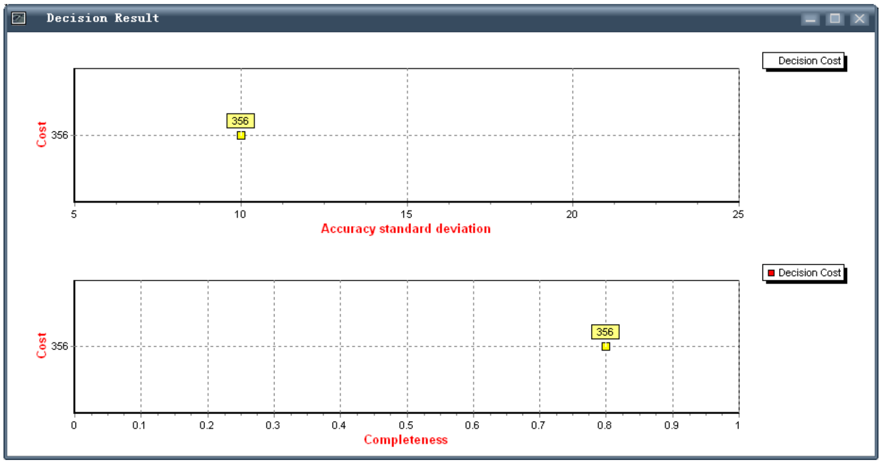

Figure 3: Decision results

As indicated in Figure 3, students can observe the relationship between IQ and decision quality. For instance, the standard deviation of information accuracy is 10 and the information completeness is 80%, the participant made 10 ordering decisions and the total cost is 356 euro. Accuracy is divided into 5 levels by different standard deviations. These 5 standard deviation levels are 5, 10, 15, 20, and 25. The greater the standard deviation, the greater value of inaccuracy is. For example, when the accurate order is 100, we use different standard deviations to generate inaccurate orders. Thus the orders generated by standard deviation 10 will be more inaccurate than the ones generated by standard deviation 5.

The levels of completeness are expressed by percentages. 5 completeness levels are used: 20%, 40%, 60%, 80% and 100%. For example, 60% completeness means only 60% of the information are provided. Note that although accuracy is expressed by standard deviation levels, it can be converted to percentages similar to completeness.

In order to examine the effect of information accuracy on decision quality, we set information completeness level to 100% and vary the 5 standard deviations of information accuracy. When we examine the effect of information completeness on decision quality, we set standard deviation of information accuracy to 0 and vary the 5 levels of information completeness. In the game, each participant is asked to make two decisions. One is based on the inaccurate data and the other is based on incomplete data.

TOOL EVALUATION AND FURTHER IMPROVMENTS

The tool was developed in the context of a taught undergraduate course. At present, we received and incorporated feedback from students of one year enrolled in the class. However the tool was yet not formally incorporated into the course. This is envisaged for the next academic year. In the meantime, we are collecting the feedbacks to further improve our teaching tool. These feedbacks are intended to improve the usability of the tool such as “is there any misunderstanding and inconvenience when using the tool?”, “how can the tool attract the students to use?”, “whether the results are what we expected?” and “what can learn from this tool”. To receive these feedbacks, we invited 30 academics and professionals to attend an IQ experiment. The participants are from Dublin City University, University of Oxford, Singapore Nanyang Technological University, University of Dundee, Microsoft Research Asian, Hibernia Atlantic Ltd., Avaya Ireland, and J.P. Morgan UK. 65% of subjects were male and the other 35% are female. The average age of subjects is 32.

The experimental data are collected through a software-based system as shown in Figure 3. All the data are checked and confirmed as valid and usable for data analysis. Based on the collected data, we carry out a regression analysis to examine the effects of accuracy and completeness on decision quality. The confidence interval of this regression analysis is 95%. In table 1, it shows the result of regression analysis between accuracy and decision cost. The dependent variable is the cost of decisions and the independent variable is information accuracy.

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.797	110.159	1	28	.000	180.283	18.977

Table 1: Regression analysis between accuracy and decision cost

The linear regression between accuracy and decision cost is found to be significant (Sig. < 0.001), indicating that information accuracy is well correlated with decision cost. 79.7% (R Square = 0.797) of the variation in decision cost is explained by the standard deviation of accuracy. That means decision cost is 79.7% accounted for or predicated by information accuracy. As the sign on the coefficient (b1=18.977) is positive, increasing the standard deviation of accuracy is expected to increase decision cost. That indicates decision quality is negatively related to the standard deviation of accuracy. A decision-maker could expect higher decision quality through increasing the level of accuracy. We show the curve estimation between accuracy and decision cost in Figure 4.

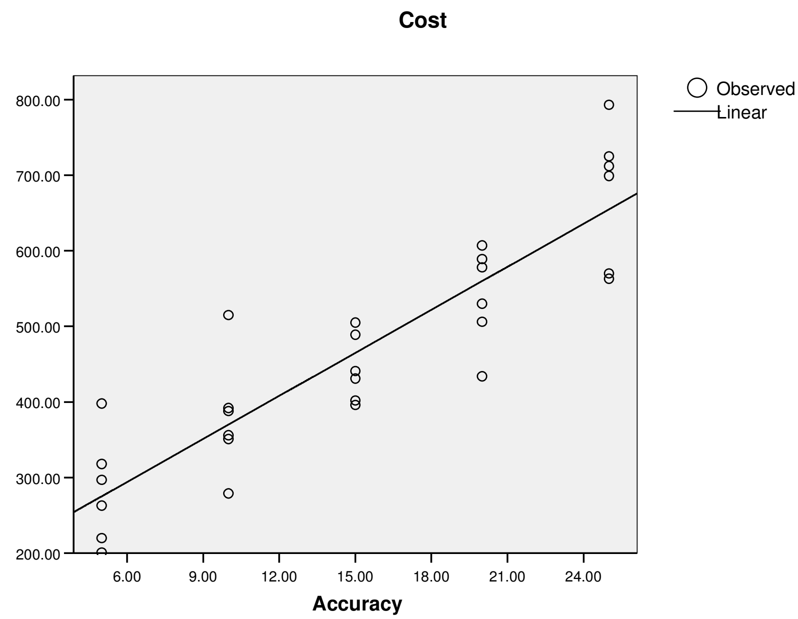

Figure 4: Curve estimation between accuracy and decision cost

As with the analysis above, we list the result of regression analysis between completeness and decision cost in Table 2. The dependent variable is the cost of decisions and the independent variable is information completeness.

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.878	202.330	1	28	.000	1023.500	-727.167

Table 2: Regression analysis between completeness and decision cost

The linear regression between completeness and decision cost is also found to be significant (Sig. <0.001), indicating that information completeness is well correlated with decision cost. 87.8% (R Square = 0.878) of the variation in decision cost is explained by the level of completeness. That means decision cost is 87.8% accounted for or predicated by information completeness. As the sign on the coefficient (b1=-727.167) is negative, increasing the level of completeness is expected to decrease decision cost. That indicates decision quality is positively related to the level of completeness. A decision-maker can expect higher decision quality through increasing information completeness. We show the curve estimation between completeness and decision cost in Figure 5.

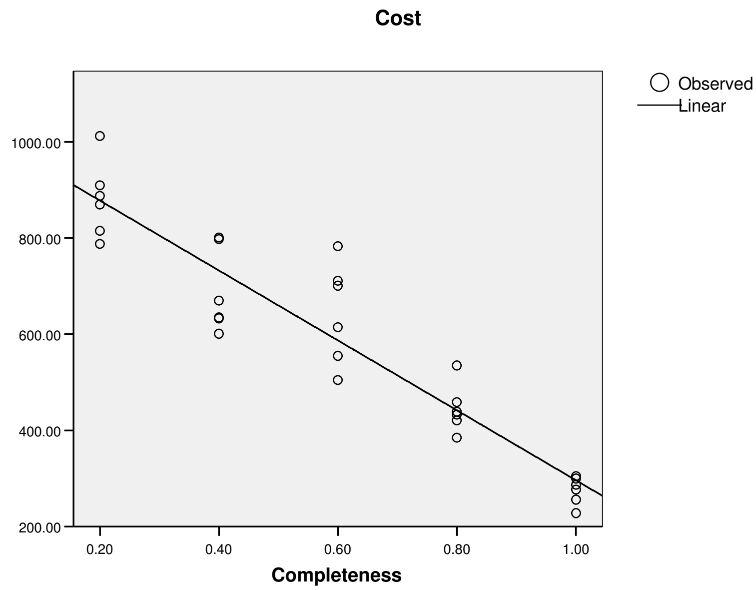

Figure 5: Curve estimation between completeness and decision cost

This regression analysis illustrated that decision quality increases as the level of accuracy or completeness is rising. This result confirmed our three-way ANOVA analysis conclusion that accuracy and completeness are positively related to decision quality.

In order to further confirm our experimental result, we carried out structured interview with the participants. The interview is structured along 4 guiding questions: (1) How is your work or study related to information processing? (2) Do you encounter any IQ problems in your work or life? (3) What do you think is the significance of information accuracy and completeness in decision-making? (4) What are the possible root causes of the IQ problems? After collating the answers, we organize the feedback from the participants as follows.

All the interviewees' works or studies are related to information processing. This information can be presented by text, audio, video, conversation etc. The most common information processing concerned checking emails and collecting business information. Some of the interviewee produced based on the information a report. This report can be considered as a result of gathering and processing different information. Therefore IQ is directly related to the quality of their work. Some interviewees' work is centred on data analysis and data management. For most of the work of the interviewees, IQ is vital since poor quality information may generate erroneous analysis results, which could incur a variety of business losses.

Most of the interviewees have met IQ problems in their work or daily life. Interviewees provided us with various examples of such IQ problems. Analysing their answers, we find that IQ problem is highly pervasive in work and everyday life. Hence it is valuable to improve IQ in people's work and daily life. However, although all the interviewees have met different kinds of IQ problems, only a few of the participants had considered IQ improvement. Some interviewees have grown accustomed to IQ problems and were not aware of the possibility of improving IQ. Some student interviewees complained that IQ problems always happened within their life and study, especially with regards to information from the internet. Some industrial interviewees had considered improving IQ in their company. However due to unknown budgets and the inexistence of mature IQ management models, high management always denied proposals for systematic IQ improvement. The answers to this question showed that although many IQ problems exist, the operation of IQ improvement procedures is very rare.

To confirm our quantitative analysis, we collect the opinions of the interviewees concerning information accuracy and completeness. The interviewees stated that both accuracy and completeness of information are crucial in decision-making. Some interviewees emphasise the difficulty of improving information completeness since in certain circumstances it might be difficult to know the completeness of information. However, all the interviewees confirm the importance of information accuracy and completeness in decision-making.

Following the work of Lee (2004), we collect the possible reasons of triggering an IQ problem. Except some typical causes such as typing errors or delayed input, interviewees are mainly concerned with two causes: system design and information processing. Some interviewees emphasized that it is important to prevent IQ problems when designing information systems. For example, the lack of constraint checking in the system can result in poor-quality data. Some interviewees considered that IQ problems can be generated in the information processing or transferring procedure. Therefore it is critical to increase IQ awareness when we process or transfer the information.

Besides the feedbacks above, we also collected suggestions for improvement of this tool. One of the main drawbacks of the current implementation is the limited interaction between participations, and further improvements for the tool could include some form of group competition. We could implement that each level of the supply chain can be played by one participant. The participants in the same supply chain are composed as a group. Thus different groups are able to compete for their performance by comparing the benefit in a determined period. In addition, we can extend the tool by including more IQ dimensions. It would enable students to observe how different IQ dimensions perform in a practical application.

CONCLUSION

In this paper, we describe a teaching tool to facilitate IQ education. The tool is based on the traditional Beer Game, originally developed at the Massachusetts Institute of Technology. We adapted this game and introduced IQ elements to the game. The tool was developed in the context of an undergraduate course in IS Strategy. The course is designed as a problem-oriented course. In order to receive feedback from professionals and academics, we invited 30 subjects to use the tool and provided feedbacks. By using our tool the participants showed an increased awareness of IQ and its importance. In addition, they have understood that IQ is multi-dimensional concept. Although the initial feedback shows the benefit of using our tool, it is an ongoing project. We aim to improve and extend its functionality and formally incorporate the tool in our undergraduate course.

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