Artificial Mind: Interdisciplinary Learning

Daegene Song*

ABSTRACT

In recent years, the importance of interdisciplinarity has been realized in the field of education, particularly to prepare students faced with practical real-world problems by mixing disciplines such as science, technology, engineering, and mathematics, an approach known as STEM. While this approach may provide a great opportunity in terms of enhancing creativity and collaboration, potentially more rewarding interdisciplinarity may be provided by the interconnection between STEM and arts-related areas. The present paper relates several interdisciplinary (i.e., the interconnection between science and arts by applying mathematical or algorithmic methods to artistry) education cases that have occurred in the last several years. More recently, with an enormous increase in the amount of data and the increasing speed of computing technology, data and artificial intelligence (AI) based approaches have been used in the stock market. Stock investment education based on simple AI-type algorithmic procedures is also described. In particular, it is significant that most participants had little or no previous experience in stock investment and limited knowledge of algorithms and mathematics, yet abundant business and market intuition combined with simple procedures resembling AI produced fruitful and interesting results.

Key Words: Information, Interdisciplinarity, Artificial Intelligence, STEAM

DOI Number: 10.14704/nq.2017.15.3.1051 **NeuroQuantology 2017; 5, 3: 107-113**

Introduction

Recently, there has been significant interest in the area of interdisciplinary education called STEM (science, technology, engineering, and mathematics) (Bybee *et al*., 2010; Brown *et al*., 2011) (also see (Lattuca, 2001; Benjamin *et al*., 2014; Lindsey, 2014; van Noorden, 2015; Brown *et al*., 2015; Rylance, 2015)). The effort was initiated in order to solve real-world problems (Johnson, 1999; O'Grady, 2012; Ledford, 2015), and the approach is appropriate and reasonable since practical problems often require not only a single discipline of expertise but also a collaboration of multiple fields. This type of education may help students to appreciate, learn, and collaborate with disciplines outside of their own major or interests.

Moreover, interdisciplinarity encourages students, particularly in the fields of basic science and mathematics (i.e., rather than in an applied field such as engineering or technology), to apply and practice their techniques in the real world, which has not usually been the case in the past.

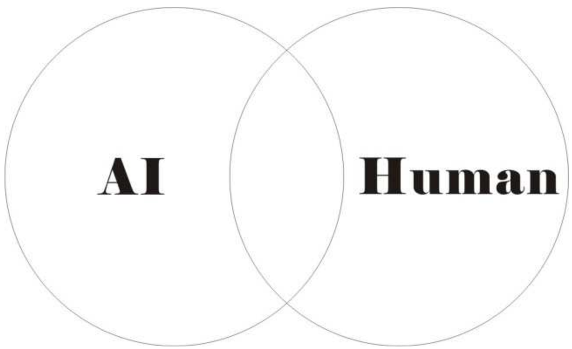

Figure 1. AI vs. Human: STEAM education is an interdisciplinary study involving science, technology, engineering, the arts, and mathematics. Initially STEM (AI) was pursued in order to solve real-world problems, and an arts and design approach (Human) was added more recently.

Corresponding author: Daegene Song
Address: Department of Management Information Systems, Chungbuk National University, Cheongju, Chungbuk 28644, Korea
e-mail ✉ dsong@chungbuk.ac.kr
Received: 21 May 2017; **Accepted:** 13 July 2017

This approach breaks a previously existing chain in which students had to practice basic science first, then applied science, and then could finally move on to industrial or commercial application; instead, the direct application of basic science in the world can now be realized more actively. There have been indications of this trend of basic science commercialization with the application of various mathematics and physics techniques in the fields of data science (Nagatani, 2002; Mattmann, 2013), security and cryptography (Ekert, 1991; Gisin *et al.,* 2002), finance (MacKenzie, 2001; Johnson *et al*., 2003), and so on. STEM will certainly be helpful for students of basic science in terms of job prospects by providing them with diverse options.

However, a drawback of STEM education is that while the approach is worthwhile, the interconnection among these fields is relatively already well established. For instance, it is difficult to imagine the discipline of engineering without a mathematics and science background. Recently, a number of proposals have been made (Yakman, 2008; Jolly, 2015) to add an art or design approach (Kramer *et al.,* 2000) into the program, and STEM then became known as STEAM (Connor *et al*., 2015; Song, 2017) (Fig.1). Nevertheless, it can be seen that while the interdisciplinarity between STEM and arts-related fields may be interesting, it appears to be rather difficult to practically implement in education. However, this new educational approach would emphasize imagination and creativity as opposed to traditional discipline and training, which experts in each discipline may not necessarily have but which relative novices, such as students who are still in the middle of training in their respective discipline, may possess. Therefore, interdisciplinary study between STEM and the arts may provide new opportunities in terms of enhancing creativity, imagination and collaboration. It is the objective of this note to discuss some cases in this endeavor that were conducted in the last few years.

Science, for example, in the case of physics, has often developed in the past based on mathematical modeling of a natural phenomenon that can then make experimental predictions. However, in the case of the arts, unlike nature (Strictly speaking, the arts is part of nature, and, therefore, if nature can be predicted, then the arts should be predictable as well), this type of deterministic prediction based on mathematical modeling would be difficult and likely impossible, suggesting then probabilistic and statistical approaches to be more useful and realistic. However, as mentioned earlier, because the connection is relatively immature (i.e., compared to the interconnection within STEM), complicated or sophisticated statistical or probabilistic techniques may not be necessary and will also require more imagination and creativity. Indeed, this is the correct prerequisite for an interdisciplinary project in education.

Order and Randomness

In order to recognize the probabilistic aspects of artistry, let us consider an illustration in the case of music: there have been numerous active interactions between music and mathematics. In particular, in the realm of music composition, the heavy involvement of mathematical structures has been noted, including rhythm and harmony as well as physical sound characteristics such as frequency and amplitude (Garland *et al*., 1995; Wright, 2009; Loy, 2011). To review the advancement of music in terms of order and randomness, let us consider Beethoven's fifth symphony. It is regarded by many to be one of most renowned symphonies of all time. This particular symphony has a main theme with which many are familiar, and the theme repeats throughout the piece. These repeated musical phrases often come to mind when this symphony is mentioned. As a more recent example, we might consider Rachmaninoff's second piano concerto. In the case of Rachmaninoff's music, the melody is not as apparent as it is in Beethoven's fifth symphony. One may question what has changed or even advanced between Beethoven's fifth symphony, which was composed in 1808, and Rachmaninoff's music from the early 20th century. One change is that the melody has evolved to become less obvious or apparent. In the case of Bartók's or Schönberg's music from the 20th century, it is difficult to find any melody at all, especially in comparison to the music of Beethoven or Rachmaninoff.

When a scientific perspective is adopted, one way to think about the melody is to consider it as musical order. In the case of Beethoven's symphony (1808), the pattern is highly ordered. In the case of Rachmaninoff's second concerto in 1901, this order or apparentness diminishes, and disorder or randomness increases, compared to the music of the previous era. In the case of 20th-century music (for example: Bartók, piano concerto no. 3 (1945)), less order is apparent, and disorder grows and eventually dominates. Thus, a more highly ordered or more complicated musical pattern may be considered to originate from a higher level of randomness or disorder (Fig. 2). There is a melody, or order, in more recent or advanced music, although it often takes time to find because it involves a more complicated order. Thus, a higher level of order or more complicated rules arise from increased randomness. If we consider the melody from a perspective of order and randomness, the present discussion is one way of examining it. In other words, the development of music can be studied throughout these three eras according to the following concept: increasing randomness leads to a more highly ordered pattern.

Figure 2. Order vs. Randomness: Although these two terms have opposite meanings, they are often used interchangeably. For example, entropy can quantify both randomness as well as information or order. In music, as randomness increases, a higher level of order is achieved.

Interdisciplinarity and Arts

Before the 20th century, in physics, deterministic theory was considered to be fundamental. However, with the introduction of quantum theory (Peres 1997), the understanding of nature with its probabilistic outcomes as well as subjectivity involving the measuring observer as an integral part of the theory was established. Moreover, as discussed in the previous section, the advancement of complexity in music also implies that a model with probability, approximation, or subjectivity might in fact be more fundamental and advanced. Indeed, it is ironic that by pursuing an objective pattern to its limit, as is seen in physics, subjectivity eventually emerges and dominates, as is seen in quantum theory (Song, 2012).

In order to discuss this point in terms of interdisciplinary education between science and the arts, we consider project cases that were conducted in 2013 and 2014 at the Korea University of Technology and Education by undergraduate computer engineering major students. In the first case, a group of students (Eou-Su Shin, Chang-Ju Ahn, Soon-Je Lee, Yoon-Yeol Pyo) decided to create an algorithm to evaluate paintings, raising the following two questions: why would anybody want to numerically evaluate the arts, and is art not about human intuition and instinct rather than a machine-like algorithmic procedure? There are at least two advantages in studying the objective evaluation of artistry in paintings. First, the objectification of something previously considered to be subjective can help students to imagine the limitations of the scientific analysis of artistry, possibly helping reveal human instinct and intuition that exists uniquely in artistic work. Second, the objective or computational evaluation of artistry may help to unearth notable unknown art work. Often, it has been the case that now venerated art has only been recognized long after the death of the artists who created it. While this scenario lends a dramatic effect to the back story of the art, it is unfortunate for many talented painters as well as for the audience of their work.

The students in this case attempted to analyze the paintings by extracting each pixel's red, green, and blue (RGB) color. Based on this extraction, they attempted to evaluate the warmth and coldness of the given painting. Although this analysis by no means provided a complete evaluation of the artistry of these paintings, the novelty of the objective algorithmic approach to this seemingly insurmountable task is that this approach is buildable, i.e., the next group can build and improve upon the previous approach. In fact, science developed in a similar manner when the laws of the nature were discovered. Secondly, this approach is useful for evaluating a large number of paintings using a computing technology that has become widely used in recent years with the development of big data (McAfee *et al*., 2012) and machine learning (Michie *et al*., 1994; Murphy, 2012) methods.

Another project connecting STEM with the arts involved analytically approach movies. Currently, making movies costs a significant amount of money. Moreover, the movie business is highly risky because, while the initial cost is high, the output, i.e., the gross income of the movie, is uncertain. One group of students (Do-Young Kim, Woo-Jin Cho, Chul-Hong Lee, Dae-Hee Kim, Sam-Sol Han) hypothesized that if the gross income of a movie could be predicted, it would benefit many involved in the business. They considered directors, actors and actresses, production companies, ratings, genre, and so on to predict gross income. One of the novelties of their approach is that this type of algorithmic method may help to provide opportunities for relatively unknown but talented directors, actors and actresses, and so on. Due to the risks discussed above, investors tend to prefer to work with well-known people, lessening the amount of opportunities for newcomers. However, using an algorithmic approach to predict the outcome of a movie's success may help to objectively evaluate success while also minimizing prejudice.

Another important factor in a movie's success is the plot. In another case, students (Kwang-Shik Shin, Byung-Kwan Choo) attempted to create an algorithm to evaluate movie scenarios. Again, this was a formidable task, yet they approached it with simple and realistic procedures. They attempted to numerically evaluate the dramatic level of the story and to determine if there was a theme or message in the story, if the conclusion was clear, and, finally, if the plot was accessible to the general public. Rather than directly analyzing the entire plot, they attempted to analyze the synopsis, which is an abbreviated version of the plot. They then applied this approach to previously released movies with regard to gross income to examine the validity of the established algorithm.

The earlier cases discussed involve the algorithmic analysis of work that was previously considered abstract. However, using the scientific method to enhance capacity in the arts may also work to attain the same goal. In another case, a group of computer engineering majors (Won-Hyung Kim, Tae-Yong Kim) were interested in music and often composed music as a hobby. In particular, one student in the group frequently composed music using a computer program. The group decided to use algorithmic procedures in music composition in addition to the composition software they were already using. They attempted to analyze the chords and beats per minute (BPM) of popular music from the 1980s to the present and learned that in the 1980s, many popular songs used three to four chords, but, presently, all seven chords are often used in popular music. Based on this analysis, they attempted to compose music that could become popular in the present day. Their approach is interesting in the sense that, although they were engineering students, they used their analytical skills to predict the popularity of music. Moreover, there is often a misconception that the analytical or scientific analysis of artistry may diminish the intuition or human abstraction involved in artistry. However, the exact opposite may be true in that converging science with the arts may enhance the unique human artistry involved, as shown in this case.

AI and Manual

There has been an active interaction between mathematical science and financial markets (Pliska, 1997; Karatzas *et al*., 1998; Johnson *et al*., 2003). Indeed, complicated mathematical methods, including the Black-Scholes model (Black *et al*., 1972), have been employed in the analysis of financial markets. However, heavy mathematics or algorithmic procedures often were thought to hinder the business instinct or intuition. More recently, with the explosive increase of data on the internet (McAfee *et al*., 2012) and ever-faster computing power, there have been a number of approaches bringing data analysis (Nagatani, 2002; Mattmannn, 2013) (also see (Michie *et al*., 1994; Kaastra *et al*., 1995; Bahramirzaee, 2010; Murphy, 2012)) to the stock market (Quah *et al*., 1999; Barber *et al*., 2000). In the following, we report the stock investment education study that was conducted in 2015, in which a simple and easy method was used without relying on heavy mathematical equations or complicated algorithmic procedures. In fact, the methods were performed by business major students who had relatively little background in math or programming but lots of business-oriented intuition and instinct.

The study was run during the fall semester of 2015 at Chungbuk National University to mostly second- and third-year business (management information systems major) students taking a programming language class. The class was designed to teach basic elements of the C language, but alongside the traditional lectures on the computer language, the stock investment projects were conducted. There were 50 students and four students were in each group, totaling 12 groups (unavoidably, there were two five-student groups). During the 16-week semester, four groups presented their results each week and eventually each group had a chance to give their presentation four times throughout the semester.

The first presentation was given in the third week, and two initial weeks were spent to pick their first choice. The rules of investment were as follows:

1. At each presentation, a group could pick one company listed on the technology sector of NASDAQ (there are more than 400 listed companies).
2. Each group starts with (an imaginary) $10,000 at the beginning.
3. The group is allowed to choose only one company (for instance, if Apple (AAPL) is chosen at $93, then the full $10,000 should

be used, therefore buying 107 shares with $49 carrying as cash). The price of the stock should be the price on the day of presentation.

4. The stocks are kept (meaning, not sold) for 3 weeks; that is, until the next presentation. When sold, the group buys the next company's stock with the amount left from the sold price plus the cash that was carried from the last presentation. For example, after three weeks, the Apple stock is $94, so $94*107 shares plus $49 of cash would bring the total to $10,107. The group will choose the next company with $10,107.
5. When choosing the company, the group cannot pick the same company again, nor can they choose a company that was previously chosen by another group, since there are 12 groups and each group gets to choose three companies, totaling 36 companies. This was easily accomplished since there are over 400 companies in the NASDAQ technology sector. The reason for this restriction was that students tended to pick well-known companies such as Google, Facebook etc. Students were expected to be more aggressive and take risks.

The students were instructed to choose the company based on data analysis of algorithmic procedures as follows. The students were sophomores and juniors in the management information systems department of the business school, and their background in mathematics was at the pre-calculus or introductory calculus level and, for many, it was their first programming class. Therefore, their math or programming skills were not as technical as their peers in science and engineering. However, their business intuition and motivation were strong and solid. Since the purpose of this stock investment was to use data analysis and algorithms, they were instructed to imagine a *manual*, one that is as precise and specific as possible. For instance, when making a pizza following an exact and specific manual, the taste of the pizza would be the same regardless of who made it. This is the case with pizza chain restaurants that strive to keep the taste practically the same regardless of the location, as opposed to homemade pizza, where the taste would change from one household to another.

With this example, they were instructed to come up with a manual for choosing a company based on the data available on the internet, in such a way that whoever chooses the company would end up with the same company pick by following the established manual. In that way, students were practically making an artificial intelligence-type algorithm of stock investment without relying on heavy mathematics, algorithms, or even large data processing software (they used only Microsoft Excel). In regards to making an investment manual, they were instructed to consider both a traditional factor, such as the profit, capital etc., and a non-traditional factor (i.e., something that is generally considered to be irrelevant to the stock price, such as if the company is located near the sea etc.). The reason behind the consideration of both the traditional and non-traditional factors was to optimize the advantage of being a novice in stock investment and maximize the previously undetected opportunity by experts (Fig. 3).

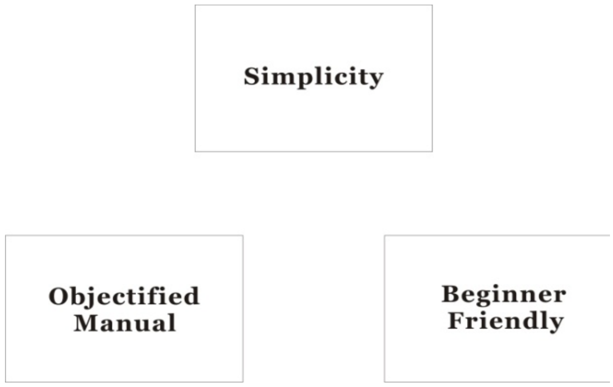

Figure 3. Advantages of the proposed education model: it maximizes objectivity while minimizing the subjective element, thereby making it a good fit for an AI-based approach. The procedure is simple (i.e., no complicated mathematics or algorithms are required). Finally, the method is beginner friendly: the procedure may work even better for students without much experience, therefore less prejudice, in stock investment.

Stock Investment Cases

Let us now consider some cases that were performed by students. One group of students (Young-Kyu Kim, Su-Min Kwon, Nan Lee, Eun-Ji Kim) considered some interesting factors in their manual or algorithm. In the first trial, they were relying on more traditional factors such as stock fluctuation rate per share, technology trends, and the world market share etc., and chose Facebook (FB). However, for the second and third trials, they considered an unusual factor: the stock price movement from a year ago. Surprisingly, they found a better than 80% of match between the price movement a year ago and the current case. That is, if the stock went up (or down) during the three-week period a year ago, 80% of the time the same stock also would go up (or down) in current year. With this new non-traditional and counter-intuitive factor added to their manual, they chose

Electronic Arts (EA) and Seagate technology (STX) for the second and third trials, respectively. Starting with $10,000, they ended up with $10,150. The profit was a moderate 1.5%, but their approach was quite innovative, creative, and interesting.

Another group of students (Mi-Sun Kim, Hyun-Hee Song, Min-Ji Ahn, Da-Ihn Lee) followed both conventional and non-conventional approaches. First, they picked 20 companies out of *Fortune* magazine's top 500 companies listed in the technology sector of NASDAQ. Putting particular emphasis on stability, they considered the beta number, which is related to stability, and the total cap of the company and chose Oracle (although their first choice was Facebook and second was Apple, both were already taken by other students). Their consideration of non-traditional factors was interesting. They considered the notion of the 'Matthew Effect', which, in the case of sports, refers to the performance difference in terms of the young athletes' birth month in the year due to relative age. They factored this into their algorithm and searched CEOs' birth months and attempted to sort this information out based on these criteria. It was eventually abandoned in their manual but the creative and aggressive attempt was well worthwhile.

Another interesting case was done by another student group (Sung-Nyun Kim, Jin-Yong Park, Seung-Woo Lee, Jin-Wook Lee). This group also started in a similar fashion to other students (i.e., by considering the usual factors to find companies with low debt ratio and high total capital), and chose one company but lost almost 10%. Because of this loss, which was not very common among other groups who were making profits as opposed to losing money, they decided to be a bit bold and take risks. They considered factors including the price-to-earnings ratio (PER) and looked for stocks that gained value dramatically in recent days or weeks. They finally chose CRAY Inc. (CRAY), and after three weeks the stock price went up drastically. In the end, the group had a 50% profit in total, which was the highest in the class.

It is noted that the evaluation of the performance of the manual, which was emphasized at the beginning of the class, was based on two aspects with the first one carrying more weight than the second one. The first factor was how well the manual is made objectively based on data and how well subjectivity is minimized in the algorithm, while the second aspect was the actual amount of money that would be left at the end of the three trials. The reason for the higher emphasis on the first factor was due to the fact that actual stock price movement prediction often depends on sheer luck, especially as the investment of each trial were carried out only in three weeks. Therefore, particularly for educational purposes, the actual process of using data and making an objectified manual was considered to be more important than the actual money that would be left after the investment.

Remarks

In this paper, we have discussed the interdisciplinary education of connecting science and engineering with artistry. In particular, analyzing artistry in terms of algorithmic procedures not only helps science students with the arts but also helps in understanding the human instinct or intuition believed to be present in artistic works. As shown in quantum physics, in which the fundamental limit of objectivity yields the domination of subjectivity, algorithmically and technically analyzing artistry may help in understanding human nature conveyed through artistic works.

The presented cases of stock investment education based on data analysis provide an example of a curriculum that can be implemented at the undergraduate (or secondary school) level, regardless of the mathematical or computer background of students. Moreover, the proposed AI-type approach provides an actual experience of investment rather than a book-oriented theoretical approach. Indeed, the reaction from students was impressive and they found the class to be not only a learning experience in the real world of the stock market, but interesting with a lot of fun.

Acknowledgments

This work was supported by the research grant of the Chungbuk National University in 2015.

References

Bahrammirzaee A. A comparative survey of artificial intelligence applications in finance: artificial neural networks, expert system and hybrid intelligent systems. Neural Comp App 2010; 19: 1165-1195.

Barber BM and Odean T. Boys will be boys: gender, overconfidence, and common stock investment. Quarterly Journal of Economics 2000; 116: 261-292.

Benjamin WD *et. al.* Phys. Rev. ST Phys Educ Res 2014; 10: 010115.

Black F, Jensen MC, Scholes MS. The capital asset pricing model: some empirical tests. in Michael Jensen, Ed.: Studies in the theory of capital markets (Praeger, New York), pp. 79-121, 1972.

Brown R, Brown J, Reardon K, Merril C. Understanding STEM: Current Perceptions. Technology and Engineering Teacher 2011; 70: 5-9.

Brown RR. Deletic A, Wong THF. Interdisciplinarity: how to catalyse collaboration. Nature 2015; 525: 315-317.

Bybee RW. Advancing STEM Education: A 2020 Vision. Technology and Engineering Teacher 2010; 70: 30-35.

Connor AM, Karmokar S, Whittington C. From STEM to STEAM: strategies for enhancing engineering & technology education. International Journal of Engineering Pedagogies 2015; 5(2): 37-47.

Dhar V. Comm. ACM, Data science and prediction. 2013; 56: 64-73.

Ekert AK. Quantum cryptography based on Bell's theorem. Phys Rev Lett 1991; 67: 661-663.

Garland TH and Kahn CV. Math and Music: Harmonious Connections. Dale Seymour Publications, 1995.

Gisin N, Ribordy G, Tittel W, Zbinden H. Quantum cryptography. Rev Mod Phys 2002; 74: 145-195.

Johnson PA. Problem-Based, cooperative learning in the engineering classroom. Journal of Professional Issues in Engineering Education and Practice 1999; 125: 8-11.

Johnson NF. Jeffries, P. and Hui PM. Financial Market Complexity. Oxford University Press, Oxford, 2003.

Jolly A. STEM vs. STEAM: do the arts belong? EdWeek.org. Education Week: Teacher, 2015.

Kaastra I and Milton SB. Forecasting futures trading volume using neural networks. J. Futures Markets. 1995; 15: 853-870.

Karatzas I and Shreve SE. Methods of mathematical finance. Springer-Verlag, New York, 1998.

Kramer J, Noronha S, Vergo J. Comm. A user-centered design approach to personalization. ACM Comm 2000; 43(8): 45-48.

Lattuca LR. Creating Interdisciplinarity: interdisciplinary research and teaching among college and university faculty, TN:Vanderbilt University Press, 2001.

Ledford H. Team science. Nature 2015; 525: 308-311.

Lindsey BA. Student reasoning about electrostatic and gravitational potential energy: An exploratory study with interdisciplinary consequences. Phys Rev ST Phys Educ Res 2014; 10: 013101.

Loy G. Musimathics: the mathematical foundations of music. The MIT Press, 2011.

Mattmann CA. Computing: A vision for data science. Nature 2013; 493: 473-475.

MacKenzie D. Physics and finance: S-terms and modern finance as a topic for science studies. Science Technology & Human Values 2001; 26: 115-144.

McAfee A and Brynjolfsson E. Big data: the management revolution. Harvard Business Review 2012; 10: 59-68.

Mattmann CA. Computing: A vision for data science. Nature 2013; 493: 473-475.

Michie D, Spiegelhalter DJ, Taylor CC. Machine learning, neural and statistical classification. Prentice Hall, Englewood Cliffs, N.J., 1994.

Murphy K. Machine learning: a probabilistic approach. MIT Press, 2012.

Nagatani T. The physics of traffic jams. Rep Prog in Phys 2002; 65: 1331-1386.

O'Grady MJ. Practical Problem-Based Learning in Computing Education. ACM Transactions on Computing Education 2012; 12: 1-16.

Peres A. Quantum Theory: Concepts and Methods. Kluwer, Dordrecht, 1997.

Pliska SR. Introduction to Mathematical Finance. Malden, MA:Basil Blackwell, 1997.

Quah TS and Srinivasan B. Expert Systems with Applications 1999; 17: 295-301.

Rylance R. Global funders to focus on interdisciplinarity. Nature 2015; 525: 313-315.

Song D. Einstein's moon. Phys Usp 2012; 55: 942-943.

Song D. Mind and Machine: Interdisciplinarity. NeuroQuant 2017; 15: 67-72.

Van Noorden R. Interdisciplinary research by the numbers. Nature 2015; 525: 306-307.

Wright D. Mathematics and music (mathematical world). American Mathematical Society, 2009.

Yakman G. STEAM education: An overview of creating a model of integrative education. presented at the Pupils' Attitudes Towards Technology (PATT-19) Conference: Research on Technology, Innovation, Design & Engineering Teaching, Salt Lake City, Utah, USA, 2008.