Prediction Markets as a Teaching Tool For Undergraduate Engineering Students

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EDUCATIONAL PREDICTION MARKETS: A CONSTRUCTION PROJECT MANAGEMENT CASE STUDY

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ABSTRACT

Effective teaching of engineering concepts relies both on carefully designed lesson plans that meet specific learning outcomes, and on classroom activities that students find engaging. Without student engagement, even the best designed plans will fail to meet their outcomes. In other words, students need to be actively involved in the learning process. The objective of this paper is to present a case study of applying a novel active learning method, specifically *educational prediction markets (EPM)*, for teaching project management classes at a major research university. This method was investigated for its effectiveness in engaging students, as well as promoting learning of probabilistic reasoning without explicit teaching. Student surveys, following the EPM implementation, revealed both advantages and disadvantages. The two key benefits reported by the students were: a) providing better connections between the materials taught in the class and realities of construction projects, and b) increasing overall interest and enthusiasm in learning about project risk management due to the game-like nature of the process. The main disadvantage was disengagement by a subset of students due to perceptions that fellow students were manipulating the market results.

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INTRODUCTION

Teaching how to identify, assess, and manage project risks presents many challenges. One of the greatest challenges instructors face is the inherent difficulty of linking probabilistic predictions with actual observations. For example, we can predict that the probability of rain tomorrow is 80 percent, but then, it may not rain. Was our prediction good? It is difficult to answer this question because predictions are only probabilistic propositions, not deterministic observations.

This conundrum of teaching probability concepts is particularly visible when trying to predict outcomes such as completion time of construction projects. While some engineering disciplines can use laboratory experiments to validate the uncertainty in prediction, this approach cannot be applied to construction management. For example, we can run 100 laboratory tests to determine the probability that a concrete sample taken from Batch A will withstand the stresses required by seismic codes. This empirical approach to determining risk is visible and obvious, even for novices to the field such as undergraduate students. However, for complex projects, where one cannot directly observe outcomes and estimate probabilities - how does one assess a probabilistic prediction?

In teaching project risks instructors often rely on numerical methods, such as Monte Carlo simulations (MCS). Even though simulations may be more transparent than other methods, they can be considered susceptible to manipulation by the simulator. In our teaching experience, students often view the MCS approach as too abstract, which in turn can make students suspicious and disengaged from further exploration. This feedback loop - *where a lack of realism diminishes student engagement; and deficiency in engagement prevents further investigation to understand abstract concepts* - represents a major hurdle in teaching engineering project risk

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management. Until we gain students' attention and engagement by grounding the learning within real world examples, the learning process is stalled.

The objective of this case study is to document implementation of EPM in undergraduate project management classes. For background, prediction markets have recently found applications in many fields including education, project management and scientific research (Hanson 1999, Arrow 2008). In a prediction market a participant buys or sells shares in the realization of a specific well-defined outcome. If the predicted outcome occurs, he/she can exchange the shares for a "reward" of 100 units per share. If the predicted outcome doesn't occur, the value of the shares becomes 0. If a particular outcome is likely, the price of shares will go up (as demand grows) and *vice versa*, as the specified outcome seems less likely to happen, the market price will go down. Hence, prediction markets represent the social trade forums that run for the primary purpose of aggregating information in an effort to forecast future events (Tziralis & Tatsiopoulos 2007; Berg & Rietz 2003; Berg et al. 2003). Arguably, the most important issue with implementation of a market is its performance as a predictive tool (Wolfers and Zitzewitz, 2004). On a practical note, in EPM these prices and rewards do not constitute illegal gambling because no money is exchanged. Nevertheless, participants are motivated and engaged by non-monetary rewards, particularly due to the competitive nature of games.

To investigate the extent to which EPM could promote engagement, active learning, and the sense of realism in teaching, we recently implemented an EPM contest in two undergraduate construction engineering and management classes focusing on project risk management. We collected and analyzed feedback data including qualitative observations of the learning process. This manuscript documents our findings and sets EPM in a larger context of using active learning methods.

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The remainder of the paper is organized as follows. First we provide a brief background on education theories that support the use of EPM. Next, we present the case study:the synopsis of the overall process, the data collection process, the results from the survey, and the interpretation of the findings. Finally, we present lessons learned and summary and directions for future studies.

BACKGROUND

Active Learning (AL) is often referred to as active engagement strategies that allow students to participate and engage in higher-order thinking tasks such as analysis, synthesis, and evaluation (Bloom 1956; Wilke 2003) as they construct their own understanding of the information. In other words, AL is an instructional method which engages students (Prince 2004); solicits active participation on the part of the students (Olgun 2009); and integrates learning through encouragement and feedback (Bernhard 2001).

The underpinnings of AL can be directly linked to *constructivism*. From the theoretical perspective of teaching and learning, constructivism hypothesizes that knowledge is constructed through learning experiences that are facilitated by the others (e.g. teachers, fellow students), in social processes and relationships (Abdul-Haqq 1998; Vygotsky 1978; Wink & Putney 2002). Learning is considered a product of ordering and synthesizing new information facilitated by the interaction of educational materials, instructor, and peer social group (Vygotsky 1978). This is precisely where EPMs would find their applications: elevating student engagement using social interactions with peers, through authentic discussions regarding the impact of recent information on the market prices. There is emerging evidence that when a prediction market is integrated into traditional communication channels, it can reinforce students' thinking in a wider range than what is proposed by the instructor (O'Toole & Absalom 2003). This means that the structure of

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prediction markets would allow students to engage in a learning experience using both channels of cognition and corresponding actions – analytical (i.e. using formal methods and processes), and affective (i.e. using "gut feeling" and instincts) (Garvey and Buckley 2010). Hence, prediction markets meet the conditions required by the Active Learning approach (Buckley et al 2011).

CASE STUDY

The educational prediction market was implemented in two engineering classes focusing on project management: a) Project Management for Engineers, a multi-disciplinary class for civil, industrial, and mechanical engineering undergraduates, and b) Civil Engineering Project Management, a required junior-level class in the civil engineering department. The market implementation was conducted in the Fall of 2010. The two courses were taught by Drs. Damnjanovic and Reinschmidt.

The market questions were based on well-defined milestone points of construction activities for a building project for the University's veterinary school, while progress data were provided by the actual construction contractor's project team. Figure 1 shows a 3-D computer rendering of the project and a site photo.

INSERT FIGURE 1

A total number of 122 student users participated in the market. Initially, all students were allocated $5,000 to buy or sell stocks in two predefined project milestone "stocks" ("Structure Top Out" and "Substantial Dry-in") that were initially priced at $50 per share, reflecting the initial likelihood of meeting the schedule milestone points of 50 percent. In other words, students individually decide to buy (or sell) shares in a particular milestone event which they think will be

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successful (or unsuccessful). Success in EPM would provide them with a "profit" over their original $5,000 at the end of the market period. Students were advised by the instructors that their grades in the class could be affected by their participation and success in trading. To provide the basis for making the trades, the contractor provided internal weekly reports and schedule updates along with a series of construction site photos. This process gave students experience with reading authentic weekly reports and schedule updates. Additionally, students could also visit the site personally and directly observe the status with regard to these milestones.

The EPM used the Hanson model (Hanson 1999) to determine the prices and avoid liquidity issues (i.e., when someone is willing to buy at a certain price, but no one is offering to sell at any price). Furthermore, the Hanson model includes the ability to short-sell (i.e., to sell stock without actually owning it at the time of transaction). Over the course of the semester, students made over 2,500 trades (buy, sell, or sell short) responding to the contractor reports, weather forecasts, and other information they found of value in determining whether the stocks are under-valued or over-valued. Figures 3 and 4 show the price changes throughout the entire duration of the market including the daily trading volumes (sells and buys) shown as bars at the bottom of the figures. As can be seen from both figures, peaks in trading volumes tended to occur in intervals of one week, when the contractors posted their reports and the images from the construction site became available.

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INSERT FIGURE 2

INSERT FIGURE 3

Chronology of Market Implementation.

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In the first week of trading, the buyers outnumbered sellers resulting in price increases, from initially $50 per share to around $80 by the end of the week. This effect can possibly be attributed to the class presentation given by the construction contractor's project manager on September 20, in which he stressed the importance of meeting project milestones. Students' comments such as the one below show the eagerness to buy the shares: *"I think it might be time to buy this question. NOW! This is the lowest it's ever been so buy quickly."* In the middle of the second week, on Sep. 28, the first weekly report and project schedule update were posted. The new project schedule showed that the first milestone (i.e. Structure Top Out) would be completed with a 4 day delay, on Oct. 26 rather than Oct 22; and the second one (i.e. Substantial Dry-in) would be finished by Dec. 2 with a 6 day delay. These anticipated delays affected students' confidence and some of them started to change their minds about the milestones' completion times. Furthermore, the summary daily activity reports indicated problems with steel fabrication. As a result, in this period, the prices of both stocks fell significantly. The following two sample comments illustrate students' feelings: *"Daily Report of 9/23 says that rebar for TOMO roof was fabricated incorrectly…which in turn pushes back TOMO roof pour from this Wednesday to this Thursday or Friday….not good sign overall."* The revised schedule published on Oct. 6 brought back the belief that the milestone points would be met. These new dates implied a positive answer to both prediction questions, thus, students responded by buying shares at discounted prices (in the range from $40 to $50), with anticipation that the final share price would be $100 and they would cash in at profits from $60 to $50 per share. The comments below illustrate this sentiment: *"Current updates say all systems go so project is now on route to success in reaching Oct 22! Actually says it will be done on October 20!"* or this one: *"You'll win tons of money. But after the previous report release its looking like the stock will go to 100. I*

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wouldn't recommend shorting unless you personally plan on sabotaging the construction site." There were no schedule updates in the Oct. 19 schedule charts, so students were left to wonder and analyze daily reports for clues. The following comments clearly present the students' reasoning process: "*As per reports, steel erection (structure top out) scheduled to start on Oct. 7th with a crane and end on Oct. 22. According to the reports, the crane doesn't show up until Oct. 13th. The steel was erected using a fork lift from Oct. 7th to Oct. 13th. Hmm interesting?"* The revised schedule posted on Oct. 21 indicated "Structure Top Out" milestone with a completion date of Oct. 27, five days later than in the initial report and the first prediction requirement, and "Substantial Dry-in" milestone with a completion date of Dec. 3, more than 7 days later than that in the prediction question. Students saw this as sign of sure failure to reach the milestone and continued to sell and short-sell, driving the price down to close to \$0. *"Game Over. Sell while you can or just beg for a bail out, I mean it's what all the cool kids are doing today.",* or *"Game Over. Might as well short sell before it hits zero. Check the schedule.*" On Oct 22, "Structure Top Out" was closed and the share value set to \$0. The reports posted on Nov. 9 and 17 did not make any changes to the falling prices for the second question. On Nov. 25 the project manager informed the students that the second milestone point was not met as well.

Data Collection

A six-item Likert survey, with a 5 point rating scale, was developed to collect data on students' learning experience with EPM. The survey required students to rate the value of the prediction markets as a learning tool for a) engagement for learning, b) understanding realities of construction, c) knowledge of probability, and d) advanced project management concepts. Additionally, using the same 5 point scale, the students rated the three other major instructional resources traditionally used in the course: a) homework assignments, b) lectures, c) textbook.

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The ratings of multiple learning tools on the same scale allowed for relative comparisons between learning activities. Finally, to collect qualitative data, students answered two open ended questions about the use of EPM as a learning tool. Surveys were conducted during the final class meeting for the semester. To reduce bias from social desirability, surveys were conducted anonymously.

INSERT TABLE 1

Discussion

To what extent do prediction markets as a teaching tool enhance undergraduate students' engagement in a construction/project management course? In summary, over 70% of students agreed or strongly agreed that the prediction market was engaging. For comparison, slightly more students, 74.1%, agreed or strongly agreed that class lecture/lecture notes captured their interest. However, fewer students, 59.3% and 35.8% respectively, felt that homework assignments and textbooks were engaging. Although lecture notes and textbooks are certainly not perfect, they took years to develop with feedback from students and instructors; the prediction market approach has had much less opportunity for development and refinement. This may be one of the reasons why lecture notes were ranked to be more engaging than EPM.

In response to whether prediction markets evoked positive emotional responses (i.e., enjoyment) approximately 63% agreed that this instructional exercise enacted a positive emotional response. In comparison, slightly more students (66.7%) rated the lecture/lecture notes as eliciting a positive response. Markedly fewer students rated the homework and textbook, 43.2% and 24.7% respectively, as creating positive emotions.

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When analyzing the qualitative reports in response to the open-ended question, *In what ways did the prediction market facilitate your learning in this course?*, numerous students cited that the prediction market exercise helped promote interest in the course. These responses support the Likert ratings, and also give insight for the rationale for the ratings. The reasons for their increased interest differed among students. Some students linked their interest in the prediction market to the project's connection to real-world construction. For example "*it … allowed an insight into the actual events at a construction project which to me was interesting*." Other students reported that it was interesting because it helped them to interact with the data, for example: "*It helped to understand how to take data and make predictions …how most [people] react to changes and the effect it has*; *I stayed interested this semester, not bored.*" Additionally, students attributed interest to the interaction among students in the prediction process. For example: "*It made the class interesting. People tried to convince each other to predict a certain way.*"

In order to measure both positive and negative emotions (e.g., frustration) evoked by each of these learning resources, we also included the following statement: *This instructional resource evoked a negative emotional response*. We were interested if the competitive aspect of the assignment would be stressful for certain students. However, the results indicate that the majority of students did not experience negative emotions from the prediction market learning experience: 22.2% strongly disagreed, 33.3% disagreed, 19.8% were neutral, 18.5% agreed and only 6.2% strongly agreed with the statement that predictive markets raise negative feelings. In other words, 24.7% experienced negative emotions through this learning experience and 75.3% did not.

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Again, the open-ended responses gave insight as to the quantitative ratings as to why some students experienced negative emotions with this project. Multiple students reported confusion with using the tool. One student reported that: it took him/her about a month to fully understand how to use the tool and what everything meant. Other students recommended more instructor clarification: "*I think a little guidance on what exactly was happening when we bought or sold stock would be helpful. I didn't really know what I was doing*." It is important to note that the students were provided with information about how to use the predictive market tool but deliberately not provided with instruction in probability theory or applications, as one objective was to observe how students used their best judgment in assessing the likelihood of events. Additionally, some students were frustrated that the system could be "gamed". For example, one student reported "*It was easy to manipulate the system that required no expertise in the field of scheduling.*" However, there is no conclusive evidence that manipulation was effective in moving the markets, although it is true that there was very high variability in the "wealth" of different students at the end of the simulation. If there was manipulation, it may be because some students did not take the exercise seriously while other students took the exercise very seriously. Those students who complained about manipulation may have been rationalizing their lack of confidence in their own ability to succeed with the prediction markets. More research is needed to resolve these questions about student involvement that were raised by the short experiment reported here.

Finally, more than two-thirds of the students, or more precisely 69% agreed or strongly agreed that the EPM helped them to connect to the real world. For context, slightly more students, 76.6%, agreed or strongly agreed that lecture/lecture notes helped them understand the realities of construction practice. However, significantly fewer students, 54.4% and 53.1% respectively,

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felt that homework assignments and textbooks helped them understand the realities of construction. Students' qualitative responses supported these ratings. Students mentioned issues regarding application to the real world more often than any other category of response. Representative responses included: "*The weekly reports were good insight into real documents and real work in the field and how ... it differs from homework and textbook examples*." Students noted that it "*helped to develop an understanding of how things [are] on a jobsite ... taught me what project managers need to plan for in a project*." Students also reported that the exercise gave them confidence because it helped them to familiarize themselves with project progress reports and the complexity of scheduling in project management situations.

LESSONS LEARNED, LIMITATIONS, AND FUTURE RESEARCH

The findings of this study offer evidence that teaching undergraduate students through an active learning method. More specifically, implementing prediction markets can promote engagement and provide a better link between the classroom and what actually occurs on the construction site. Students were afforded the learning opportunity to use their best judgment, or take relevant material from the classroom curriculum and apply it to make trades.

Our feedback leads us to several recommendations. To have an effective EPM in construction management applications, it is essential to: a) select a project, preferably a site that students have some visual access to, or can walk by, b) carefully select milestone points that are well scoped and visible to the participants, so there is no ambiguity in interpretation of the outcome, and c) provide real and unedited data that students can use to make educated trade decisions.

One of the major concerns raised was "gaming the system". For example, students posting misleading comments to influence trading decisions of others, so that they can profit from short-

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term price changes. The point is that the actions by some students in manipulating or "gaming" the system appear to violate some unstated ethical principle that the game should be fair and equitable to all users. If it is not, then the other students may feel that playing the market might not be a good use of their time and effort, thus dividing the students into two categories: those who played the game straight (i.e., treated the market seriously and focused on the prediction that the milestone event would be on time), and those who tried to manipulate the others by preying on the fears of the other students and persuading other players to take actions contrary to their own interests (e.g., by advising other students to buy when the manipulator was sure that the milestone event would not be on time and the market would fall). Although it was clear to all that the prediction market was just a game (real money did not change hands) more research needs to be done concerning the reactions of students to the ethical issues raised by this manipulation and /or how such manipulation should be addressed. In summary, however, the reactions by the manipulators, who spent considerable time on preparing their strategies, and by those straight students who resented these manipulations indicate the high level of engagement in the prediction markets by both categories of students.

Several limitations of this study focus on the survey instrument, and the single form of data collection. First, the survey was a newly designed instrument, and had not been previously tested. In addition, the data collection process for the study was based on a self-report measure. Answers provided by participants may be influenced by the desire to provide responses which are socially acceptable. For example, participants may rate their understanding of the realities of construction practices as agree or strongly agree, because they were successful in utilizing the prediction market. Third, the study only used one form of data collection. The survey instrument was only administered to the participants at the end of the treatment with the implementation of

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the prediction markets. The use of a comparison group was not employed which does not allow us to consider causality of learning.

To gain further insights in ability of predication markets to promote students' learning of project risks, we plan to extend the study effort to include full experimental design with control and treatment groups. More specifically, we plan to look for the effects of both endogenous and exogenous factors on learning outcomes, as well as investigate modalities of integrating prediction markets into class material on project risk management.

SUMMARY

This paper presents an investigation of the effects of using prediction markets in teaching engineering project risks. We focused on two important aspects of teaching that are critical to the students' ability to study abstract concepts such as risks: engagement and realism. To analyze how prediction markets affect engagement and realism in learning environment we have formulated four research questions, implemented the market, and collected data. The study results show that the use of prediction markets were particularly valuable for helping students make connections to real world applications and to help promote interest and enthusiasm which are integral factors in long-term learning.

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REFERENCES

Abdul-Haqq, I. (1998). *Constructivism in teacher education: considerations for those who would link practice to theory*. ERIC Clearinghouse on Teaching and Teacher Education.

Arrow, K. (2008). "The promise of prediction markets," *Science*, 320, 877-878

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Bernhard J. (2001). *Do active engagement curricula give long-lived conceptual understanding*? in R. Pinto & S. Surinach (Eds.) Physics Teacher Education Beyond 2000 (pp. 749-752). Paris, Elsevier.

Berg, J. E., Nelson, F. D., & Rietz, T. A. (2008). 'Prediction market accuracy in the long run," *International Journal of Forecasting*, 24 (2), 285-300.

Berg, J. E., Nelson, F., & Rietz, T. A. (2003). "Accuracy and Forecast Standard Error of Prediction," Working Paper, Tippie College of Business, University of Iowa.

Bloom, B. (1956). (Ed.). *Taxonomy of Educational Objectives, the classification of educational goals Handbook I: Cognitive Domain*. New York: McKay.

Buckley, P., Garvey, J., & McGrath, F. (2011). "A case study on using prediction markets as a rich environment for active learning," *Computers & Education*, 56, 418–428.

Garvey, J., & Buckley, P. (2010). "Teaching the Concept of Risk: Blended Learning Using a Custom-Built Prediction Market," *Journal of Teaching in International Business*, 21, 346–357.

Hanson R. D. (1999). "Prediction markets," *IEEE Intelligent System* 14, 16-19

Olgun, O. S. (2009). "Engaging elementary preservice teachers with active learning teaching methodologies," *The Teacher Educator*, 44(2), 113-125.

O'Toole, J. M., & Absalom, D. J. (2003). "The impact of blended learning on student outcomes: Is there room on the horse for two?" *Journal of Education Media*, 28 (2-3), 179–190.

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Journal of Professional Issues in Engineering Education and Practice. Submitted June 21, 2011; accepted May 22, 2012; posted ahead of print May 24, 2012. doi:10.1061/(ASCE)EI.1943-5541.0000127

Prince, M. (2004). "Does active learning work? A review of the research." *Journal of Engineering Education*, 93(3), 1-9.

Tziralis, G., & Tatsiopoulos, I. (2007). "Prediction markets: An extended literature." *The Journal of Prediction Markets*, Vol. 1, 7591.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological functions*. Cambridge, MA: Harvard University Press.

Wilke, R. R. (2003). "The effect of active learning on student characteristics in a human physiology course for nonmajors," *Advances in Physiology Education*, 27(4), 207-223.

Wink, J., & Putney, L. (2002). *A Vision of Vygotsky*. Boston, MA: Allyn and Bacon.

Wolfers, J., & Zitzewitz, E. (2004). "Prediction Markets," *Journal of Economic Perspectives*, 18 (2), 107-126.

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FIGURE CAPTION LIST

Figure 1. 3D Model of TAMU Vet Imaging and Cancer Treatment Center and the Site Photo

Figure 2. Price Changes for "Structure Top Out" Milestone Point

Figure 3. Price Changes for "Substantial Dry-in" Milestone Point

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Figure 2

Journal of Professional Issues in Engineering Education and Practice. Submitted June 21, 2011; accepted May 22, 2012;
posted ahead of print May 24, 2012. doi:10.1061/(ASCE)EI.1943-5541.0000127

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Figure 3 new

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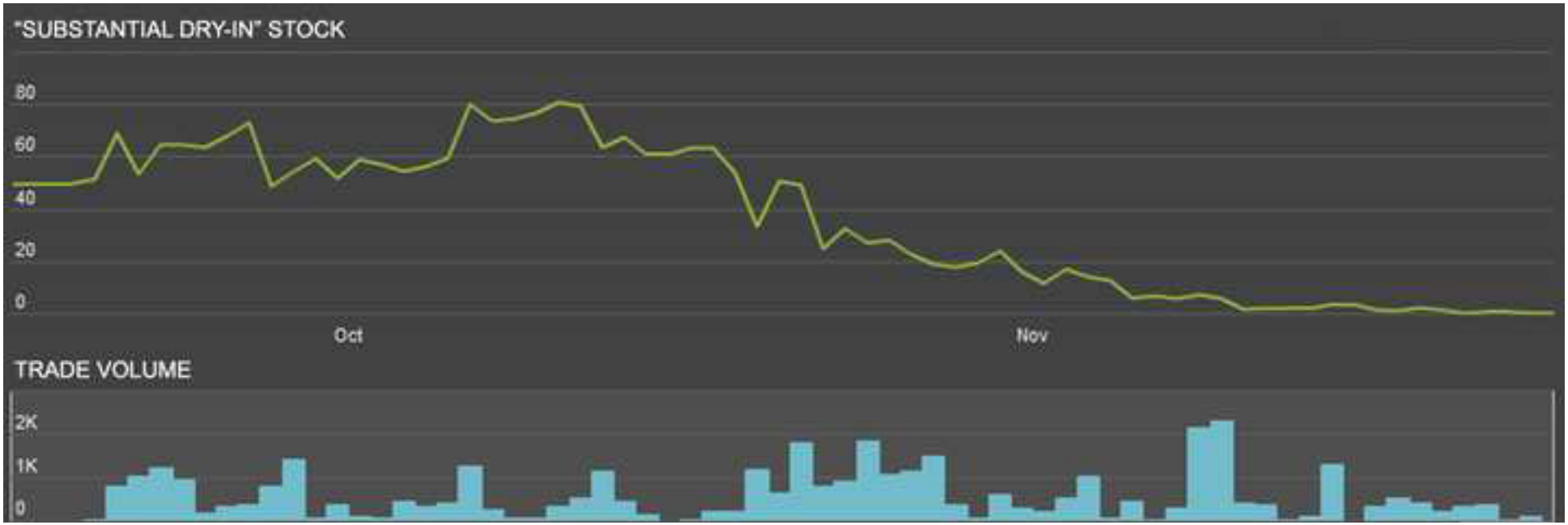

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Table 1: Students' Survey Results Related to Effectiveness of Prediction Markets

Likert Ratings (in percentages)				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q1: Prediction markets captured my interest and/or attention:				
28.4	42	14.8	9.9	4.9
Q2: Prediction markets evoked positive emotional responses (e.g., enjoyment).				
50.6	12.3	21	8.6	7.4
Q3: Prediction markets evoked negative emotional responses (e.g., frustration).				
6.2	18.5	19.8	33.3	22.2
Q4: Prediction markets as a teaching tool enhance understanding of the realities of construction				
39.5	29.6	16	8.6	6.2

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