The STEAM Journal

Volume 4
Issue 2 *The Specimen of 2020*

Article 19

December 2020

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STEAM is a bi-annual journal published by the Claremont Colleges Library | ISSN 2327-2074 | http://scholarship.claremont.edu/steam

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Abstract

This research paper explores drawing as a tool to facilitate interdisciplinary practice. Outlined is the personal experience of PhD researcher [name removed] in their physics/craft research project, combined with thoughts and opinions from collaborators gathered through group discursive interviews. Interdisciplinary projects face interpersonal and conceptually ambiguous challenges which can be addressed through adopting drawing techniques for educational purposes. Findings highlight that drawing can assist across a breadth of applications as a learning tool for everyone, regardless of drawing ability, to improve the functionality of collaborative projects. Specifically, drawing combined with other communication techniques develops a performative communicative approach that enriches interaction and empathy between participants. However, challenges exist around inclusion between individuals from different disciplines when adopting drawing as an integrated practice. Overcoming deep-seated beliefs and perceptions of what drawing is facilitates efficient problem-solving in a research context. Examples made in this report signify the benefits of drawing without concern for the quality of drawn renders when the purpose is to share ideas and develop processes. The paper advocates that drawing practice has the potential to build empathy and develop stronger interpersonal relationships between those from different disciplines where verbal barriers exist - a key asset to interdisciplinary practice.

Keywords

Craft, Physics, Drawing, Holistic learning, Communication, Information literacy, Knowledge exchange

Cover Page Footnote

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Funding: The research leading to these results received funding from The Engineering and Physical Sciences Research Council (EPSRC) under Grant Agreement No. 2010116 Conflicts of interest/Competing interests: The authors have no relevant financial or non-financial interests to disclose. Ethics Approval: UOD-DJCAD-2019-0165 Authors' contributions: Principal Author: Karen Westland. Supervision: Dr. Keith Wilcox, Prof. Sandra Wilson. All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Karen Westland. The first draft of the manuscript was written by Karen Westland and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Introduction: Amalgamating Disciplines Through Pen & Cursor

Drawing to learn and educate in the scientific field varies wildly beyond traditional textbook illustrations: from projective techniques such as the Rorschach test, to scientific comics and the exploratory renditions of Leonardo da Vinci. Drawing has been utilised as a tool to record data (essential before photography was invented), to problem solve, communicate and has been a beneficial practice for the sciences generally. However, how is drawing utilised today to facilitate innovative practice in scientific and creative collaboration? The following is a case study of drawing as a learning tool in an interdisciplinary research project between physics and craft. The data outlined here is drawn from silversmith, [name removed] PhD research whereby custom optics were being fabricated to improve the efficiency of a solar laser, and tools within physics were tested for their potential in sustainable craft practice. This research was intended to be a collaboration for mutual benefit between the disciplines, with the over-arching theme of sustainable outcomes as a common link. The collaborative process has been recorded throughout, to gather insights into the benefits and challenges of knowledge exchange in interdisciplinary projects such as this.

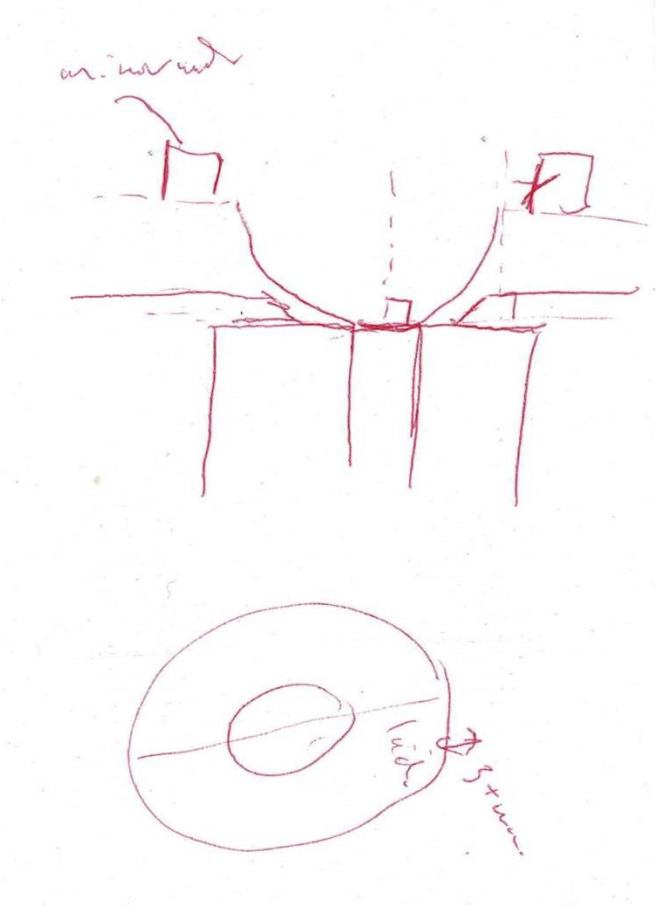

Fig. 1 *Cross-sectional sketch indicating how a CPC will be positioned against the laser chamber*

This paper focuses on three key areas in drawing related to my experimental research, with reference to related literature. Firstly, I will highlight how and why drawing became an educational tool that underpinned the research through my own observations. Secondly, I outline findings from a series of group interviews conducted with collaborators involved in the project, to reflect on different modes of knowledge exchange including drawing, in collaborative contexts. Thirdly, I explore the conceptions and perceptions of drawing in collaborative projects. Lastly, I conclude by highlighting insights from this project to summarize the use of drawing in physics and craft practice for interdisciplinary and collaborative functions.

This paper outlines my personal account and reflection through the experimental research project in response to drawing as a learning tool. It is intended that this

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contribution is seen as a case study of drawing in interdisciplinary research, as many elements are subjective for the individuals involved. The aim here is to explore the research to gain insights into the current need for drawing within collaborative projects and how one might learn from the observations and insights gathered to inform future collaborations.

The Curious Role of Crude Drawing

Here, I will highlight why drawing became an educational tool that underpinned the research through my own observations. I first learnt about the science contextualising my project through performative activities: physicists drew while gesturing and verbally explaining a law of physics, process or experiment. As many of the topics discussed involved motion - through explaining four-level lasers for example - it was key for these to be drawn and explained in stages within the same diagrammatic drawing. Supplementary drawings of photons would also be doodled to help visualize the same concept from different perspectives. These drawings in themselves are ambiguous unless you were present during their creation (See Fig. 1). The drawings were animated by the creator on their terms: they chose how accurate and detailed to render their vision and chose to pause to emphasize a point before continuing the drawing and explanation (Carlson, 2017). Although these drawings are technically inaccurate and lack detail, they are drawing-based models (Heijnes et al., 2017) that act as a great record of discussion and can later act as visual aids to stimulate one's memory back to the time of creation and the verbal discussion which occurred. As the discussion prompted the use of drawing, standard ball-point pens and scrap paper or white boards were used as it was a responsive form of communication rather than a planned activity. This performative mode of drawing as a vehicle to convey theory brought great depth to my understanding by comparison to a static diagram in a textbook. For example, the sketch in Figure 1 was created by my supervisor as I had asked how the solar concentrator I was fabricating would be mounted into the laser system. The simplistic cross-section clearly outlined the key priority: to have a step at the exit aperture to allow it to be positioned parallel and flush against the laser chamber. The repeated square symbols drawn emphasised the right-angled positioning required for optimisation. Without this drawing it would have been difficult for me to discern how much material to remove to form the step, whereas the sketch defines that approximately 0.5mm - 1mm of material is required before the step-in is created. The drawing brought scale to the fore without needing to ask or imagine what this might be. This example runs parallel with the theory of drawing as a research tool (Makela, et al., 2014) but in this case drawing aids the teaching of physics rather than design. This learning process offered a space for the physicists to actively educate me in new concepts, incorporate their personality into the process with light hearted jokes, and allowed them to receive instant feedback to clearly gauge how much I had understood and could then clarify any confusion immediately. This experience highlights the benefits drawing as a communicative learning tool has and the additional social benefits that taking the time to illustrate a design can have.

There appears to be two clear types of drawing adopted in physics research: drawing to explore, document, track progress and communicate freely (See Fig. 2a) to benefit those involved (Gentes et al., 2017; and Schon, 1991), and drawing data visualizations to communicate a factual narrative that follow strict principles (See Fig. 2b) (Rougier, N. P., et al. 2014; and Tufte, 2001). In this research, drawing formed a foundation upon which physicists' explained

photonics concepts and aided my storytelling of manufacturing narratives (See Fig. 2) to bridge disparity of knowledge within the collaboration. Drawing, like the other modes of communication mentioned in this multilingual approach, were subservient to the narrative in this collaborative context.

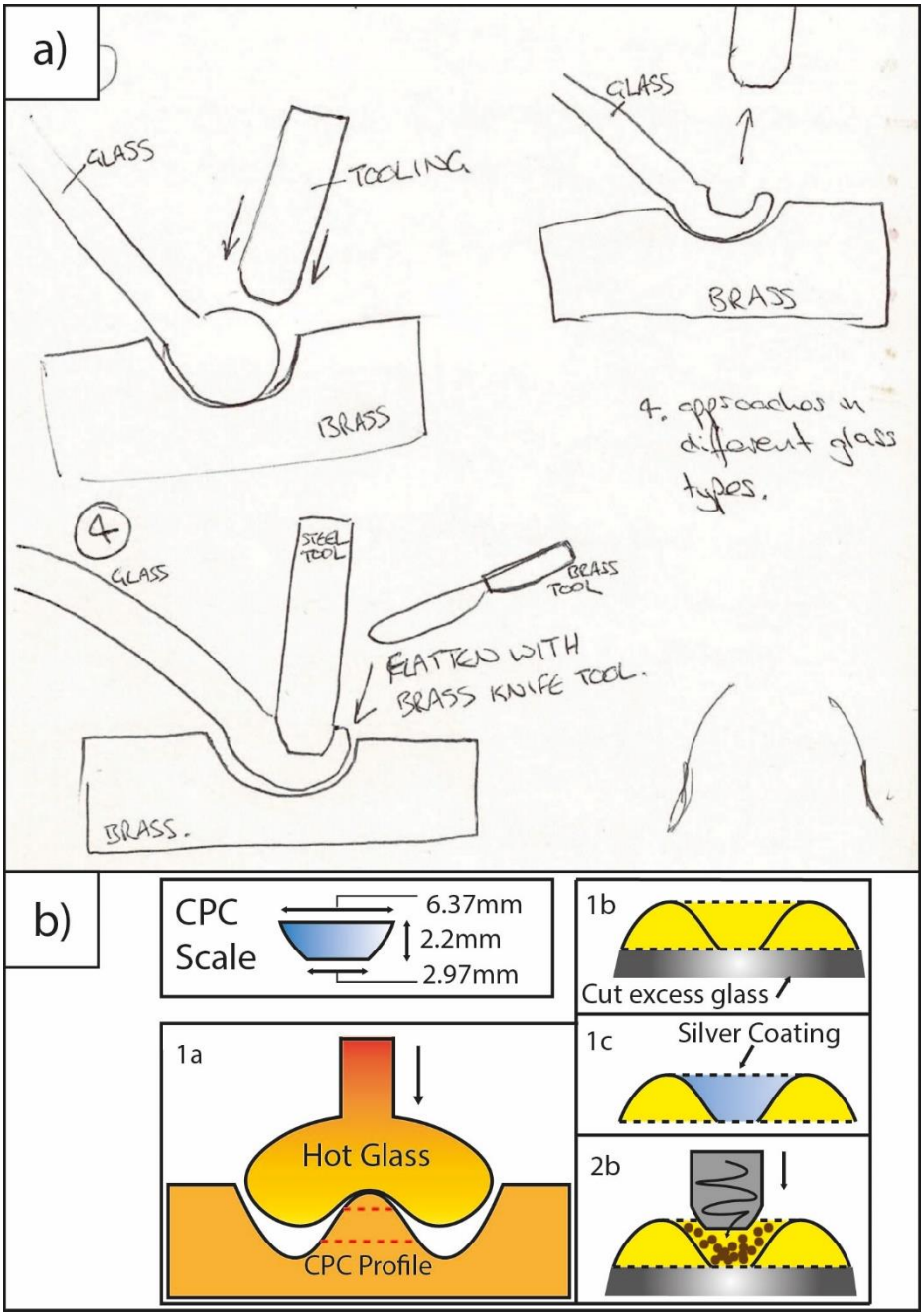

Fig. 2 *a) Sketch with notations for an improvised lampworking technique. b) Scientific visualisation of cross-sectional flow diagram outlining developed glass process (caption would be used to explain steps in scientific paper)*

Insights Drawn from Interdisciplinary Group Interviews

Moving on, this section will outline findings from a series of group interviews related to drawing in collaborative projects. An aim of this research was to better understand the nature of interdisciplinary research projects, by gathering insights through discussions with eleven experienced members of technical and academic staff from the disciplines of physics,

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engineering, design, craft and further afield at the [institution name removed] to form a case study. Three questions were discussed over the course of an hour which allowed the interviewees to express their thoughts and feelings on interdisciplinary research. These questions were:

1. What are the benefits of disciplinary collaboration?
2. How can different disciplines communicate better with each other?
3. What could realistic goals for interdisciplinary research be?

Below I have outlined points made during the interviews which specifically referred to drawing in interdisciplinary projects.

It was discussed that visually combining different disciplinary perspectives may help distil information and clarify what everyone essentially needs to know, in terms that everyone can understand. Sketching was believed to be key at the discussion stage since it is a medium open to change and can be a useful process to discover new knowledge. Verbal language between disciplines was considered a barrier, particularly with the precision involved in scientific definitions: it takes time to build verbal empathy, yet an image has an immediacy and communicates more effectively in many cases. Drawing was thought to fill the space between individuals as you can check if your vision is the same or similar.

Continuing with the idea of simplicity, interviewees considered organising group meetings to include pens, paper, what's in your head and no distractions as an effective way to focus on a practical task. A point was made to be mindful in group scenarios that the 'best draftsman' does not become the sole participant, particularly in discussions where everyone has valuable ideas to convey. It was highlighted that recognition needs to be developed in knowing that anyone can draw in interdisciplinary contexts and that we are not void of such an ability (Landin, 2015). There was a noted challenge when individuals refuse to sketch by hand and simply want to convey a design idea verbally or as a 3D CAD render as their vision is difficult for others to grasp. Some interviewees mentioned that taking a basic approach to drawing is often most effective: whether drawing a ray diagram in physics (See Fig. 3) or a technical drawing in design, it is easier working on a practical/tangible illustration than something entirely conceptual. Lastly, participants noted that sharing your work-in-progress will allow others to gain insight into what you are doing as a leader or contributor of an interdisciplinary project to raise issues early in development.

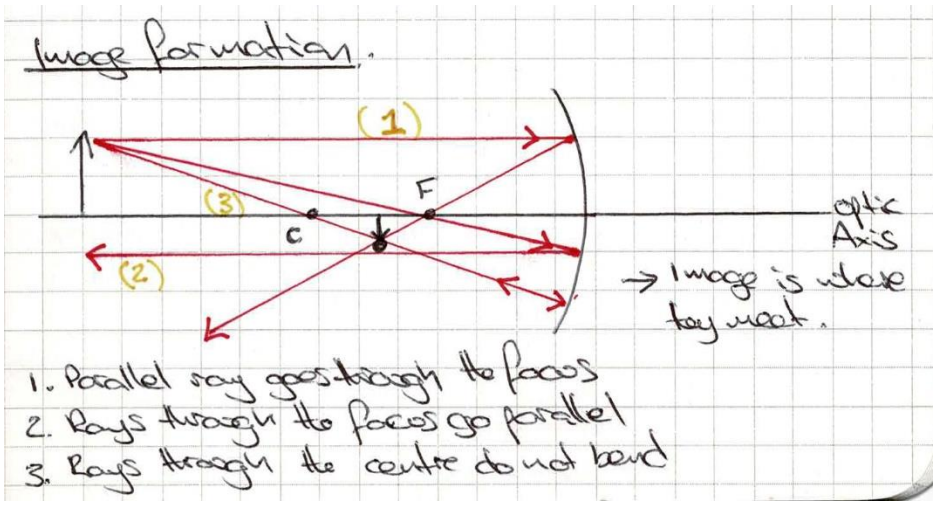

Fig. 3 *Hand Drawn Ray Diagram*

From the data gathered during the interviews, I surmise that drawing is an incredibly useful visual aid to clarify ideas and communicate information across disciplines, particularly when discussing physical objects to be fabricated. The immediacy of drawing was preferred among the interviewees to using digital technologies when engaging with others to problem solve. Perceptions surrounding the value of drawing and interpersonal relationships when drawing in a group context can be a challenge with the multitude of subconscious factors influencing the situation. There is a case to go back to basics with drawing to recognise its fundamental benefits in establishing an idea for all to see and provide feedback on without care for the quality of drawing, as long as it has served its function.

Conceptions and Perceptions of the Drawing Narrative

Lastly, I explore the conceptions and perceptions of drawing in the collaborative context further and the impact this has on the process. During the project, I had several physicists apologise as they sketched an idea because they perceived their drawing as somehow inadequate. Embarrassment or shame in our perceived ability to draw is a large factor negatively impacting drawing for the purpose of discussion. Another conception is that artists and designers ‘can’ or ‘should’ render beautiful drawings, which again detracts from the aim of sharing ideas through drawing (McDermott, J., 2018) and instead becomes a situation where some fear judgement. As mentioned in the interviews, individuals may choose to exclude themselves from drawing scenarios altogether or encourage others to take charge in group drawing to allow them to take a more passive role. This suggests that creating an environment in which everyone from diverse fields collectively feel at ease to draw would improve collaborative knowledge exchange. It is not solely the individual at fault if they are not comfortable to draw, but instead needs to be a collective conscientious responsibility.

To expand on the discomfort experienced around drawing activities, there are a multitude of factors that could be influencing the level of interaction. Those who consider design and drawing to prioritise aesthetics leaves artists and designers undervalued in their offering and limits the imagination of how drawing can aid research enquiry in other disciplines (Brown, T., 2009). Design is not simply an ‘add on’ service to make things pretty (Driver et al., 2011) as seen in Figure 4. To elaborate on the points above, the first sketch was drawn in the laser lab while discussing the design parameters for a new laser chamber with my supervisor. We were measuring old laser chambers and optics mounts to develop a new mounting configuration. Key changes made were scribbled down for the purpose of building a 3D model which was later checked for any inaccuracies. The drawing served as a crucial tool to record measurements and problem solve through the various design limitations we faced. This particular task had no aesthetic consideraton, making a great example of the employment of creative problem solving through drawing in a technical context. Here drawing created a safe space where we were both able to explore and contribute towards the challenges faced with confidence in our drawing skill to serve as a collaborative tool.

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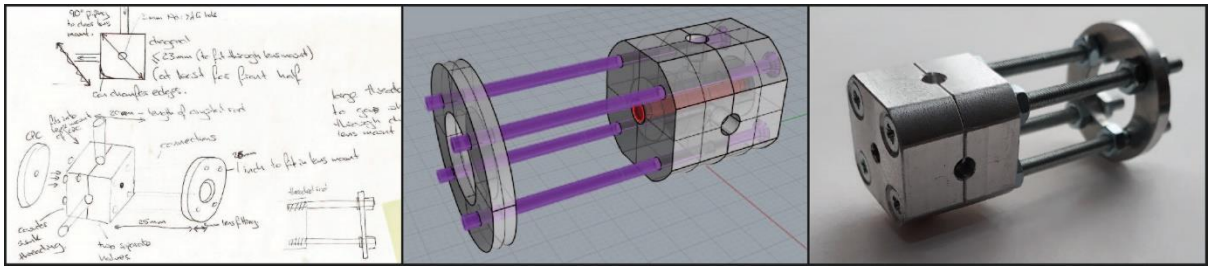

Fig. 4 *Laser chamber design developed through collaboration with physics academics and technicians: sketch, CAD & machined parts*

It is necessary to be vulnerable and interact in creating drawings to facilitate the sharing of narratives between disciplines with common interests (Kovats, T., 2014). Furthermore, Garner (2012) states that as society changes and influences drawing, our understanding and values associated with drawing too will change. This stresses our need to adapt as we move into cross-disciplinary projects and acknowledges digital and hand drawing as valid methods in storytelling.

Here, issues have arisen around the perceived stigma of 'bad drawing' which can hinder the objective of sharing ideas visually for knowledge exchange. To collaborate through drawing, an awareness for the personalities involved, any power imbalance and perceptions about the activity itself are necessary to build empathy between participants to grow together and draw in the middle-ground between people and disciplines. In some cases, re-learning what drawing is and the functional benefits of drawing in research may ease social tensions surrounding this universal educational tool.

Discussion & Conclusion

This report has highlighted my personal account and interview feedback from project collaborators of the value of drawing in an interdisciplinary research project between physics and craft. There has been a clear emphasis on the use of drawing in the learning and development process as an informal activity to communicate ideas to break through interpersonal and verbal literacy barriers. The act of sketching has reduced the margin for misinterpretation as the project is visible to respond to in an engaging way. However, drawing was not employed in isolation: a holistic approach was naturally adopted, combining different methods of communication to express ideas. In contrast, drawing can also exacerbate interpersonal tension if an individual is reluctant to draw. This can negatively impact group projects as it is a challenge to share knowledge if key communication and learning tools are not utilised. This highlights the need to reinforce the idea that drawing in this context is regarded as neither a qualitative or quantitative outcome, and therefore does not need to have pressure applied to the activity. The reflections gathered here could be investigated further: for example, to compare different drawing approaches and to evaluate the impact of the drawings within the context of interdisciplinary research.

To conclude, interdisciplinary collaboration is an opportunity to share ideas and methods to innovate and creatively solve problems. There are an array of benefits including finding new product markets, tackling challenges no discipline can solve alone and to build awareness and empathy that can inform practice. Drawing is a tool through which we can share our narratives

and explain a process or idea visually, which helps break down the barrier of information literacy between disciplines and ultimately build strong collaborative relationships. Drawing in the collaborative context, allows everyone to make their vision tangible and provides a focus to discussion and development. Realistic goals for interdisciplinary collaboration in relation to drawing would be to focus on building the human relationships in the project through drawing and discussing drawing as an empowering tool to underpin the project. Developing an awareness of the malleability of drawing and how it can be integrated into unique interdisciplinary projects will undoubtedly improve the collaborative experience and quality of outcomes in future projects.

List of Illustrations

- Figure 1: Cross-sectional sketch indicating how a CPC will be positioned against the laser chamber.
- Figure 2: a) Sketch with notations for an improvised lampworking technique. b) Scientific visualisation of cross-sectional flow diagram outlining developed glass process (caption would be used to explain steps in scientific paper).
- Figure 3: Hand Drawn Ray Diagram.
- Figure 4: Laser chamber design developed through collaboration with physics academics and technicians: sketch, CAD & machined parts.

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