Theme: Collaboration

Linda Candy, Ernest Edmonds and Fabrizio Poltronieri

This chapter explores the nature of collaboration in inter-disciplinary art and technology projects. It draws upon the COSTART project described in Chapter 'A Million Millennial Medicis'. Other inter-disciplinary initiatives took place outside the academic context. For example, in 1996 the Wellcome Trust U.K. launched the 'SciArt' funding programme in response to a growing field of artists embarking on new projects in conjunction with scientists. Many of these initiatives are no longer active but nevertheless, the precedents were important in demonstrating the potential benefit for creative work. Communication for interdisciplinary collaboration, shared languages, cognitive styles, and the role of knowledge are all discussed. Finally, observed success factors for good collaboration are reported. The core chapter is followed by eight contributions on the subject from artists and researchers.

Introduction

Creativity often needs collaboration because creative practitioners do not always have each and every kind of skill necessary to turn ambitious creative ideas into material outcomes. The pragmatics of making aside, however, people may seek collaboration when they want to exchange ideas with people from different backgrounds. Having already had previous opportunities to work with others, they may be aware that exposure to different ways of thinking can be very stimulating and provocative. Nowhere is this more so in the field of art and technology, where not only is the use of digital tools an initial driver in the direction of collaboration, but the rewards extend beyond the pragmatics into personal and long-term benefit.

In the contemporary digital art world, collaboration is taking place between artists and artists as well as between artists and technologists and technologists and technologists. The label 'artist' covers many types of art and a 'technologist' can be anything from a software programmer to a hardware systems and electronic devices implementer. Sometimes, artists act collectively and give this a single name to

L. Candy et al., *Explorations in Art and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-1-4471-7367-0_29

indicate shared responsibility and ownership; sometimes the technologists are much more than assistants to the artist and are actually creative technologists with their own artistic profile and activities. Given the many kinds of collaboration across different fields and disciplines, it is always interesting to ask if there are shared characteristics and whether successful collaboration has distinctive features that we can learn from and apply more generally? How are innovative ideas developed and made into artefacts in a collaborative context? How do people develop complementary ways of working together to create something extraordinary despite the fact that they often have different ways of thinking and communicating? It seems very unlikely that there is a perfect recipe or ideal model for good collaboration but by drawing on evidence from research studies, we can learn much from the experiences of those who take part in collaborative ventures whether in large or small scale creative situations.

This chapter explores the nature of collaboration in the context of inter-disciplinary art and technology. Almost two decades have passed since the foundational work for the first edition of 'Explorations in Art and Technology'. The book drew mainly on initiatives of the late 1990s when there was a resurgence of interest in the creative potential of digital technologies. At that time, the COSTART project, funded by the Engineering and Physical Science Research council (EPSRC), was an unusual provider of opportunities for research into collaborative creative practice in the UK (COSTART). Other inter-disciplinary initiatives were taking place outside the academic context but these initiatives did not always result in cross fertilisation of practices and outcomes at the time. In 1996, the Wellcome Trust U.K. launched the 'SciArt' funding programme in response to a growing field of artists embarking on new projects in conjunction with scientists (Glinkowski and Bamford 2009). Funding opportunities such as this were critical to the development of a community of practitioners who were at the forefront of a new form of interdisciplinary collaboration, leading to many examples of innovative creative work. The role of far-sighted programmes in fostering the development of experimental digital art has been a crucial element in the growth of inter-disciplinary collaboration is essential. Many of these initiatives are no longer active but nevertheless, the precedents were important in demonstrating the potential benefit for creative work.

We begin with a brief excursion into some of the initiatives in collaborative art and technology before going on to signal new developments in the field. The final part of the chapter includes a description of the studies and findings of the first phase COSTART research that was foundational to the first edition of this book (Candy and Edmonds 2002a, b).

Creative Collaboration: Research and Practice

Creative collaboration between individuals plays an important role in the generation of innovative ideas. Mamykina et al. (2002) note the challenges of interdisciplinary collaboration and a vital need to facilitate a better exchange of creative ideas

between disciplines. Creative work can be very rewarding when it is performed in a social context where two or more individuals collaborate and contribute to the work (Csikszentmihályi 1996; Fischer et al. 2005). As opportunities were increased by the advent of personal computers, collaborative work grew significantly. In the 1990s, initiatives for art-technology collaboration were rather thin on the ground: the PAIR project at XeroxPARC California was a notable exception. PAIR developed an organisational strategy intended to encourage innovation (Harris 1999) and similarly that goal was implicit in the UK's EPRSC's IT programme that funded research on collaboration at the Creativity and Cognition Research Studios (C&CRS). C&CRS was a joint venture between the Art and Design and Computer Science at Loughborough University. The aim was to make art practice the central focus of the work and to give artists a primary voice. It provided an environment where artists and technologists could work in collaboration on art projects. A specific objective was to facilitate the co-evolution of art works and technological innovations from which the 'studio as laboratory' concept as described in Edmonds et al. (2005) evolved.

Research that springs from a need to know more about what happens in practice so as to be able to design better computer support systems for creativity has provided valuable insights into the nature of creative collaboration (Candy and Edmonds 2002a, b, 2003). In the initial artist residency projects and subsequent research in the COSTART project, the primary attention was focused upon realizing the concepts as material artefacts and evaluating them within the closed studio environment. There was, however, a wider audience and open public context to consider and this was addressed when the Creativity and Cognition Studios Sydney (CCS) was formed in 2003 based upon the lessons of the UK research. What followed was an attempt to embed practice and research in 'real world' environments by establishing Beta_Space at the Powerhouse Museum (now Museum of Applied Arts and Sciences) in Sydney in 2004, when the studio concept was extended and reimagined as a 'living laboratory' (Muller and Edmonds 2006). The notion that a museum could act as a working, studio, site for artists, curators, and the audience to collaborate was first publicly articulated by Alfred Barr:

> The museum of modern art. Art is a laboratory; in its experiments, the public is invited to participate. (Barr 1939)

At Beta_Space creative practitioners were able to develop artistic ideas and create new digital forms and at the same time assess audience experiences in a real live exhibition context. This unique venture blurred the distinction between production and presentation through an iterative approach to creating and displaying art works. The space was an exercise in establishing a new type of programme, one that became a model for partnership within the museum (Muller and Edmonds 2006; Turnbull and Connell 2011).

Concurrent with the Beta_Space initiative, systematic research was carried out via the CCS post graduate research programme, examples of which are reported in Candy and Edmonds (2011). A frame of reference for practice-based research

methodologies and discussion of Ph.D. programmes in advancing research and practice in art and technology is also presented (Candy 2011).

Opportunities for art and technology collaboration continue to flourish in many countries and are increasingly normal within the digital art world. Whilst creative work is ongoing and organisations and networks are being supported by funding initiatives, especially in Europe, our knowledge of what makes collaboration work well in such contexts remains limited. There are lessons from anecdotal evidence to be sure but we need to achieve more than a superficial understanding of the attributes and skills needed across a wide range of creative activities. Studies of collaboration in art and technology are nowadays more often to be found in practice-based research programmes carried out by the practitioners themselves than in larger research projects. Nevertheless, these studies by artists and technologists provide valuable insights into how collaboration can contribute to long term partnerships: see for example, Rowe (2015).

The initiatives and studies referred to above have added to our understanding of inter-disciplinary collaboration. Each successive generation of artists is exploring the many ways in which digital technologies may be introduced into their practice. In the 1990s, not only were artists largely unfamiliar with the latest technologies, what was available at that time was very primitive in comparison with what became available in later years. The problem was that technologists did not always understand the needs of art and artists did not understand fully what the digital possibilities might offer. Bringing artists together with computer scientists was an adventure that involved the risk of complete incomprehension on both sides. A critical question was whether people from such disparate backgrounds and experiences would be able to communicate with one another sufficiently well to make the collaboration successful. Examples of research into communication in collaborative work is presented below. For a more comprehensive set of recent research studies see Candy and Ferguson (2014).

Communication for Collaboration

Collaboration refers to the process where several individuals work together towards the realisation of a shared goal. On the other hand, communication refers to the specific process of sharing and transferring information, ideas and knowledge. Communication is a critical component that conditions the outcomes of collaboration but good communication can at times be difficult. Challenges can vary whether the collaboration occurs within a Community of Practice (CoP) where there is a history of shared learning (Wenger 1998) or a Community of Interest (CoI) (Fischer and Ostwald 2003) where histories, skills and knowledge are very varied. Collaborative projects with teams of experts from different backgrounds and different skills, working together are instructive. In some creative industries, people who come from a similar background and collaborate can, nevertheless, have different working practices and bring different kinds of expertise to the process.

For example, in the context of film scoring, whilst composers and filmmakers are part of the same movie industry, they have different educational backgrounds and specialist skills that heavily influence the way they work creatively and determine the terms of reference used, i.e. the technical jargon of the given field. Julien Phalip's research into collaboration between a film director and a composer showed how practitioners overcome potential hurdles arising from such collaboration and the kinds of strategies that work well in these situations. Phalip's aim was to establish an understanding of how to establish common ground within a community of interest, and in doing so to match the efficiency in communication that communities of practice benefit from their shared history (Phalip 2011).

Yun Zhang studied collaborative styles of an interactive art team building on the foundation work of the COSTART project. Her approach was to carry out an observational and 'non-participative' study of how creative ideas were developed and implemented and provides an understanding of the communication patterns between people with different kinds of expertise and roles in the process. She identified five communication modes in three different forms (Zhang and Candy 2006, 2007; Zhang 2011). It was found that the technologists' contribution to creative ideas extended across all the different modes, but when it came to 'computer or interactive tool mediated' mode, they led the conversation more often than the other types of mediation.

We can continue to learn from previous research about the attributes and skills needed for inter-disciplinary collaboration that provided the foundations for the studies referred to above. In the following sections, we return to the art-technology residency studies that first informed this book. The methodology and findings are described with reference to more detailed source material and other articles that document the research. There have been some minor changes from the first edition but the substance remains as it first appeared in the edition of 2002.

Studying Interdisciplinary Collaboration

Art and technology projects provide an opportunity to try to understand just what the ingredients of successful creative collaborations are. This section describes some of the characteristics of collaborative work that were identified from the COSTART residency studies. Here we examine the way the information was collected and analysed followed by a discussion of some implications for collaborative creativity. We concluded that the idea of providing supportive environments for art and technology needs to be broadened to encompass the establishment of ongoing collaborative relationships that are fostered by the organization.

How can we study art and technology collaboration? How can we learn what is appropriate in terms of the environment of expertise and technology? How can we identify the requirements for new computer systems or environments? These questions require a research process that can address the complexities of collaborative creative practice in art and technology. A theoretical framework provides a

route map for directing the overall aims and objectives of any research activity. For gathering information about events and experiences of real practice, appropriate methods are needed.

The question that follows from this is what are the most effective methods for studying artists working collaboratively with technologists? Artists are very individual and unpredictable in many ways. They are also inclined to be very strong-willed in the pursuit of their art and, therefore, not likely to welcome being treated as subjects in standard laboratory experimental situations. In truth, scientists and technologists are no different, it is just that they are often involved on the other side of the fence as the investigators. The methods to be used need to take account of the particular circumstances of the people involved. In research into human activities, controlled laboratory conditions are not achievable without sacrificing the context that gives them meaning. There are rich layers of meaning which are relevant to the description and interpretation of what is happening. When studies of creativity are carried out, the real-world context is an important consideration.

A starting point is to establish situations that makes it possible to ascertain the artists' needs and expectations, not only in terms of technology required, but also access to the skills and knowledge of other experts. The requirements gathering exercise is an ongoing process that informs the acquisition of new technology and access to the technical expertise. The way forward was to organize a series of artist-in-residency programmes and once in place to conduct case studies of creative projects in actual development situations as described in Chapter 'A Million Millennial Medicis' previously.

The Artist Residency Research Process

Art and technology projects provide an opportunity to try to understand just what the ingredients of successful creative collaborations are. One of the research questions that was posed was how to identify the support requirements for art and technology collaborative projects. This chapter describes some of the characteristics of collaborative work that were identified from the COSTART residency studies. In this chapter, we examine the way the information was analysed and the results of that exercise followed by a discussion of some implications for collaborative creativity. We conclude that the notion of 'support' for art and technology needs to be broadened to encompass the establishment of ongoing collaborative relationships that are fostered by the organization.

The research process begins with the collection of many types of information about the activities, exchanges and outcomes of the art-technology residency projects. This is recorded, compiled and structured in transcription records and case study reports. This provides primary evidence for the extraction of features and the allocation of feature values. The results of this exercise may be applied to individual case studies which are then compared. Figure 1 is overview of the process.

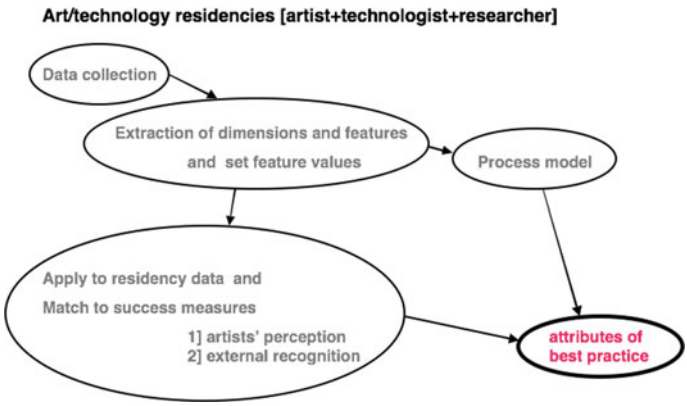

Fig. 1 The research process

Analysis Framework

The analysis framework and the mechanisms used to evaluate the art-technology collaborations are presented below. The information was compiled and structured in transcription records and case study reports which could then be analysed by different researchers. This provided the primary evidence for the extraction of features and the allocation of feature values or descriptors of collaboration. This was carried out by two researchers who arrived separately at an independent assessment. Textual data can be subjected to various forms of analysis. The one used in this case was as follows:

- The first pass over the case study texts looked for features of collaborative behaviour that relate to an existing theoretical model of creativity including cognitive style, communication, knowledge (Candy 1997).
- Values were then attached to the features: e.g. feature is, for example, approach: values are exploratory, open-ended, goal-driven, etc.
- The second pass over the texts assigned values to features for each case study
- The results for all cases were tabulated and compared (see Tables 1 and 2).

Table 1 shows the values selected for a single collaboration by each researcher. The degree of agreement is exact for two features (approach and role) and close for three (ethic, control, methods). This pattern of agreement occurred also in the Communication and Knowledge features. Further discussion of the features of creative collaboration can be found later on in this chapter. To complete the explanation of how the data was analysed, we show how each case study was compared.

Table 1 Features with values for case study 7

Cognitive style feature	Value selected-res. 1	Value selected-res. 2	Values not selected
Approach	Exploratory	Exploratory	Goal-driven
Role	Different	Different	Same/ interchangeable
Ethic	Art-Led	Neither/both	Technology-led
Control	Important	Necessary	Optional
Methods	Digital	Mixture	Traditional

Table 2 Comparison of features for all cases

Case Studies	CS1	CS2	CS3	CS4	CS5	CS6	CS7	Result ALL	Result FULL
Cognitive Style									
APPROACH									
Exploratory	***			***			***	3/7	2/3
Goal Driven		***	***		***	***		4/7	1/3
ROLE									
Different	***	***	***			***	***	5/7	3/3
Interchangeable				***	***			2/7	
Same									
ETHIC									
Art-led	***	***		***		***	***	5/7	3/3
Tech-led									
Neither/Both			***		***			2/7	
CONTROL									
Important		***	***		***		***	4/7	2/3
Necessary	***			***				2/7	1/3
Optional						***		1/7	
METHODS									
Digital	***					***		2/7	1/3
Mixture		***	***	***	***		***	5/7	2/3
Evaluation									
Viewpoint (V)	V	V	++	V	++	++	V	**4/7**	
Outcomes (O)	O	O	++	++	O	++	O	**4/7**	
V + O	V/O	V/O	++	++	++	++	V/O	**3/7**	

Comparisons Across Case Studies

In order to characterize the different collaborations, the case study data was examined for each of the above features and associated values. The researchers then compared results and compiled the features and values as tables. The results were

then compared (see Table 2). The next stage in the process was to evaluate each case study in terms of two success measures: subjective and objective. "Subjective" was defined as the perceived views of the participants in the collaboration as to whether it worked well or not. "Objective" was defined in terms of recognised outcomes (e.g. exhibitions, commissions, reviews as public demonstrations of the value coming from the work done).

Having identified which collaborations were successful or otherwise in terms of the two measures, it was then possible to look back at the features and descriptors for each case study and infer which was associated with success. By combining these with success measures, the quality of the collaboration was assessed. In three cases, the collaboration was assessed as successful both subjectively and objectively. These collaborations could be described as full partnerships and are shown in Table 2.

This exercise may be used in a number of ways. The results can provide a basis for generalizing the results in the form of models of collaboration (Candy and Edmonds 2002a, b). Such outcomes provide a method for evaluating collaborations in terms of best practice. The method we have presented here is being refined for future use in the ongoing research.

Collaboration involves, amongst other things, three key areas of participant activity: cognitive style, communication and the use of knowledge. For each of these types of activity, a set of features with associated descriptors was identified and values were ascribed to each collaboration.

Cognitive Style in Collaboration

In this section, we focus upon the cognitive style area of creativity and discuss the features we identified in the case studies. The term "cognitive style" is used here to denote the characteristics of thinking and making in the creative process as revealed in external behaviour and self-evaluation. Five main features of cognitive style were identified as follows:

- the approach used to carry out the project
- the role adopted by the participants
- the ethic adopted that drove the process
- the value placed upon level of control over the process
- whether the methods used were wholly digital or traditional media combined with digital ones

As an example of the approach used to carry out a project: an *exploratory* approach involves the generation of ideas, often from small details, in an iterative manner until a clear path is determined. The process may be tentative and opportunistic. By contrast a *goal driven* approach means setting a well-defined goal at the outset of a project and carrying it through with minor deviation only.

The notion of an art-led or technology-led "ethic" arose from observation of the different priorities given to domain-oriented concerns. For example, in the art-led case, the importance of audience awareness or personal engagement and, in the technology-led case, finding the right solution first time or using best fit technical solutions.

The following quotations are direct quotations from the participants in the research: the artists, technologists and observers. They provide viewpoints on which the evidence of the feature values of cognitive style, knowledge and communication are based.

Approach: Exploratory versus Goal-Oriented

"A's approach to her work, is very developmental and hands-on, which essentially means that whilst she has a rough idea of what she wants to achieve, her ideas constantly develop as she produces the work." (Observer)

"Sometimes I believe I've resolved the problem with A but the next time we talk it seems he meant something else. It seems difficult to impress upon him the need to look at the problem logically and be very specific. This is not his fault but the problem must be expressed in sequential logical terms." (Technologist)

Role: Complementary versus Different

"The main focus of the collaboration was on a personal level rather than a goal in that we talked together about various things on a very personal level and it became apparent that our interests were very complementary …." (Artist)

"The work with A has been extremely enjoyable. It was a feeling as if we were both working together at times, gently changing roles, where I would suggest to her something from an art point of view and she would suggest to me things from a technical point of view." (Technologist)

"This was a collaboration in which the participants had separate background concerns driving their own art practice that, in turn, informed the individual contributions and direction of the collaboration." (Observer)

Ethic: Art-*Led versus Technology-Led*

"T does not think like an animator." (Artist) "One of the main things I have found working with artists is their feeling that the resources are unlimited and bear no cost. I agree that they want high resolution for their work but with a little bit of technical understanding they could have the image they want and keep the cost down." (Technologist)

Control: Important versus Necessary

"Trying to adjust thinking to work more closely with programming … I want to make unexpected or unplanned patterns of animations but still control overall style. Discussed with T about the control that I could have over final work—Defining *all*

the images would limit the sense of unpredictable growth and 'unseen' images evolving." (Artist)

"T raises question, 'how much control do they want over the sound?' A. replies 'as much as necessary'. T says 'At the moment we've got absolute control over all the visual information … the reason that I wrote the code is that I wanted to have complete control over the sound which was why we had to go down to that low level'. (Technologist)

Methods: Traditional versus Digital

"Both were more comfortable with their preferred techniques and were not able to adopt the perspective of the other very easily. In this situation, a traditional animator wished to explore the possibilities of augmenting conventional techniques with computer-based ones for which purposes an expert in computer-based modelling was essential. This meant that the blending or migration of techniques such as a frame-based approach to a digital one proved impossible. At the heart of the problem, was a lack of a shared vision of what the end result should look like." (Observer)

These quotations are examples of viewpoints by artists, technologists and observers, taken from notes and log books, that were used to identify features of cognitive style for each art and technology collaboration. The same procedure was applied to communication style and the use of knowledge as shown in the following examples.

Communication *in* Collaboration

Six features of collaborative communication were identified as follows:

- whether openness of communication was adopted by both parties or was restricted to one or none;
- whether the relationship existed only for the residency or was ongoing; whether the language as demonstrated by terminology used, was shared or restricted to one or other individual;
- whether the exchanges took place in a continuous manner or only intermittently;
- whether there was mutual flexibility in respect of the way communication was used;
- whether the process of arriving at an agreement involved affirmation of each party towards one another or was an agreement to differ.

Examples related to the problem of not having a shared language are shown below. In the first, the technologist thinks he is using too much technical language and in the second, the artist needs more understanding of the software application's procedures for development. These form part of a lengthy series of exchanges

between the two collaborators during which they struggled to arrive at a common view of both requirements and software capability to achieve the artist's goals.

Shared Language

"We are now looking at lighting. I seem to understand what type of effect she wants with lights but I am not able to explain to her properly that lighting does not work in this software as she thinks it should. Maybe I am getting a bit too technical in my explanation." (Technologist)

"Having to re-do all drawing as once the objects have been manipulated, I cannot change the number of segments. This aspect of workflow is so important and it would be good to have had more of this pointed out as I am currently repeating tasks and I feel the process is getting messy. Maybe needed some more of the overall philosophy of the development process in relation to this particular software". (Artist)

Knowledge in Collaboration

The features of the use of knowledge in collaboration are concerned with:

- how each party to the collaboration acquired and used the knowledge required to carry out a specific task
- whether there was sufficient technical knowledge to achieve the tasks
- whether there was shared domain knowledge (art or technology)
- whether research proved necessary or not
- how critical the inter-dependence of the knowledge between the collaborators was to the success of the collaboration.

The quotations from the case reports that follow illustrate the features related to the artist's level of technical knowledge and the effect of this on the amount of support needed. A related feature was a need for further research despite an already high level of technical expertise on the part of the artist.

Technical Knowledge and Level of Support

"So far the initial idea that A would be a 'safe' artist to support is proving to be less simple than first thought. He has needed more constant presence to get started: O was drawn into it: he commented on lack of learning strategies." (Observer)

Need for Research and Learning

"In spite of the unusually high level of technological expertise in comparison with other artists taking part in the residency programme, particular gaps in the artists' knowledge about software and hardware meant that, on several occasions, they had to spend a great deal of time learning about the technology before they could make progress … some software required for the piece had to be learnt from scratch." (Observer)

Success Factors for Collaborative Creativity

The COSTART studies brought out several issues about the nature of art-technology co-creativity. In particular, we need to recognize that the artist may be seeking more than access to technology and expertise. Being able to develop a partnership, as distinct from having an "assistant" relationship was a significant plus point for the success of collaborative projects between artists and technologist.

Learning new skills and techniques is an important facilitator for creative practice. If the artist does not have the skills or the time to learn them, the role of a human collaborator is essential. Some artists may want to take full control of the reins of the technology because it is pivotal to the way they work whilst, for others a temporary need can be met by a technology assistant. However, technologists with little knowledge of art practice do not easily make good collaborators. Artists need collaborators who understand or are empathetic to their need to exercise control for themselves. Working through and with the eyes and hands of the person who provides technical expertise is not right for the core creative activities, although it might be acceptable for the more mundane ones.

Seeking a Partnership

One of the interesting things we observed was how much further the artists themselves wanted to extend the supportive relationship of their assistants. A significant number were looking for more than technical knowhow but rather were seeking a partner for an artistic exploration. For that to work, the assistants needed to engage more actively in the creative process and to resist imposing a standard technical solution. Likewise, the artists needed to be more open about their intentions and to be prepared to reveal tentative ideas that would normally remain hidden until they reached a more mature state.

Complementary Interests for Mutual Benefit

In a true partnership, complementary interests exist even where the outcomes by each individual may differ. Indeed, one of the most successful ongoing partnerships operates in such a way as to serve convergent interests but, at the same time, produces quite distinct artistic outcomes. In this way, the partners are able to achieve mutual benefit but, at the same time, retain ownership of their individual achievements. To be able to enjoy such mutual benefit, requires the relinquishing of individual control of the creative process: having differentiated but complementary roles appears to be best suited to achieving that end. Having a respect for differences in methods is also important to a successful partnership. The trick is for the

people concerned to be able to identify in what way their differences in approach can benefit one another.

Art-Led Versus Technology-Led Partnership

Where the partnership is perceived as art-led by both parties, this seems to lead to better collaboration. The technology-led situation, on the other hand, may place the non-technologist at a disadvantage both in terms of control of the creative process and the eventual outcomes. If the implications of adopting a particular technology solution are not fully understood by the artist, then it may not be possible to steer the direction of the work to suit, resulting in a loss of artistic control.

For the technologist, the disadvantage of a technology-led assistant model lies in a lack of ownership of the project. This may occur even as they are providing critical input to the process through such contributions as software programming design. Where the relationship is of the assistant type, it is more productive if the artist explicitly acknowledges the value of the technologist's contribution and actively tries to learn from it. In some cases, the danger of one-sidedness for the technologist may be overcome if the artistic problem to be solved provides a sufficiently interesting technical challenge.

Sharing Knowledge

An effective working relationship exists where both parties exchange knowledge resources in order to progress the work and resolve difficulties of both a technical and artistic nature. The sharing of knowledge is an important facilitator of creative collaboration. It also depends upon the parties having complementary skills rather than at the same level. A partnership that aims to be self-sufficient must also know its limits and be willing to carry out the necessary research when the knowledge is insufficient. Indeed, self-sufficiency in technical know-how, or at least the quest for it through research, can be in itself a stimulus to creative thought. Being able to learn through knowledge sharing is beneficial and it particularly applies where having direct contact with a new way of thinking stimulates the generation of options. In one such case, as the process of programming became clearer, the artist was able to understand more fully the basic logic. This enabled her to consider more carefully her options and how the aesthetics of the piece could operate.

Communication Skills

Naturally the ability to communicate well with others is an important part of the collaboration process, but art-technology collaborations have particular requirements. For successful partnerships, being able to have a longer-term relationship during which trust and confidence can be built up, has real advantage. A communication barrier may manifest itself in a whole variety of different situations, bringing with it frustrations and problems. For example, a high degree of openness and flexibility and a willingness to engage in discussion with one another in a whole-hearted manner, facilitates the partnership whereas a lack of flexibility may indicate that there are unspoken differences about the way the project is developing. Difficulty with the language of communication sometimes reflected a different way of thinking about the problem in hand and how to go about solving it. Developing a common language (particularly when discussing technical issues) that both parties can understand and work with is essential if anything useful is to be achieved. Where an "assistant" style of collaboration operated, there was more difficulty in finding a shared vocabulary.

Requirements for Art and Technology Collaboration

A major lesson that came out of the first residencies was to do with the concept of "support" itself. In responding to the demand from artists for technological facilities and expertise, the preparation for the residencies concentrated on two things:

- the technology: the required software packages and hardware devices needed to carry out the artists' projects
- people with the technical skills to enable the use of that technology.

For the technology, we had an established base of 'high-end' computing equipment, network facilities and a repertoire of office and drawing software as well as specialized packages for 3D modelling and a position sensing system. Where a specific piece of technology was needed, it was acquired for the purpose of the residency. Whilst a number of the artists had well-developed skills in the use of some technology, because the projects were set up with a view to exploring *new* digital forms, we anticipated the need for help from experts in the more advanced technology.

For the experts, we turned to a sizeable network of willing experts at the university. We envisaged artists driving the projects and technical people supporting the process in response to their requirements. This did happen, of course, and the programmers, in particular, found their skills were in twenty four hour demand for the duration of the residencies. The support provided was, in fact, never really enough but there was no doubt that the artists appreciated the time and commitment that was given. That said, support for specific activities such as programming or

digital video editing, was only part of the story. The idea of supportive environments for art and technology needs to be broadened to encompass the establishment of ongoing collaborative partnerships that are fostered by the organization.

A summary follows of a basic set of requirements for support for artists and desirable characteristics of technologists that can be viewed as essential for a successful partnership in this field. Further studies will explore these requirements and consider their relevance to other domains.

Artists need:

- heterogeneous resources for a broad range of needs
- access to high end facilities and tailored digital systems
- access to appropriate human expertise that is communicated well
- an ability to reflect and learn from technologists.

Technologists need:

- good communication skills as well as technical skills
- an ability to *listen* and learn from listening
- an ability to suppress the urge to promote a course of action that is technically feasible but not artistically valid.

Successful collaboration can be learned. Based upon the experience of this research, some basic requirements for sound and productive partnerships are:

- devise a shared language
- develop a common understanding of artistic intentions and vision
- engage in extensive discussions and "what if?" sessions
- give time to establish the relationship and recover from mistakes.

A number of artists have continued their association with the C&CRS and new people have joined. To be successful over time, creative partnerships needed appropriate organizational support. An environment for art and technology collaboration involves much more than the choice of which technologies and technical skills are needed, vital though that remains.

> The main support I observe artists needing is that of people support. It is not enough to have systems that artists can use, they need real contact with people who understand the technologies and that can effectively communicate with the artists. These people would be more than technicians. For the best results they would need to be sympathetic to the artists' concerns and not just interested in solving technical problems. (Artist)

Conclusions

Collaboration and artistic practice are not always easy bedfellows. The artist is sometimes perceived to be a 'difficult' person to work with because of the primacy of ownership of the artwork and an uncompromising concern for every detail.

Nevertheless, artists often seek partners to help them realise their artworks and, increasingly, collaboration with technologists has become pivotal for many. Even where artists have acquired some technological knowhow, there are many levels of expertise that require years of training and a high degree of aptitude to be effective, especially when it comes to accessing the latest techniques. This often poses a dilemma for artists who wish to retain complete authorial control over the design and making process. Using tools about which you have little understanding, can place the artist at a disadvantage when it comes to assessing whether or not you have what you were seeking. Getting the most out of having a partner to help you realise your intention, may depend heavily upon your ability to communicate what you want as well as the trust and openness that is between you. There are skills to collaboration and the success factors often depend upon people's willingness to acknowledge the contributions of others.

The results of the COSTART studies are relevant to our understanding of the nature of collaboration. Art-technology collaborations benefit from a partnership model of collaboration. The assistant or support model of collaboration is also needed but for different purposes. The quality of the type of collaboration can be assessed in terms of its durability and stimulus to creative thinking. It follows from all this that learning *how* to collaborate successfully is very important and cannot be assumed to be a natural to everyone. Of course, we can facilitate it by making the environmental conditions more than sufficient but we need to be more aware of the critical human issues at play. For any organizations wishing to promote collaborative creativity, attention should be paid to ways of developing learning strategies for successful collaboration. Referring to the longer-term nature of the personal creative process, Harold Cohen said:

> Creativity is not a random walk in a space of interesting possibilities, it is directed. The difficulty in tracking how the individual proceeds is that it is directed less by what the individual wants the single work to be than by what he wants his work as a whole to become. (Cohen 2002)

This implies supporting a sustained process. For sustainability to be possible in the context of digital creativity, that can only be achieved within an organizational context that is appropriate to a special kind of collaborative partnership. Therefore, understanding how good partnerships evolve and flourish is very important for developing creativity enhancing environments.

References

Barr AH (1939) Art in our time: the plan of the exhibition. In: Art in Our Time. Ayer Publishing, New York

Candy L (1997) Computers and creativity support: knowledge, visualization and collaboration. Knowl Based Syst 10(1):3–13

Candy L (2011) Research and creative practice. In: Candy L, Edmonds EA (eds) Interacting: art, research and the creative practitioner. Faringdon, UK, Libri Publishing Ltd. pp 33–59
Candy L, Edmonds EA (eds) (2002) Explorations. In: Art and technology. Springer, London
Candy L, Edmonds EA (2002) Modeling co-creativity in art and technology. In: Hewett TT, Kavanagh T (eds) Proceedings of the fourth international conference on creativity and cognition, ACM press, New York, pp 134–141
Candy L, Edmonds EA (2003) Collaborative expertise for creative technology design. In: Cross N, Edmonds EA (eds) Proceedings of expertise in design, design thinking research symposium 6, University of Technology, Sydney, November 2003, Creativity and Cognition Studios Press, pp 295–310
Candy L, Edmonds EA (2011) Interacting: art, research and the creative practitioner. Libri Publishing, Faringdon, UK
Candy L, Ferguson S (2014) Interactive experience in the digital age. Springer Cultural Computing Series, Springer
Cohen H (2002) A self-defining game for one player, special section on creativity and cognition. Leonardo 35(1):59–64
COSTART. http://research.it.uts.edu.au/creative/COSTART/overview.html. Accessed 28 May 2017
Creativity and Cognition Studios. https://www.creativityandcognition.com/about/. Accessed 28 May 2017
Csikszentmihályi M (1996) Creativity: flow and the psychology of discovery and invention. Harper Perennial, New York
Edmonds EA, Candy L, Fell M, Pauletto S, Weakley A (2005) The studio as laboratory: combining creative practice and digital technology research. Int J Hum Comput Stud 63 (4):452–481 (Special Issue on Creativity and Computational Support)
Fischer G, Ostwald J (2003) Knowledge communication in design communities. In Bromme R, Hesse FW, Spada H (eds) Barriers and biases in computer-mediated knowledge communication. Kluwer Academic Publishers, pp 213–242
Fischer G, Giaccardi E, Eden H, Sugimoto M, Ye Y (2005) Beyond binary choices: integrating individual and social creativity. Int J Hum Comput Stud 63:482–512
Glinkowski P, Bamford A (2009) Insight and exchange: an evaluation of the Wellcome Trust's Sciart Programme London. Wellcome Trust. www.wellcome.ac.uk/sciartevaluation. Accessed 28 May 2017
Harris C (ed) (1999) Art and innovation: the xerox PARC artist-in-residence program. MIT Press, Cambridge, MA
Mamykina L, Candy L, Edmonds EA (2002) Collaborative creativity. Communications of the ACM Special Section on Creativity and Interface, vol 45, no 10, pp 96–99
Muller L, Edmonds EA (2006) Living laboratories: making and curating interactive art. In: SIGGRAPH 2006 electronic art and animation catalog. ACM Press, New York, pp 160–163
Phalip J (2011) Creative communication in film scoring. Interacting: art, research and the creative practitioner. Libri Publishing, Faringdon, UK, pp 136–149
Rowe A (2015) Immersion in mixed reality spaces. Ph.D. Thesis published by The Oslo School of Architecture
Turnbull D, Connell M (2011) Prototyping places: the Museum. Interacting: art, research and the creative practitioner. Libri Publishing, Faringdon, UK, pp 79–93
Wenger E (1998) Communities of practice: learning, meaning and identity. Cambridge University Press
Zhang Y (2011) Investigating collaboration in art and technology. Interacting: art, research and the creative practitioner. Libri Publishing, Faringdon, UK, pp 122–135

Zhang Y, Candy L (2006) Investigating collaboration in art and technology. Co-Design: International Journal of Co Creation in Design and the Arts, Interactive Art Collaboration (Special Edition), vol 2, no 4, pp 239–248

Zhang Y, Candy L (2007) An in-depth case study of art-technology collaboration. In: Proceedings of creativity and cognition 2007. ACM Press, New York, pp 53–62