Making sense:
The value of making as a research methodology with reference to the development of solid state diffusion bonded Damascus steel

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ABSTRACT
This paper puts into context a continuing investigation into the development of solid state diffusion bonded Damascus steel within discussion on practice based methodologies in design and applied arts research. It identifies the role and value of craft making as a research method; integrating research problems and results of other methods to literally 'make sense'.

The project is being conducted at the interface between 'hard' scientific and 'soft' practice based research within the field of metalwork and jewellery research. It demonstrates how the use of differing approaches to validate each other and how using the two types of methodology, strengthens the overall investigation. This study uses a multi-method approach to the research. Although carried out mainly within a craft context, the investigation is highly metallurgical in subject matter, which is reflected in the methodological approach.

Introduction

This paper explores an approach to a practice based investigation. This investigation utilises an image of research outlined by Sir Christopher Frayling in 1993 and also employs ideas from Donald A Schon's 'Reflective Practitioner' (1983). The original theories of both Frayling and Schon will be discussed and how these theories relate to this practice will be demonstrated through examples and illustrations.

The nature of the researcher's work as a practitioner has lead to the research being constructed using a multi-method model with both quantitative and qualitative data been sought. The two strands are used to reinforce each other to validate the findings and 'ground' the research in workshop practice.

Background

Solid state diffusion bonding is a proven technology, frequently used in industry, but this research sets out to use it in a different way and document how a product of this technology might be of use to a craft knife maker. It builds on the research done by Ian Ferguson in his thesis on solid state diffusion bonded Mokume Gane. Although

Damascus steel has enjoyed a resurgence of interest in the last 20 years, mainly due to knifemakers, very little has changed with the technique of manufacture.

One of the important features of diffusion bonding is the ability to bond metals with very dissimilar properties. Hot pressure solid state diffusion bonding avoids many of the limitations of other production methods.

The diffusion bonding of dissimilar metals, both ferrous and non-ferrous, is well established as a successful industrial technique[1] for example, welding in high performance aerospace applications. One of the aims of this study is to develop laminated metal suitable for applications within a custom knifemaking context. Even the most limited results could be used for decorative purposes but with a tightly controlled reactive testing procedure it is anticipated that laminated metal suitable for structural and mechanical uses will be made.

Aims and objectives of the research

- Examine the role of Damascus steel within contemporary knife making, establishing its creative and technical relationship within contemporary custom knife making practice.

- Assess the feasibility of Damascus steel production using solid state diffusion bonding and use of the resulting material by knifemakers.

- Conduct practical experiments that explore solid state diffusion bonded Damascus steel.

- Assess the acceptability of the resulting material by knife makers and other contemporary craft people.

- Produce a thesis that documents the results of the academic research and methodological approaches taken during the course of study.

- Produce an exhibition of work made by knifemakers as a reaction to the non-traditional Damascus steel.

Work to date

The work to date is to establish the feasibility of using solid state diffusion bonded techniques for the manufacture of Damascus steel.

The first part of the investigation was a literature review designed to establish definitions and highlight potential areas of investigation. It has also enabled me to review work, both historical and contemporary, that has been done in this field.

The second part of the process was built upon Dr Ian Ferguson's research on Mokume Gane. Small-scale tests were performed to confirm suitability of materials, facilities and technique. These tests also enabled bonding parameters and access to heat-treating and rolling facilities to be established.

During this process, testing parameters and protocol were established and assessed for suitability. Arrangements were made for some testing of the samples to be performed by CATRA to ensure that industry standards were met.

The third part of the study involves a selected group of knifemakers exploring and experimenting with the most promising laminates in a workshop setting. Data gathered during this 'live' testing stage would add validity to the quantitative data and increase the understanding of the new material.

Application of theory to research

In 1993, Sir Christopher Frayling outlines three distinct possibilities for the role of research and art and design; research ***into*** art and design, research ***through*** art and design and research ***for*** art and design.

Research ***into*** art and design could look at issues such as theoretical viewpoints and their relationship to art and design or, for example, straightforward research into design history.

Research ***through*** art and design uses creative practice as an integral part of the research but the findings are translated into traditional expressions of results, for example, a written thesis. Materials research (new material or new use of material), development work (accepted technology used in a different way) and action research (studio work as experiment) are all examples of research ***through*** art and design.

Research ***for*** art and design is more complicated. Frayling says that this is "research where the end product is the an artefact – where the thinking is, so to speak, ***embodied in the artefact,*** where the goal is not primarily communicable knowledge in the sense of verbal communication, but in the sense of visual or iconic or imagistic communication."

Using these definitions, this work clearly bridges two categories (and maybe the labels can be altered slightly to fit better): research ***through*** craft and research ***for*** craft.

In this investigation, 'research through design' is used as a reactive filtering process (see figure 1). Material is made and it is tested against set parameters. The quantitative data is gathered through a modified 'scientific' approach. It deviates from a traditional 'scientific' model because the experiments are iterative and cyclical. Each sample is compared to a set of predetermined parameters and new samples are made based on this information.

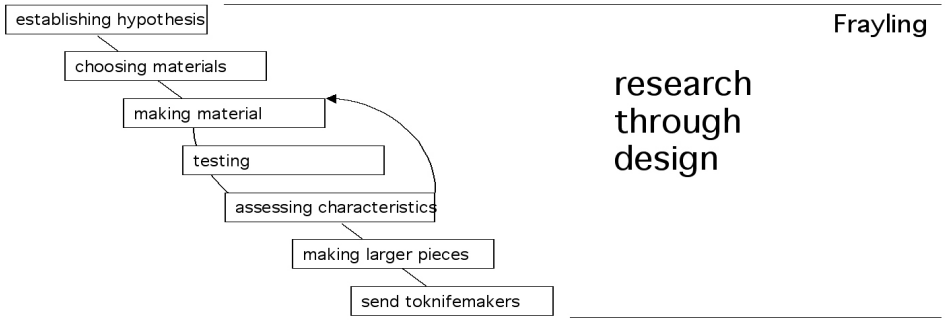

figure 1
Frayling's model applied to this research

Data is collected through laboratory notes and observations noted through experiment diary. The data gathered will be transferable within a metallurgical setting and could be used to construct further investigations and experiments.

Metal that falls within the predetermined parameters will be made into full size billets and distributed to a selected group of knifemakers. They will be asked to produce a knife in response to and embodying the new material.

A model of research for design has been developed for the second stage of this research. (see fig 2) A selection of makers will form a set of pre-structured case studies. The selection is not chosen to provide statistical generalisations and large scale extrapolations but it is rather to provide a cross section of different approaches to the creative process of making.

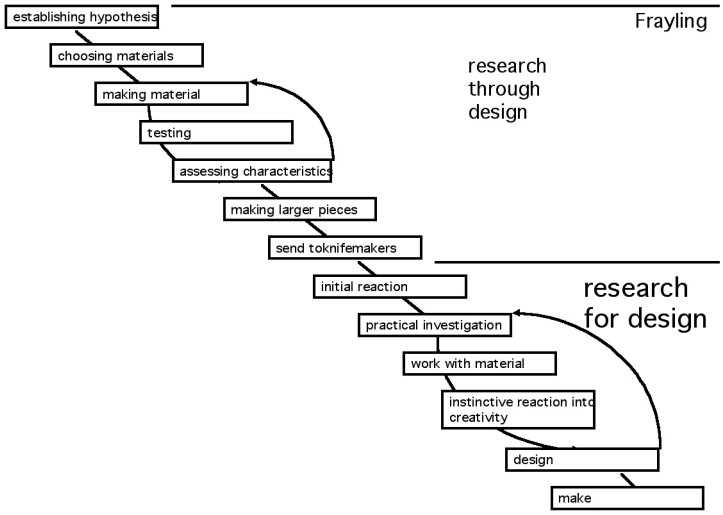

fig 2
Frayling's model applied to this research

Data collection within these case studies will be through workshop notes, sketchbooks or diaries depending on the preferred method of the maker. In effect, they will be asked to perform some of the roles of a reflective practitioner in performing this act of analytic enquiry and self-observation. These records will detail their investigation of the metal and the design/creative response to it as revealed through the making process using hard data as a platform for the intuitive responses to the metal. The end result will embody the characteristics of the new metal.

As reflective practice is a key element to this research it is important to define it within this body of work.

In an attempt to establish reflection-in-action within a scholarly practice, Schon identifies three valid types of experimental practice within a formal research context: "each of which has its own logic and it's own criteria of success and failure" (p145 Schon 1983)

Hypothesis testing experiment
This is the generally accepted experiment model. It tends to be the most widely used for reporting in research publications as it contains readily identifiable controls. The end result (positive or negative) is anticipated when used for research.

Exploratory experiment
"...is the probing, playful activity by which we get a feel for things. It succeeds when it leads to the discovery of something there" (p145 Schon 1983). 'What if' questions are posed (normally early in a research program) to establish more concrete questions and to test how research questions will respond. The end results are not predetermined.

Move-testing experiment

> "...where any deliberate change or action that affects the problem can be considered as a testing of that move" (Newton, 2001)

These can be applied to the research as shown in fig 3 with Frayling's model giving an overall structure.

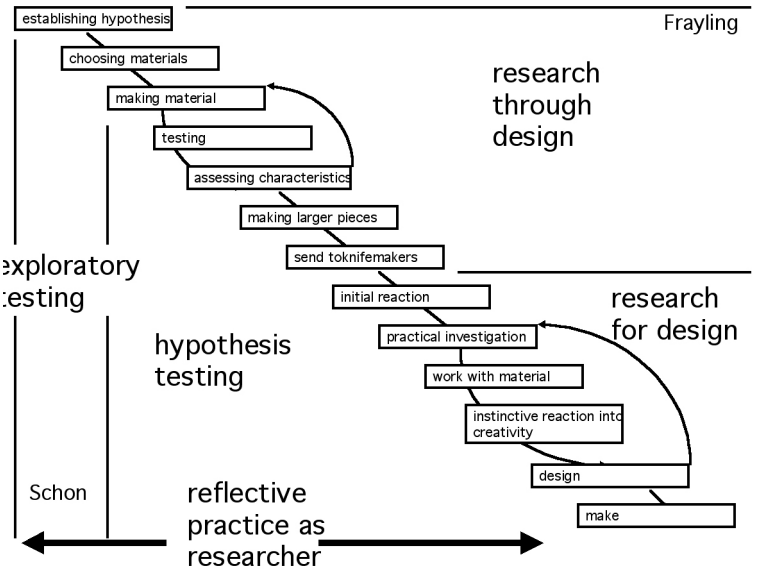

fig 3
Frayling and Schon applied to this research

During the initial stages of this research (establishing a hypothesis, choosing parameters etc) an 'exploratory' model was used to think around the research problem and establish a working hypothesis.

During the 'hypothesis testing' stage, the initial ideas were tested and quantitative data was gathered on the new material. Both the exploratory and hypothesis testing stages came under the umbrella of Frayling's 'research through design' model as outlined earlier.

The final stage, 'research for design' (Frayling), involved extensive use of Schon's 'reflective practitioner' model both from a researcher's and a practitioner's point of view.

The experimental models detailed above (excluding move-testing, which wasn't used in this study) can be approached from the researcher's and from the practitioner's point of view, providing very different contexts and applications. It is the role of research to attempt to produce conditions that ***refute the given hypothesis***. It is the role of the practitioner to elevate the status of the hypothesis and change the variables, in other words, ***to make it work.*** These different approaches radically affect the application of the models. For example, "the practitioner's hypothesis testing consists of moves that change the phenomena to make the hypothesis fit" (p149, Schon, 1983). In this situation the experiment is both a move and a probe, investigating and establishing, answering and creating questions.

When a research programme includes reflective practice within it, it is essential that these fundamental differences are clear.

> "...There is a different motivation and perspective to the application of experiments in practice when compared to experiments in research...Conventional research demands objectivity and distance in the search for an abstract account of the phenomenon. Reflective practice demands an implication of the practitioner within the problematic situation. The paradox lies in how a practitioner, fully implicated in the situation, never-the-less can transact in a way that produces objective knowledge (in the sense that it can be tested) that is communicable (in the sense that it can be shared)." (Newton, 2001)

Schon proposes the 'reflective conversation' as a solution to this problem. The problem is framed and the complex, uncertain situation is shaped to fit the hypothesis. The practitioner is emerged in the problem in order

to gain understanding and clarity. Order and responsibility are imposed on the conversation by the practitioner acting in accordance with the view that has been adopted (the hypothesis

In this investigation, reflective practitioner model is used in both from the practitioners and the researcher's viewpoint. The makers (including the researcher) will be engaged with the process as practitioners and they will be engaged in a 'reflective conversation' with the researcher (fig 4). This conversation is achieved through specific comparative questions, open recording methods, such as diaries, logbooks, sketches, notes, photographs, drawings, journals, and clarification interviews. They will in affect be engaged in exploratory, hypothesis and move testing within their practice but they will engage with these processes in the manner of 'practice' rather than 'research'.

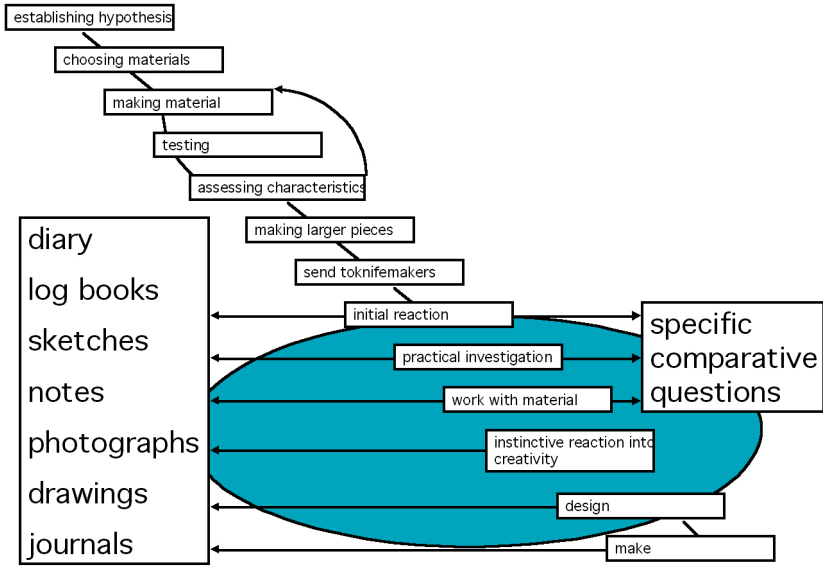

fig 4
'Reflective conversation' between Reflective Practitioners (makers) and Reflective Researcher

Implications for further practice based research in material centred design principles

This paper illustrates how research theories can be combined and customised when applied to a practice based investigation. This study could have been conducted as a straightforward piece of scientific study. However, the research model that has been adopted acknowledges the broader picture. By accepting tacit, hands-on, qualitative information alongside the quantifiable data it is possible to gain a clearer picture from the research. The strengths of the various models and methods have been appropriated to form a strong and coherent research strategy that may have wider applications for other pieces of research. It is possible that some aspects of this methodology can be applied to other research in this, and related, fields.

No fundamental flaws have been discovered in the methodology so far. Although some of the stages are very flexible and fluid, the other components of the methodology add structure, ensuring that the research maintains focus and the shape of the research is clearer.

The role of the reflective practitioner within practice has been clearly distinguished from the reflective practitioner as researcher. The clarity of this separation is enhanced by using the data from the researcher's own practice as 'just another case study'. This ensures that the creative information produced by the researcher is as explicit and transparent as all the other participants' are.

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