KNOWLEDGE STOCK EXCHANGES: A CO-OPETITIVE CROWDSOURCING MECHANISM FOR E-LEARNING

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Prototype

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Abstract

Modern information and communication technologies (ICT) provide numerous opportunities to support e-learning in higher education. Recent devlopments such as Massive Open Online Courses (MOOCs) utilize the scalabiltiy and interactivity of the ICT to broaden the accessibility of university education. However, the potential of ICT in enhancing students' learning experience and success is far from being fully utilized. One potential area for the development of new e-learning mechanisms is at the intersection of collective intellegence and crowdsourcing mechanisms: The knowledge-disseminating ability of a collective intelligence platform combined with the interactivity and participative nature of crowdsourcing knowledge from fellow students may enhance motiviation and acceptance of students' learning. Following a crowd-based approach we present a prototype that offers a highly collaborative and competitive learning environment to improve the mutual exchange of knowledge as well as to encourage the development of a knowledge community. Our approach draws upon the principle of virtual stock markets (also "prediction markets"), a well-known collective intelligence mechanism which we enhanced with crowdsourcing elements. We describe the proposed system architecture, evaluate the practical feasibility of our prototype in the field and provide implications for future research.

Keywords: Knowledge Sharing, Knowledge Communities, Virtual Stock Markets, Prediction Markets, Collaboration, Competitive Environments, Crowdsourcing, Collective Intelligence, E-Learning, Higher Education

1 Introduction

Collective intelligence (or "Wisdom of Crowds"; Surowiecki 2004) and crowdsourcing are two related concepts which aim at utilizing knowledge, tasks and ideas of users connected through information and communication technology. Numerous applications emerged from this concept, for example: forecasting the future (e.g., prediction markets), designing new products (e.g., Jovoto), funding of initiatives (e.g., Kickstarter), diverse crowdsourcing tasks (e.g., Amazon's Mechanical Turk) or several public co-creation tasks, such as the mapping of crime (e.g., www.hatari.co.ke). Another very challenging field for any form of collaborative intelligence and crowdsourcing is the field of knowledge sharing and e-learning such as students' interest to exchange knowledge in order to prepare for exams.

The key challenges for crowd-based approaches, not only in e-learning, are to effectively build up a community and motivate a large group of people to pursue certain co-creation tasks (Leimeister et al. 2009; Zheng et al. 2011). In particular, the motivation to share knowledge is a challenge which has received considerable interest in previous literature (Ardichvili et al. 2003; Cho et al. 2010; Lin 2007; Nov 2007; Wasko/Faraj 2005). Within the context of crowdsourcing, tournament-based (i.e., competitive) or collaboration-based mechanisms have been proposed to motivate the crowd (e.g., Afuah/Tucci 2012; Leimeister 2012). However, in case of e-learning, additional aspects such as the motivation of students to learn need to be considered (Qin et al. 1995). Recently, several studies in the field of e-learning and knowledge management strongly endorse the development of "co-opetitive" environments, which combine competitive and collaborative approaches (Fu et al. 2009; Ghobadi/D'Ambra 2012; Tsai 2002).

Based on these concepts, this study proposes a new crowd-based and co-opetitive knowledge sharing mechanism for the higher education sector that is able to effectively motivate students in their efforts to learn and share knowledge. Our goal is to present a prototype that is able to make use of the wisdom of the crowd by applying the principle of virtual stock markets (VSM), a collective intelligence mechanism that is commonly used to predict future events enhanced by crowdsourcing elements. We want to provide a proof-of-concept that VSMs can be established as a motivation mechanism to encourage students to exchange knowledge as well. A major design objective is to offer a co-opetitive solution that allows the pooling of competitive as well as collaborative elements within one knowledge sharing mechanism.

In order to empirically evaluate our proposed mechanism within the area of higher education, we picked a medium-sized lecture (on the fundamentals of electronic commerce (ECOM)) and implemented the so called ECOM prototype. The results of the evaluation and the ECOM platform itself will be presented in a live demonstration at the ECIS 2014. All hardware and software needed to present the prototype will be provided by the authors themselves.

2 Background and Related Literature

2.1 E-learning and a student's motivation to learn and share knowledge

Modern ICT offers a wide range of e-learning tools for the higher education sector. Forums, authoring systems, virtual classrooms, wikis, micro blogging, or online self-tests represent a variety of categories from which students can pick numerous solutions to fill their needs (Brockbank 2003; Williams 2003; Steiner et al. 2013). Nevertheless, the mere provision of sophisticated ICT cannot guarantee the student`s learning success alone. Instead, numerous studies single out the gap between technology potential on the one hand and the motivation to learn and share knowledge by making use of these e-learning technologies on the other hand (e.g. Keengwe et al. 2008; Liu et al. 2009; Park 2009; Steiner et al. 2013).

Although one might assume that there is already a strong motivation for students to learn, many students are familiar with a very common phenomenon, called "academic procrastination" – the act of needlessly delaying academic duties and responsibilities (Deniz et al. 2009; Haycock et al. 1998). According to a study conducted by Orellana-Damacela et al. (2000) and consistent with previous findings in college student samples (Hill et al. 1978; Solomon/Rothblum 1984) around 50% of students reported moderate to high levels of procrastinating behavior. While numerous studies investigated the causes, effects and interrelations of procrastination (e.g. Haycock et al. 1998, Hess et al. 2000; Klassen et al. 2008; Steel 2007), little is known about effective mechanisms to counter the phenomenon.

Beneath a student's motivation to learn, every e-learning system that relies on the principle of collaboratively created content also requires a student's motivation to share his private knowledge. Looking at public internet services, such as content sharing networks, open content production, newsgroups, forums, or virtual communities, we find many people participating in different kinds of knowledge-exchange practices (Zhang/Zhu 2011). Despite the threat of free-riding behaviour and the absence of any monetary sources of motivation, people seem to be willing to share their private knowledge with strangers they never physically met before (Wasko/Faraj 2005). While this may hold true for large public sites on the internet, numerous closed communities seem to face insurmountable difficulties when filling their non-public knowledge repositories with collaboratively created content (Kankanhalli et al. 2005). This is not surprising, as knowledge is intangible and guarding this knowledge to obtain a competitive advantage is an obvious strategy in a competitive environment (Gupta/Govindarajan 2000; Nonaka/Konno 1998; Ipe 2003). Furthermore, intrinsic benefits to share knowledge, such as self-efficacy and the enjoyment to help others are hard to be generated artificially in a competitive environment. Beyond that, recent studies in the context of e-learning and knowledge sharing push for “co-opetitive” environments that integrate competitive as well as collaborative elements to achieve a higher overall knowledge level (Fu et al. 2009; Tsai 2002). They argue that students in competitive learning environments develop higher analytical skills, while those in collaborative learning environments show higher synthetic skills (Fu et al. 2009).

2.2 Crowdsourcing: competition vs. collaboration

The artificial word “crowdsourcing”, derived from the full term “crowd-based outsourcing”, was initially coined by Jeff Howe in an article of Wired Magazine (2006). Since then, crowdsourcing mechanisms gained much attention in research, especially in the context of open innovation (Enkel et al. 2009; Leimeister et al. 2009), where we also find a growing need to establish coopetitive environments (Cassiman et al. 2009). The basic idea behind any crowdsourcing initiative is to assemble a large group of people and make use of the Wisdom of Crowds to perform different company-related tasks (Leimeister 2010). This allows organizations to find solutions and to co-create contents for a variety of challenges by involving as valuable groups as pioneers, fans, lead-users, gifted tinkerers or other creative minds inside and outside the organizations’ boundaries.

Previous literature distinguishes between tournament-based (i.e. competitive) and collaboration-based crowdsourcing mechanisms (Afuah/Tucci 2012; Leimeister 2012). By using a tournament-based crowdsourcing mechanism, members of the crowd self-select to find their own solution for a given problem (Afuah/Tucci 2012). This provides the initiator with many options. The incentive design is of critical importance here. In order to motivate a great number of users, the tournament mechanism should not deter new entrants to join the competition at a later point in time (Terwiesch/Xu 2008). However, an extrinsic motivation to gain money may have no effect on the intention to participate or the quality of results (Chen et al. 2010; Zheng et al. 2011). Instead, the possibility to gain reputation and in particular the users’ intrinsic motivation are playing a more important role to generate a highly motivated crowd.

In contrast to tournament-based mechanisms, the self-selected members of the crowd in a collaboration-based crowdsourcing approach offer just one single solution (Afuah/Tucci 2012). An inherent characteristic is that all members of the crowd work on one overarching objective on the basis of teamwork. One further characteristic is the breakdown of a super-ordinate task into many subsidiary tasks. Therefore, finding the right level of task detail is a key element in the design of collaboration-based crowdsourcing projects. In order to find a solution the operating agency needs to control the direction that the crowd has to go, as well as to find the appropriate mechanism for information aggregation.

2.3 Virtual stock markets – a coopetitive crowdsourcing mechanism?

Virtual Stock Markets (VSMs) are digital securities exchanges with the overarching purpose to gather and aggregate shared information and expectations of a crowd of people. Their scope of application is the prediction of future real and fictitious events, such as election results (Berg et al. 2008; Snowberg et al. 2007), sales forecasts (Spann/Skiera 2003; Ostrover 2005), and risk prognosis (Wolfers/Zitzewitz 2004). Further areas of application are the identification of experts (Spann et al. 2009), the comparison of decision alternatives (Berg/Rietz 2003), the generation and evaluation of ideas (Soukhoroukova et al. 2012) or new product concept testing (Dahan et al. 2010). The corresponding terms “prediction market”, “decision market”, “idea future”, or “preference market” are indicators for their manifold areas of application and the particular focus of their market design. In contrast to financial stock exchanges a VSM’s mechanism – generally implemented as a web platform – does not depend on the usage of significant amounts of money (Servan-Schreiber et al. 2004). Instead, trading is often based on non-significant amounts of money or virtual play money (Soukhoroukova/Spann 2006).

The theoretical underpinnings of VSMs are the Hayek hypothesis and Fama's efficient market hypothesis (Spann/Skiera 2003). According to Fama, asset prices in an efficient [capital] market fully reflect all value-related information available to participants and by that aggregate all expectations on the likelihood of future pay-outs (Fama 1970; Fama 1991). In addition, Hayek provides the explanation why markets – due to their competition-based design – may be seen as the most efficient mechanism to aggregate asymmetrically dispersed information (Hayek 1945; Smith 1982). Applied to VSMs, the general idea is to link the pay-out of a contract (i.e. "virtual stock") to a future event. For such an event we can imagine the outcome of a political election, sales figures or the results of a sports event. This way, each virtual stock represents a bet on a future market state (Spann/Skiera 2003). Participants of the VSM are then invited to adjust their virtual stock portfolios by using their virtual play money to buy or sell shares of these virtual stocks. Thereby the trading price of a virtual stock reflects the crowd's expectation about the occurrence of the pay-out event at any time.

3 Knowledge Stock Exchanges: Design of the ECOM Prototype

We propose a prototype that is designed to motivate students to overcome procrastination tendencies and to proactively engage in a knowledge sharing process at an early stage of their exam preparation. Our goal is to fill a knowledge repository with different types of knowledge contents. These contents, hereinafter called "knowledge objects", can be for example student transcripts, literature overviews, numerical examples, brief explanations or terminology dictionaries. Generally, such a repository can store any type of knowledge object that might be helpful for students to prepare for their exam.

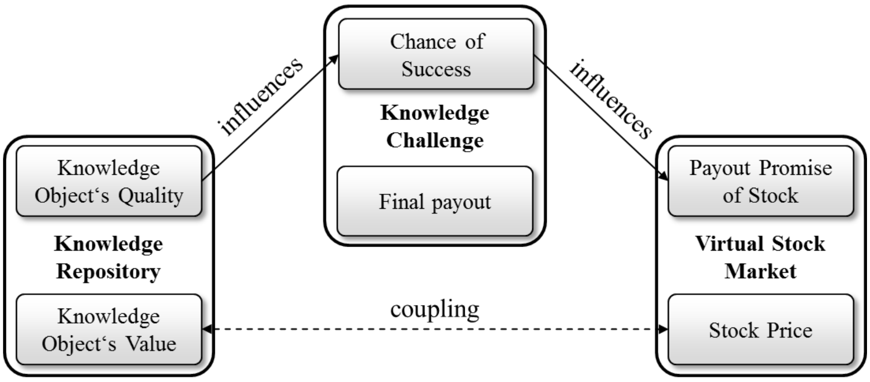

Figure 1. General principle of a knowledge stock exchange

The basic idea of the proposed mechanism is to couple the value of explicit knowledge with the price of a virtual stock (see Figure 1). Therefore each knowledge object is represented by a so called "virtual knowledge stock" that can be traded on a VSM. To derive the value for a knowledge object, every stock encloses a pay-out promise related to a knowledge challenge. Each of these challenges compares a group of knowledge objects based on some predetermined criteria. These criteria – which can be freely chosen by a market supervisor – may comprise a knowledge object's level of detail, its relevance and suitability to a problem or its coverage of a particular topic. Depending on a knowledge object's chance to win the challenge, all market participants can place bets on the stock's final pay-out by buying or selling shares of the corresponding stock. Similar to classical VSMs, the resulting price provides a reliable prognosis for a stock's future pay-out and by that indicates the knowledge object's overall quality.

Since all participants are incentivised to invest in the most promising stocks to maximize the value of their virtual stock portfolios, the mechanism's competitive character is obvious. We suggest a 10%-Edit-Rule which states that the contents of a stock – texts as well as attached images or documents – can be edited as long as a market participant holds at least 10% of the particular stock's share. This rule is supposed to encourage a trader to also buy shares of stocks he considers to be of low quality. With a share of 10% he can now start to improve the quality by uploading additional images and documents or by editing the textual description of the stock. Since the price is supposed to always reflect the stock's probability to receive a pay-out and by that represents its quality, the trader can now sell his shares at a higher price (as long as the quality of all other stocks in the market has not been improved as well). This allows us to use a VSM as a competitive as well as collaborative incentive mechanism that is directed to build up a knowledge repository. Depending on an effective knowledge challenge design, we are able to guide the knowledge creation and sharing process into any desired direction.

In order to explain the prototype for practitioners and a technology-oriented audience in more detail, we now focus on the overall course of competition and the dynamic processes within the system (see 3.1). This includes the description of process stages as well as their logical and temporal dependencies. The subsequent chapter 3.2 explains the systems structure with its most essential subsystems and elements including all functionalities needed to ensure a smooth operation of the whole system.

3.1 The course of competition – a dynamic perspective

The course of competition is mainly determined by its embedded knowledge challenges. Although the challenges run independently from one another, they all follow the same lifecycle (see Figure 2): (1) proposal stage, (2) offering stage, (3) trading stage and (4) pay-out stage. This implies that some challenges might start earlier than others and allows to synchronize the e-learning platform with the progression of a lecture.

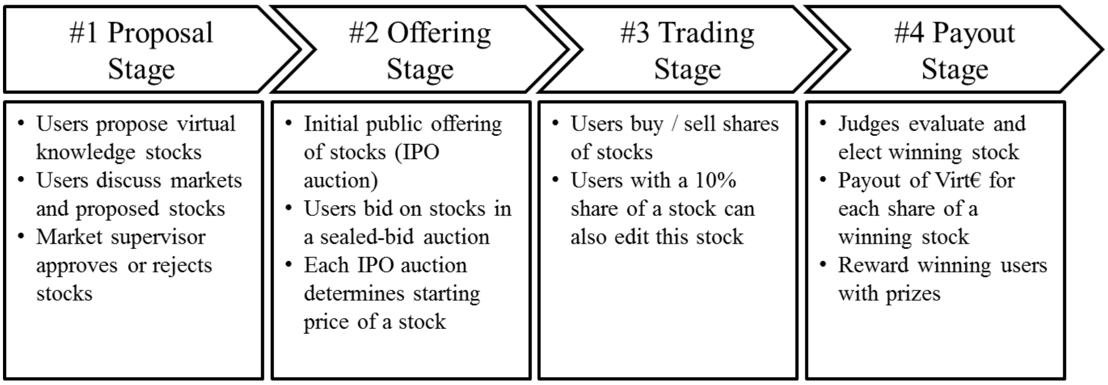

Figure 2. Knowledge challenge lifecycle

3.1.1 Proposal stage

First, the system is initialized with several knowledge challenges by a so called market supervisor. By creating a knowledge challenge, the market supervisor simultaneously creates a VSM. So from a technical perspective, both concepts, "knowledge challenge" and "virtual stock market", are interchangeable. Moreover, it is advisable for a market supervisor to prepare at least one sample proposal for each challenge to give the participants a hint of how a knowledge object may look like.

After their registration, students are expected to propose knowledge objects for each of the challenges. In doing so, students can earn so called "contribution points" – the essential currency to win the contribution ranking (Appendix – Figure 3). To gain additional points, students are invited to suggest further improvements or extensions for existing knowledge objects as well as to rate and comment on discussions that were started by others. Finally, the market supervisor approves all serious knowledge stocks.

3.1.2 Offering stage

Approved stocks are now initially offered to all participants by using a sealed bid auction (also "initial public offering" resp. "IPO"). For the ECOM prototype, we use a single-day fixed price auction mechanism that derives the starting price from the number of ordered shares. Alternative IPO methods are the discriminatory or the uniform price auction (Bower/Bunn 2001). Nevertheless, a major advantage for the fixed price auction mechanism is its high level of transparency and easy communicability to the participants. To represent the opposing side of such an IPO auction, we introduce an automated bank role that can handle the auction revenues as well as the final pay-outs.

IPO auctions offer the students (in a trader role) the opportunity to compose their initial portfolios according to their personal preferences and their individual appreciation of the stocks. Since all bids are submitted in a concealed manner, traders remain uninfluenced in their preferences by other traders unless the auctions end. As soon as an IPO auction is cleared, the aggregated demand of shares will be revealed, indicating a first evaluation of the stocks for the corresponding knowledge challenge.

3.1.3 Trading stage

As soon as the trading stage starts, all stocks are listed on a virtual stock exchange, ready for trading. In case of the ECOM prototype, all traders receive an initial endowment of Virt$ 1,000 to buy and sell shares of each listed stock. All orders along with their associated money and securities transactions are executed immediately. This can be achieved due to the use of an automated market maker algorithm that provides permanent liquidity within the market (see 3.2.3). Right from the start of the trading stage, all participants are encouraged to increase their financial assets (in Virt$). The performance ranking offers a permanent comparison of all traders' financial situation by publishing the aggregated value of their liquid funds together with their current portfolio value. While this allows users to compare with each other, it also underlines the mechanism's competitive character.

Although the final pay-outs only take place in the following pay-out stage, users can already realize significant arbitrage profits through the continuous trading of stocks. In particular, the 10%-Edit-Rule offers traders the possibility to edit a stock's content or upload complementary images and other files. This allows traders to influence the value of a stock and thereby make use of arbitrage effects. It is also a key differentiator compared to conventional VSMs such as prediction markets or preference markets that offer stocks with fixed contractual specifications.

3.1.4 Pay-out stage

In this stage, a group of judges evaluates the contents of the virtual knowledge stocks with regard to the related challenge and vote to find a winning stock for each challenge. Subsequently, the final pay-outs of Virt$ 1.00 per share can be executed by the automated bank. As soon as all pay-outs were distributed to the shareholders of the winning stocks, these stocks can be liquidated. Finally, participants can receive prizes according to their position in the performance and contribution ranking.

3.2 Subsystem and functionalities – a structural perspective

The whole prototype consists of four major subsystems: (1) the knowledge challenge subsystem, (2) the knowledge repository subsystem, (3) the virtual stock exchange subsystem, and (4) the social interaction subsystem. Their essential objects and functionalities are described in the following.

3.2.1 Knowledge challenge subsystem

The knowledge challenge subsystem contains all user accounts and offers basic functionalities such as the user registration, the account management and the system's role management (Appendix – Figure 4). Since each trader possesses a bank account to store his money and a securities account to deposit his securities positions (Appendix – Figure 5), the subsystem also needs to provide some elementary mechanisms to carry out money and securities transactions between those accounts.

The subsystem's primary functionality – solely for market supervisors – is to create and manage knowledge challenges (Appendix – Figure 6 and Figure 7). This includes the ability to set a challenge's lifecycle or to trigger certain events, such as the final payouts. Apart from a short task description, each knowledge challenge requires the fulfilment of several criteria – e.g., a reasonable level of detail, understandability, high quality and relevance – as conditions for the final payout. Other key elements of the subsystem are the two independent rankings – the performance ranking and the contribution ranking. While the performance ranking lists each user account according to its aggregated value of financial assets, the contribution ranking gives an overview of all contribution points gathered so far.

3.2.2 Knowledge repository subsystem

The knowledge repository subsystem can be any sort of content management system (CMS) that offers the basic functionalities to create, store, edit and publish diverse types of knowledge content. In addition, the knowledge repository is supposed to provide co-authoring functionalities which we can find in wikis or some other sort of collaborative CMS (e.g., Ebersbach/Glaser 2005).

For reasons of simplicity, the ECOM prototype uses a knowledge repository that is reduced to the most basic capabilities of such a collaborative CMS. It allows users to create and edit a textual description for their solution on a given knowledge challenge. These textual solutions are called “knowledge objects”, each of them representing a virtual knowledge stock. To complement a textual description by illustrations and additional documents, the ECOM platform allows users to upload additional file types.

3.2.3 Virtual stock exchange subsystem

The virtual stock exchange hosts several markets, each representing a knowledge challenge. Each of the markets contains several stocks (Appendix – Figure 8). Both objects – markets and stocks – require scheduling and workflow management functionalities to traverse the respective object’s lifecycle.

This subsystem needs a continuous trading mechanism to match demand and supply during trading stage. An important requirement for such a mechanism is its ability to work in an environment with very few traders and a large range of stocks. For this reason, we strongly advise to use an automated market maker mechanism (e.g. Slamka et al. 2013). While a market maker algorithm is primarily used to ensure permanent liquidity, its reaction time and adaptability to the crowd’s collective intelligence should not be neglected (see Brahma et al. 2012). The market maker used for the ECOM prototype is based on Hanson’s logarithmic market scoring rules (see Hanson 2003; Othman et al. 2010). Depending on the number of shares circulating in the market, the market maker calculates the reference price for each stock. This reference price indicates the current price for a minimum amount of shares and simultaneously signals the market’s aggregated information about a stock’s probability to receive a pay-out. The more shares a trader ordert, the higher the price increase. Traders can easily interpret the price of each stock as its probability to win the corresponding challenge.

3.2.4 Social interaction subsystem

A crucial part to support coordination and communication between all users is the integration of a social interaction subsystem. Some exemplary technologies that can be used to encourage collaboration among users are discussion boards or private messaging. In order to prevent participants from collusion, the usage of real-time communication should be treated with caution. At least a fraud detection mechanism for certain trading and communication patterns in combination with a deeper understanding of the arising social networks is advisable. The ECOM prototype offers a simple forum functionality that allows users to start discussions either on the knowledge challenges or on the proposed knowledge objects. Discussions can be used to provide feedback for a knowledge object. Besides the possibility to post comments, users can also rate contributions of others by using a simple thumbs-up /-down functionality. This helps the owners of knowledge objects whether to integrate a suggestion or not.

3.3 Key results of the prototype application

In order to evaluate the ECOM prototype, we picked the medium-sized lecture “Electronic Commerce” with around 100 students regularly visiting the lecture and a related exercise course. As the only exogenous incentives we raffled three university-branded coffee mugs worth € 7.00 for the mere participation and offered two university-branded main prizes worth € 25.00 for the winner of each ranking. Students participated voluntarily and did not receive any form of grade improvement or other bonuses. This shall not preclude the possibility for students to profit from information of other students that were exchanged over the platform. The platform stated five weeks before the final exam. In sum, 28 participants (54% female; 46 % male) created 91 logins; each of these students visited the platform 3.25 times on average.

The platform offered six knowledge challenges (and two sample stocks) and participants proposed a total of 15 virtual knowledge objects and related stocks. We observed that these 17 knowledge objects were edited by up to five different users (with 2.8 different editors per object on average). These were accompanied by 12 vivid discussions that were started by users along with 77 forum visits, 32 posts and 42 forum ratings. These numbers underline the prototype’s collaborative potential. Based on exploratory findings, we suppose that requests for simple as well as iterative tasks are more likely to meet the users’ intention to contribute. These observations support the importance of a modular problem structuring in accordance with other researchers (Afuah/Tucci 2012, 363; Baldwin/Clark 2006).

We also find evidence for the prototype’s competitive nature. During offering and trading stage, 21.4 % of all participants submitted 93 orders in total. These orders can be separated into 29 IPO bids during offering stage, and 40 buy- as well as 24 sell-orders during trading stage. With an overall share of 30 % of all ordering activities and due to its limitation to only one day, the offering stage received an above-average attention of the active participants compared to other stages. The 29 IPO bids were almost equally distributed over each of the 17 IPO auctions, which indicates that the usage of a single-day fixed price auction mechanism to obtain an uninfluenced first guess on the value of the virtual knowledge stocks succeeded very well. If we take a look at the trading activities over time, we see a continuous number of orders over the whole trading stage. The students’ interest on the continuous improvement of knowledge objects over the whole project duration is promising for future studies in this area.

4 Conclusion

The study’s primary contribution is the proposal of a crowd-based and co-opetitive knowledge sharing mechanism in higher education. We offer a detailed description of the prototype’s architecture to facilitate its implementation and reproduction for practitioners and researchers. Based on a medium-sized lecture we made the first step to evaluate the proposed system architecture. The experimental implementation demonstrates that the general principle of a VSM can be applied as an incentive mechanism that invites students to share their private knowledge with others. This permits lecturers to take a step back and allows students to build up a knowledge base largely on their own. Based on our prototype’s positive evaluation which was however limited by a rather small sample size, we already plan to introduce the mechanism to a massively open online course (MOOC). Given the high drop-out rates of these courses (Adamopoulos 2013), we see great potential here to further evaluate our prototype and improve the students’ motivation to learn and share knowledge.

Appendix – Additional Screen Shots

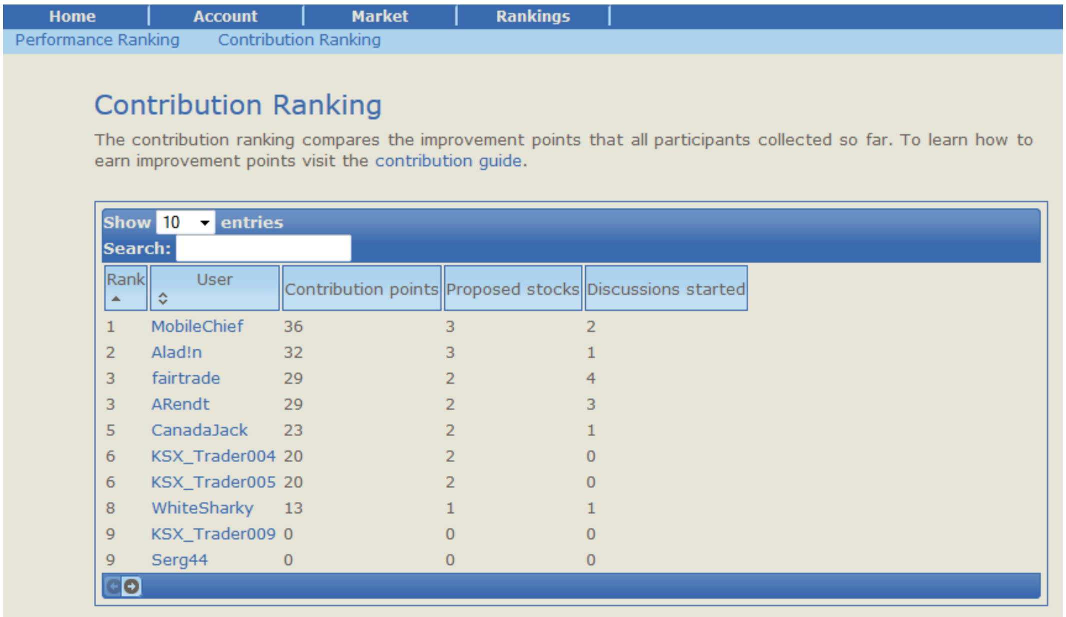

Figure 3. Screen Shot: Contribution Ranking

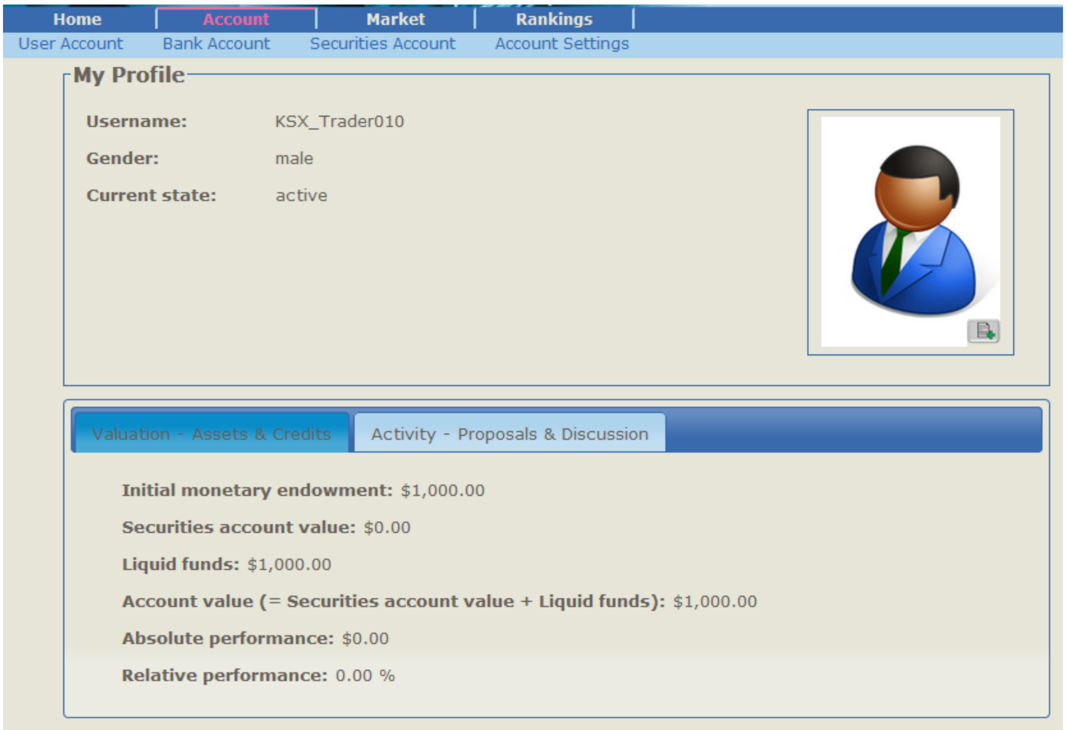

Figure 4. Screen Shot: User Profile

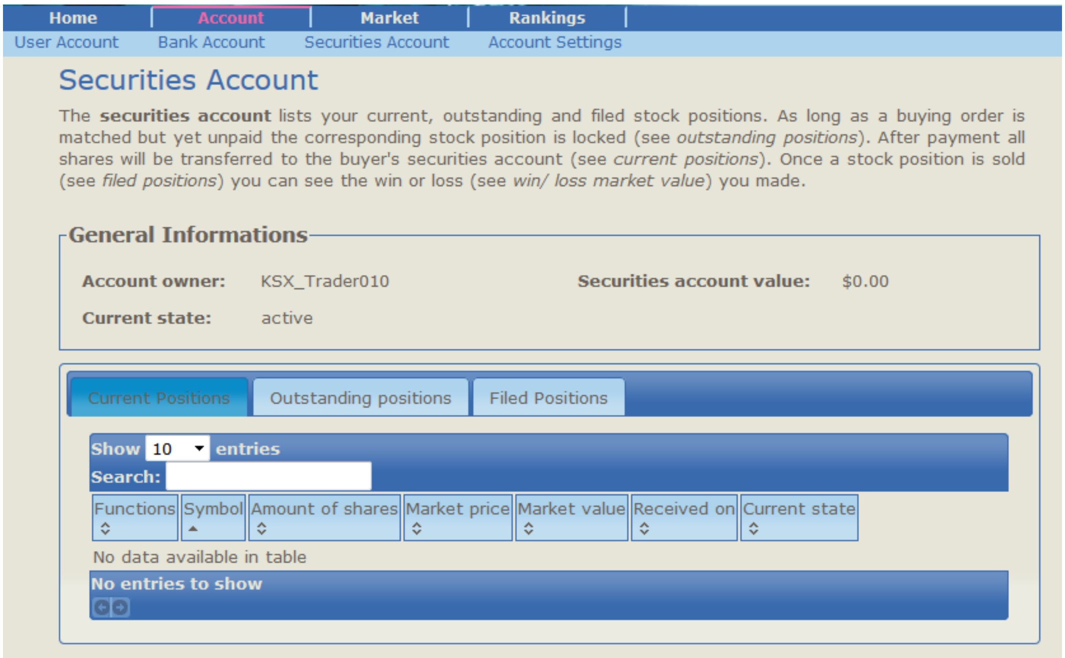

Figure 5. Screen Shot: Securities Account

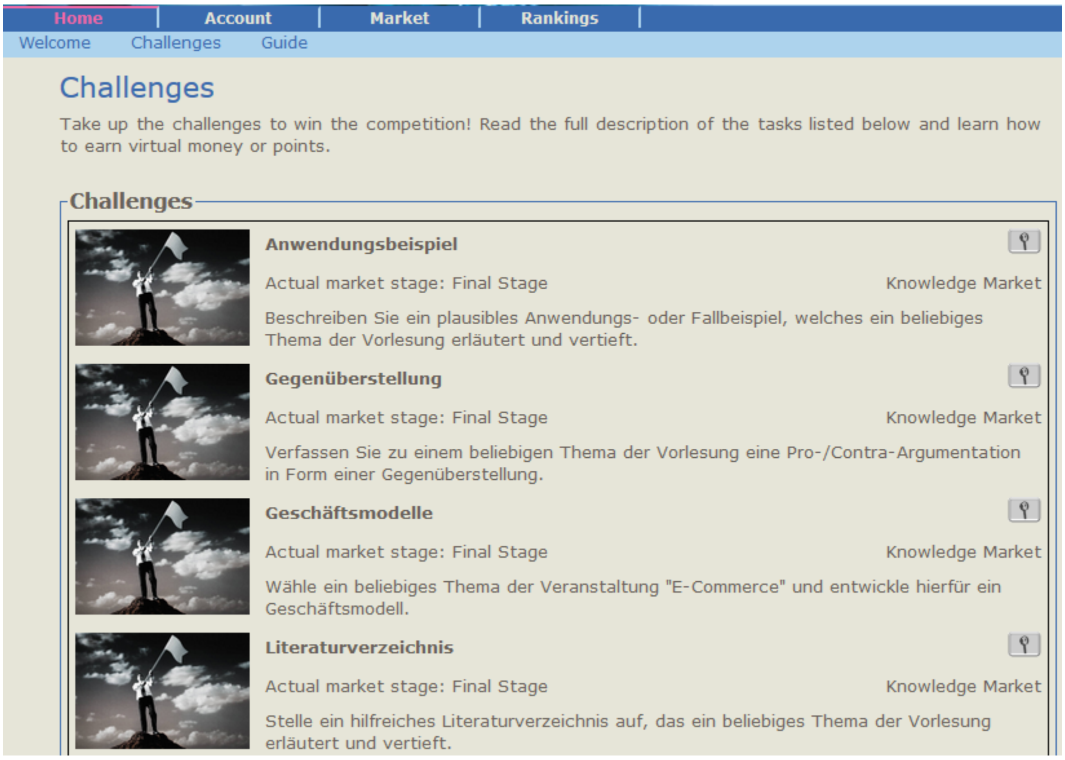

Figure 6. Screen Shot: Challenges Overview

Figure 7. Screen Shot: Knowledge Challenge

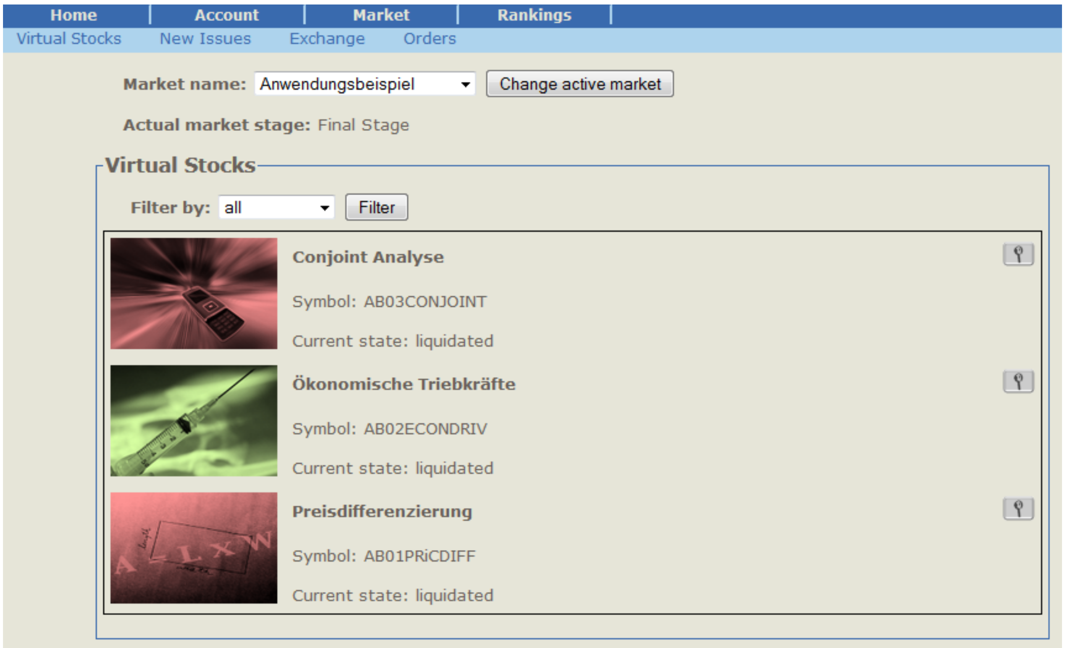

Figure 8. Screen Shot: Virtual Stocks

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