A Tale of Two Visions
Exploring the Dichotomy of Interest between Academia and Industry in Visualisation

Richard Roberts[1], Robert Laramee[1], Paul Brookes[2], Gary A. Smith[2], Tony D'Cruze[2]
and Matt J. Roach[1]

[1]*Computer Science Department, Swansea University, Wales, U.K.*
[2]*QPC Ltd, Mold, North Wales, U.K.*

Keywords: Visualisation, Industry, Collaboration, Software.

Abstract: The pairing of a commercial organisation with an academic institution is a typical example of a symbiotic relationship. Commercial organisations dedicate money, time, and often data into a university project with the ultimate goal of a financial return on their prudent investments. Academic institutions welcome these relationships as it supports their research in a field where obtaining funding is extremely competitive. Specifically in the field of visualisation, the culture, visions, and goals of both academia and industry differ in unique ways. In this position paper we explore the dichotomy of interests between the two groups, based on first hand experience and interviews, deriving recommendations for any organisation considering entering into a working relationship with either party.

1 INTRODUCTION

Imagine two organisations. Each has an input, and each has an output. Both require financial capital as an input, but their outputs are not the same. The first organisation outputs a product or service; neatly polished and saleable. The second organisation outputs knowledge; packaged in the form of a written document or an educated person. The nature of knowledge is such that it isn't ever really complete - just further developed, whereas saleable products should be final and complete. The juxtaposition between the two organisations is so evident that it seems difficult to imagine a symbiotic relationship developing between the two.

Despite the duality between the university and industry operational processes, relationships are often formed between the groups. To maximise the potential of these relationships, each organisation must consider how the relationship can be of mutual benefit to for both parties by considering some questions; What do I expect to receive from this relationship? What do I expect to provide in this relationship? What are the deliverables of my project? What are the deliverables of their project?

Depending on the subject field, the two groups have varying degrees of shared interests. For example

the field of oncology is almost entirely research based (Johns et al., 2003), where the difference between the industrial component and academic component is minimal, relationship challenges still remain (Stossel, 2005). However, as we stray away from charitable organisations and medical groups and move towards the business-oriented industries we see a shift in motivation. No longer are the scientific breakthroughs mutually beneficial to both parties, but instead a dichotomy appears whereby a business intends to utilise the partnership for financial reward, and the academic partner desires to produce publishable research. This isn't necessarily incompatible, but the scope and expected output of each party should be thoroughly discussed before entering into the partnership.

We have worked with our industry partner since 2013 and have mutually learned a lot from one another. Whilst we would describe our working relationship as positive, we have definitely found that expectations of each project rarely line up perfectly.

In this paper we explore how the knowledge transfer between the two parties benefits each side. We identify where businesses can learn from data visualisation practices as well as describe the value of working with industry has provided us. We examine the nature of this relationship in the field of data visualisation and perform an interview study with our in-

319

dustry parter and others to explore both sides of the scenario. The result is a set of recommendations both parties should consider when initiating an academic-industry relationship.

In the next section we cover related work in this topic, followed by our analysis of the dichotomy of interest within university/industry collaboration. Then we present some informal interview studies from both our industry partners and small business owners who are at varying stages of university collaboration. We conclude with an evaluation and recommendations for any party considering a collaboration.

2 RELATED WORK

The study of this unique relationship spans almost all of the academic disciplines. Due to the nature of these studies, the viewpoint is often from the perspective of the university and not the industry partner. Each study focuses on a slightly different facet of the relationship, ranging from motivations and benefits to the introduction of a third party – the government.

Ankrah and AL-Tabbaa present a systematic review of the literature surrounding this field (Ankrah and Omar, 2015). Showing the top three publication venues to be *'Research Policy'*, *'Technovation'*, and *'R&D Management'*. The survey contained 109 articles from all areas of academic collaboration with industry.

Appropriately, a sizeable amount of the university and industry research focuses on the benefits of their collaboration. De Fuentes and Dutrènit examine the long term benefits of these relationships (De Fuentes and Dutrenit, 2012). The research addressed three primary questions, why do universities collaborate with industry? What are the main types of knowledge transferred? And what are the benefits of the collaboration? In this example the industry viewpoint is focused on, addressing the benefits to companies working with a university. Chan and Anderson explore the benefits to academic students when collaborating together in what they describe as 'Action Learning' (Chan and Anderson, 1994), the paper concludes by stating that the union of the two groups provide students with an excellent opportunity to experience *'real world'* business interactions first hand. The motivation behind the relationship has also been studied (Deste and Perkmann, 2011).

Fujisue explores the transfer of knowledge from academia to industry within a collaborative relationship (Fujisue, 1998). This transfer of knowledge is important as it contributes to the businesses inputs to be converted into profit (Friedman and Schwartz, 1975).

Whilst these research papers broadly explore the nature of university-industry collaboration, this paper focuses specifically on visualisation research in academia along with the strengths and weaknesses of such a relationship. It also examines a very specific relationship - that of Swansea University with QPC Ltd.

In Ben Shneiderman's book 'The new ABCs of Research' he encourages the pursuit of real solutions to real world problems (Shneiderman, 2016). He highlights the double value that a real world solution brings to both academia and industry or civic organisation. Shneiderman highlights that the selection of a project with actionable problems triggers great research.

A panel discussion addressing the themes of industry and academic partnerships took place at an event called "Uncertainty Management & Uncertainty Quantification for Industry" in 2017. At the panel a range of barriers were discussed that prevent academic contributions from eventually impacting real-world applications. Some of the factors include, cost, knowledge of customer demand, engineering knowledge, time, computing resources, data validation and uncertainty, results and interpretation. Also presented was a phenomenon we call, "The Software Development Death Cycle" which describes the fate of 99.9% of research prototype software at the end of a PhD degree (Robert S Laramee, 2017).

3 A TALE OF TWO VISIONS

Consider again those two organisations. Identifying the standardised processes of inputs and outputs in these organisations is necessary to create the model for collaboration. First we will look at each organisation individually and then attempt to merge the two processes and create a symbiotic model where each organisation contributes and benefits from the relationship.

First we look at the industry organisation. Simplified, businesses operate in a state of production, whereby profit is generated from the creation of a product or service. Most of this profit is then reinvested into the business to grow and expand the business. See Figure 1.

This simplified model shows the generated profits reinvested into the company. Some of the capital will contribute towards research and development or investment in new infrastructure, and some may be used to pay the shareholders dividends to encourage retention of their investors. A significant proportion
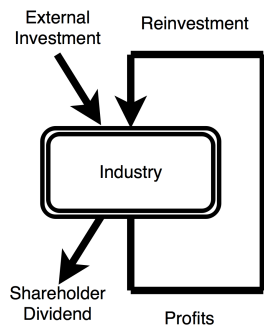
Figure 1: This figure shows the simplified process of business. Internally money is invested on many things such as R&D or marketing, but ultimately profits should be made on investments through the sale of products. Profits are either saved for liquidity, re-invested in the company, or paid to shareholders (In the case of a public limited company).

of it, however in some way contributes as input back into the business.

The academic model looks quite different. Specifically in the field of visualisation, the inputs required are both capital to fund research and access to interesting data. The generated outputs for this model centre around knowledge, either as an education student or as a published research paper. See Figure 2.
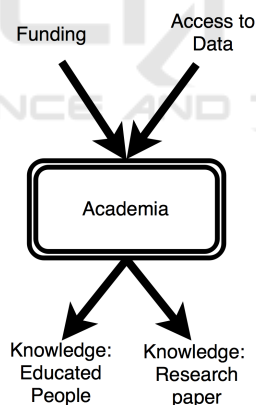

Figure 2: This figure shows the academic process model for data visualisation. Unlike industry, it cannot utilise its outputs as inputs. The larger organisation makes money from education, however academic research typically requires external funding to operate. The outputs of educated people and publishable research cannot be directly reinvested in the organisation.

The standard method of merging these models in collaboration is for the industry partner to provide funding and/or data to the university generate research around a topic. In return, the university should provide something of value to the industry partner. See Figure 3. However it is rare for industry funding alone to be sufficient to cover all costs of collaboration. A

third party funding body is usually required to provide a large proportion of the capital.
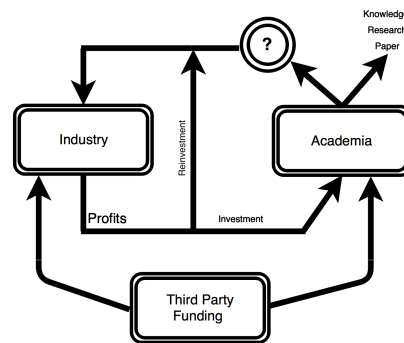

Figure 3: This figure demonstrates the union of both organisations in a symbiotic relationship. Third party funding is typically necessary to encourage such collaboration.

The method in Figure 3 utilises the outputs of the industrial partner as well as in the inputs of the academic partner. Third party funding is often necessary to create the collaboration as industry partners are sometimes reluctant to invest large amounts of money in something considered experimental or risky. Notice the outputs of the academia model are incompatible with the inputs of the industry model. A big question mark remains over what contributions can be made to industry. How is this gap in the utility workflow filled?

3.1 A Case for Collaboration in Visualisation

In this section, we address how exactly visualisation research is capable of providing unique value to a business. The gap in the utility workflow is best solved by addressing data challenges that the industry partner faces.

If we look at the strengths and weaknesses of both the software development industry and academia in visualisation, the former is structured to create software that is saleable. Their staff posses generalised development skills, with the intention to create a well-built and durable piece of software. Visualisation research operates with more experimentation in mind, often utilising quicker development lifecycles that enable visualisation ideas to come to fruition quickly. Moreover the academic researcher has the knowledge specialisation to know what visualisation methods are available and which suit the industry partner's data.

The value of visualisation centres around the idea of visual data interpretation (Van Wijk, 2005). It's not possible for a human to read and understand a large dataset. Even reducing the data down into statistics

and reports limits the audience ability to interpret results. Visualising the data in the right way opens up interpretation to a broader audience as well as simplifies the important aspects so that analysis can explore and better understand the data. There is an inherent value locked up within real-world datasets, but the knowledge required to unlock that value is rarely held. This is where academic research can help industry parters in their data challenges. Both through the transfer of knowledge from academia to industry, but also in the creation of visual designs tailored specifically to the datasets provided by industry. This skill is not widely taught and so industry staff members are generally limited in their ability to attempt visualising complex data without the university support.

Whilst we've established that the academic field of visualisation offers unique value through knowledge and ability to unlock value in large datasets, it is still unclear what deliverables are beneficial to the industry partner. Whilst the transfer of information to industry is useful, it may not fully compensate the cost of funding a research position. Typically visualisation research involves the creation of new software that facilitates the analysis of data. If designed for the use case of industry analysis, then the software could be handed over to the industry partner as part of the deliverable. However, research software is unlikely to be saleable. A company would find it difficult to profit directly from the software itself, but instead take advantage of the insights from using the software.

These new insights into industry datasets hold a unique value. Companies often employ teams of analysis to discover features in datasets or even validate theories they may have about the data. Visualisation offers the ability to discover and explore very large datasets whereby the output can be interpreted by staff members beyond just analysts. Therefore we propose that the most significant contribution to industry is the outsourcing of information exploration.

3.2 Dichotomy of Interest in Visualisation

Whilst there is a significant case for collaboration among academia and industry, there are a number of cases where the interest of the two organisations diverges. We do not consider these to be 'deal breakers', but we do recommend that they are considered and discussed before entering into a collaboration effort.

PhD Research is Niche. If the university funding is used to employ a PhD candidate in the research, the goals of that student are mostly fixed around the proposed topic. The researcher will spend long periods

of time working on a number of similar projects in order to complete their studies. This can result in less interest from industry partners.

Visualisation Research Has to be Novel. The development of unique visualisation methods may sound appealing to industry partners. However some data challenges may best be addressed using already existing visualisation methods or off-the-shelf tools. Whilst there is scope for research visualising new data with old methods, it is not the most desired form of output from the perspective of the university. Developing new visualisation techniques and interactions can improve the output of analysis, but the time/reward ratio for industry may be unfavourable.

Research Has Necessary Outputs. An absolute requirement of academic research is the publication of research. The writing of a publishable research paper is a long process of uncertain duration. Rejected papers may take years to be published which can be off putting to potential industry partners who gain very little from being associated with a high quality publication. A serious challenge also arises if visualisations of the industry data cannot be published for data protection reasons.

Pressure of Profits. Businesses operate with the absolute requirement to make a profit. Academia does not operate under the same conditions and so the work requirements place less emphasis on reducing project overheads. Less creative freedom is allowed within business software development to streamline the creation process.

In the next section we discuss a range of informed opinions from individuals within industry who seek collaboration with academia and also the views of academics seeking partnerships with industry to further their research.

4 INTERVIEW STUDY

In order to fully evaluate the collaboration sentiments, we performed a number of interviews with both academics and industry. During a business technology conference (dig, 2017) we talked to small business owners about collaboration opportunities and collected their thoughts and feelings on working alongside a university for their research. We also interviewed our industry partners to evaluate their experience of collaborating with us.

Additionally, we discuss industry collaboration with other academics who have engaged in relationships of this nature so that we can explore both the visions of both organisations.

4.1 Industry

Digital Conference. Over the duration of the Digital Festival we talked with many people from different backgrounds about the relationships between businesses and computer science academia.

We note that so much of the initial relationship between academics and industry is focused around writing grant bids. It appears that universities have more experience in writing these bids and so they potentially have more bargaining power in the negotiations of the relationship. Third party funding is essential for relationships with SMEs (Small-Medium Enterprise) as these projects are seen as unexplored and a potential risk.

One technology business owner discussed with us the reasons he has previously engaged in a university collaboration - *"We realised that universities have invested a lot of money is R&D which has become more advanced than what's available in industry. They have this deep well of knowledge that we can access, and we're looking to convert that into saleable products"*.

Throughout the conference we demonstrated the utility of data visualisation at our exhibition stand. A business employee was interested in the concept and spoke about how they needed their software to be more comprehensive in its analsysis, *"We want to be able to visualise our data so that we can monetise its output. our software is really good but it lacks that visual component"*. Showing the demand for visualisation but the lack of availability for third party funding may be preventing a number of these relationships from forming.

Whilst businesses were very keen to instigate a collaboration, their interest was either in the knowledge and insight a university can offer, or simply cheap manual labour of software development. The latter being incompatible with the output of academia. The former is certainly possible, but the university would still have academic obligations such as paper publication. The company would need to provide an outlet for that, e.g. supply interesting data.

Alternatively, the output of academia is a contribution towards the product. In most cases in the visualisation world, this would be in the form of a visualisation design or even the visualisation research software handed over as a deliverable. This can be the perfect outcome for both organisations, but intellectual property rights need to be discussed first. During our conversations at the conference, a number of people raised IP as a potential issue with starting a collaboration.

Industry Partner Interview. We've been collaborating with QPC Ltd. since 2014. During this time we have engaged in a two-way knowledge transfer, spending time learning about the operations of the other party and then developing visualisation software that utilises their data. We instigated our relationship through an Innovate UK funding opportunity and continued our relationship using the KESSII PhD funding scheme.

We interviewed the key collaborators in QPC Ltd. to explore their experience in partnering with us. The central theme was the funding opportunity that brought us together - *"So any commercial business has to have one eye on its cost, and then how do you invest that money wisely? What grants and funding opportunities are available that would create opportunities we wouldn't normally have?"* We asked them about the benefits of funding. *"What funding with this type of relationship offers is the ability to finance and create something new that we would normally have the opportunity to do - the best example is where we are today."*.

We ask what academic collaboration offers to industry - *"Our focus is 100% on things that we can build to sell. We can't really focus on anything outside of that. With you guys, you have the ability to step back and experiment to create something different which is actually where the real growth comes from in any business."* Reinforcing our ideas about academic creative freedom. They go on with; *"So in R&D, it's the research part of the development we just don't have the time to do because of the numerous deadlines imposed upon us."*.

Another benefit this collaboration offers is a fresh perspective on insights - *"It was also good to have you guys look our data with a fresh set of eyes. We didn't want to guide you too much in the early stages because we wanted to see what insights you would make without our biases of what we already know."* They continued; *"The visualisations you make always explore different avenues to the ones we make."*

We then ask specifically what we have been able to contribute over the project duration. *"When we first set up with you guys, we found it to be very competitive. We wanted to keep pace with what you were teaching us. Knowledge transfer was huge! There was so much we didn't know and so we tried to just absorb as much information as we could... It was useful to have you guys to provide validation for our visualisation work to show that we've actually done something unique, and then we could provide validation for your visualisation work to show that it has a real world application."* .

Whilst our collaboration has been successful, we

ask about the challenges they have experienced during the relationship - *"I think there's a bit learning curve for both parties in this. I think it took longer than we both expected to complete that knowledge transfer. I felt that by the time it was complete, the Innovate UK project was almost over. Which is why the KESSII funding was so great for us so we could start a new project without the learning curve we previously had."* reiterating the value of third party funding.

When asked what advice they would give to companies starting a collaborative relationship with a university they claimed - *"The values and objectives of both entities are very different, they do conflict in a way. And that's something that needs to be discussed and brought into alignment by compromise on both sides."*

One of the interviewees summarised the collaborative experience by stating *"It offered us as a small company a way of complimenting our current skillset with resources we probably wouldn't have been able to afford at any other time."*

4.2 Academia

In this section we discuss our own views on academia industry collaboration in visualisation, as well as perform interviews with staff members responsible for developing collaborative relationships with industry.

From the perspective of academia, collaboration efforts are usually for the purpose of furthering research. In our discussion with a university staff member whose role is to encourage the development of these relationships, they emphasise that philanthropic motivations from either organisation are rare. An academic is unlikely to engage in a collaboration project that demands complete focus on the business product without any opportunity for publishable research. Engaging in a knowledge transfer program from academia to industry also may not benefit the university. Conversely, a business who invests in collaboration where they are unable to utilise any of the research is also not likely to benefit.

When asked why they thought that university collaboration still appealed to businesses, they claimed that it came down to creative freedom to explore potential solutions to problems. In business, time is considered money. Which means that any time spent not working on a direct solution is often considered wasted. They are not allowed the freedom to explore new ideas as it seen as a risk whereby money will ultimately be lost if the research is unfruitful. This is where academic research becomes appealing, but also explains the reluctance to invest large amounts of their own money into the project as it might not

produce the output they desire.

"Industry is rife with rules and regulations, they are very limited in their creative processes. However they can outsource their thinking time, buying a creative research outlet." states the university collaboration staff. *"The reason industry moves to academia is that sometimes they want the credibility of their knowledge. It comes with the validation of peer review."*

Whilst talking to some of the staff members at the university who are collaborating with industry we noticed a trend in some of the stories. A number of these relationships attempt to force an unbalanced of workload on one party. We were told stories of companies requesting more time to be invested in generic software development projects that cannot further academic research. Where companies see the collaboration as a cheap source of labour. These stories were told as a warning to clearly define the boundaries of the project requirements before entering into collaboration.

Primarily, visualisation research offers valuable and unique insights into data. The approach used often looks at the data from a different angle to that of a standard data analyst due to these creative freedoms allowed in research. These insights are a valuable deliverable for a collaborative project.

5 EVALUATION & CONCLUSION

After spending time talking to individuals who are exploring potential for new relationships to either further their business or to further academic research, we see that the dichotomy of interests is not insurmountable. In fact, a collaborative relationship can be extremely beneficial to both parties through knowledge transfers, data insights, and novel research opportunities.

Below we summarise the primary arguments for collaboration and outline a number of recommendations to potential collaborators based on our experiences as well the experiences of our interviewees.

Visualisation Collaboration Evaluation. Creating a symbiotic relationship between a business and academic visualisation research organisation can produce great value for both parties. The academic institution is provided with an opportunity to explore new and interesting datasets that would typically be unavailable to them. Using these datasets, new visualisation methods can be devised to explore and unlock the value held within the data and publish the results. The collaboration opportunity provides the research

organisation a funding platform to conduct their research as well as a real world dataset to apply their skills to. Ben Schneiderman explains this *"Choosing actionable problems triggers great research. Working on real world problems with real data can lead to real solutions and enable theory validation in living laboratories."* (Shneiderman, 2016).

The business is provided with an opportunity to develop visual data analysis tools without the creative restraint that corporate operations typically impose. More risks can be taken in the research and so the potential for unique and valuable output is increased. The business will have access to the specialised knowledge that the university holds which can be utilised in their own development processes. Additionally the publishable research the university creates should contain valuable insights into the businesses datasets.

Because the process is still seen as a risk, third party funding is usually a requirement, especially for SMEs who may not be able to fund external research entirely by themselves. From the informal interviews conducted with small business owners and staff members, we established that governmental financial support is a necessity for the development of small businesses. The future of the UK is uncertain, but we sincerely hope that this vital funding remains available to small businesses and universities in the United Kingdom as it leaves the European Union.

Recommendations. Below we make a series of recommendations for entities planning to engage in academic - industry collaboration;

1. Discuss what contributions each party might bring to the collaboration.

2. Discuss what personal requirements each party has for the project. i.e. published papers or saleable software.

3. Discuss what each party wishes to gain from their collaboration partner. i.e. knowledge transfer, access to data.

4. Firmly establish expected outputs for the collaboration project as well as the deliverables from each party, placing emphasis on the deliverable from academia to industry.

Whilst simple, this process helps prevent either organisation entering the collaboration with any misconceptions as to the requirements of the project. A common theme among the interviews was a propensity to change requirements or modify deliverables of the other party over the lifetime the project. This system ensures that expectations are managed correctly.

In this paper we have attested the potential for collaboration between academia and industry. Although the two organisations might not align perfectly all the time, we believe that there is much potential for valuable research and business development. We are grateful for the opportunity to work alongside our industry partner QPC Ltd. and for their contributions towards our continuing research.

These relationships are valuable because we believe it is important to implement the knowledge we develop in the real world. Without it our visualisation research has less meaning, living only as words on an unread document in some digital library. We also benefit from experiencing how industry operates in the real world, learning about their differing requirements and processes - which helps us align our creative development to maximise utility in the real world scenarios. The future of this collaborative relationship is uncertain within the UK. As EU funding dries up, both industry and academia could suffer from having this tie cut - especially the small, developing businesses who might one day become major contributors to the UK economy.

REFERENCES

(2017). *Digital Festival: for Innovation, Investment, and Industry*.

Ankrah, S. and Omar, A.-T. (2015). Universities–industry collaboration: A systematic review. *Scandinavian Journal of Management*, 31(3):387–408.

Chan, K. and Anderson, G. C. (1994). Academia–industry fusion: Action learning for teaching enterprise. *Industrial and Commercial Training*, 26(4):28–32.

De Fuentes, C. and Dutrenit, G. (2012). Best channels of academia–industry interaction for long-term benefit. *Research Policy*, 41(9):1666–1682.

Deste, P. and Perkmann, M. (2011). Why do academics engage with industry? the entrepreneurial university and individual motivations. *The Journal of Technology Transfer*, 36(3):316–339.

Friedman, M. and Schwartz, A. J. (1975). Money and business cycles. In *The state of monetary economics*, pages 32–78. NBER.

Fujisue, K. (1998). Promotion of academia-industry cooperation in japanestablishing the law of promoting technology transfer from university to industry in japan. *Technovation*, 18(6):371–381.

Johns, M. M., Barnes, M., and Florencio, P. S. (2003). Restoring balance to industry-academia relationships in an era of institutional financial conflicts of interest: promoting research while maintaining trust. *Jama*, 289(6):741–746.

Robert S Laramee, Tony O'Hagen, A. D. (2017). Academic - industry gaps. Uncertainty Quantification and Management for Industry.

Shneiderman, B. (2016). *The new ABCs of research: Achieving breakthrough collaborations*. Oxford University Press.

Stossel, T. P. (2005). Regulating academic-industrial research relationships-solving problems or stifling progress? *The New England journal of medicine*, 353(10):1060.

Van Wijk, J. J. (2005). The value of visualization. In *Visualization, 2005. VIS 05. IEEE*, pages 79–86. IEEE.