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# A STUDY OF CREATIVE BEHAVIOUR IN THE EARLY AND LATE STAGE DESIGN PROCESS

C. M. Snider, E. A. Dekoninck, S. J. Culley

*Keywords: creativity, behaviour, design process*

## 1 Introduction

The importance of research into creativity is well recognised within design research, with extensive studies performed in a wide variety of disciplines. However, with few exceptions, research to date has focused on creativity in a general sense or on the earlier stages of the process, thereby excluding study into the appearance and effect of creativity and creative behaviour during later stages. Benefits within later stages have recently been identified in the field of computing (Brown, 2010), and in case studies of late stage problem solving using creativity methodology within engineering (Frobisher et al., 2006). The increase in constraint present towards the later stages of the design process (Howard et al., 2011, McGinnis and Ullman, 1990), and the processes described by well-established design models (such as Pahl and Beitz (1984) or Pugh (1990)), show that the later stage design process presents a unique situation within which the designer must work. It may therefore not be sufficient to supply designers working within the later stages with the same methods of creative support as those working within the earlier stages; it cannot be assumed that the appearance of creativity will be of the same form in each.

**Table 1: Differences found in later-stage engineering design, compared to early stages**

| Difference | Reference |
|---|---|
| Focused on output behaviour and structure | (Gero, 1990, Gero and Kannengiesser, 2004) |
| Higher constraint | (Howard et al., 2011, McGinnis and Ullman, 1990) |
| Activity focus on layout, analysis and finalisation | (Pahl and Beitz, 1984, Pugh, 1990, Ullman, 1997) |
| Higher design process complexity | (Eckert et al., 2012) |

To begin to address this concern, this paper presents results from two studies focused on developing an understanding of individual designer behaviour through the design process, with a focus on the differences between early and late-stages. This is completed through the use of a creative behaviour coding framework, briefly summarised here and presented in greater detail within past work (Snider et al., 2013). This study aims to identify differences in the types of tasks that designers complete throughout the design process, particularly with reference to those that are completed in a creative manner. This understanding can then be used to develop methods of working and support for designers that allow more control and potentially improve output, identifying ways to encourage creative behaviour in a way that is particularly suitable to the situations of early and late-stage design.

### 1.1 The Coding Scheme

This work uses the coding scheme presented in Snider et al. (2013), which is designed to identify creative design approaches followed by designers during the later stages of the design process.

This is achieved through study of the designers task activity through design, specifically on the use of each task either to develop the information that they have about the design, the brief or the domain (called *information*-type tasks); or on the use of each task to develop the design itself, e.g. the physical components, layouts and materials for example (called *application*-type tasks). A designer's *behaviour* is then described in the sequence and summation of the types of task that they complete; based on the assumption that different designers will achieve the same goal in different ways.

Following the MOKA methodology (Stokes, 2001), each task is defined through its input and output, described as the "task transformation" between each. The coding scheme describes both input and output as relating to information or application as described above; an information input being based on the information, knowledge and resource present for the design; an application input being a starting point of a physical product, artefact, layout, system, or component.

Each task is then defined according to its initial and final state based on their properties as information-type or application-type, creating four possible options. A designer may use the information that they already have, and develop it into a broader or more developed version (I → I)(*information* input to *information* output); they may apply the information that they have to create the design itself (I → A)(*information* input to *application* output); they may take the current form of the design (application) and re-work it into a more developed version of itself (A → A); or they may take the current form of the design (application) and analyse it to develop information (A → I).

In addition to these task categories, the coding scheme identifies creative behaviour within each task according to whether it is completed in an *expansive* or *restrained* manner. Relating to the work of Guilford (1956), to be *expansive* refers to creativity in both divergence and convergence (as studied by Cropley (2006)) within the design process, through the pursuit of alternative products and technologies, or through the development and integration of new part combinations. Expansion is then recognised through *exploration* in a task. To be restrained refers to a lack of creativity in either divergent or convergent processes.

| | Information (I) | | Application (A) | |
|---|---|---|---|---|
| | Within-entity | Cross-entity | Cross-entity | Within-entity |
| **Non-Creative** | I → I | A → I | I → A | A → A |
| **Creative** | I → I | A → I | I → A | A → A |

**Figure 1: The eight task types**

A final categorisation within the scheme is whether tasks begin and end with the same type of entity (information-type or application-type), or different entities (see Figure 1). This distinction denotes the manner by which a designer produces their output; either through development from a basic version to an output of the same type, or through the use of either information or application to inform their development of the opposite type. For example, a within-entity task may involve the refinement of dimensions on a single component (A → A) or an investigation of the properties of a group of materials (I → I); while a cross-entity task may include the forming of an initial group of solution concepts (application-type) based on requirements (information-type), or a study of the impact of altering a design to reduce part count (study of application informing an information output). This categorisation therefore partly describes *how* a designer produces their outputs, while categorisation by information-type output or application-type output alone informs of *what* they are producing.

In all then, the coding scheme places tasks into one of eight groups; determining the focus or subject of the task output (information-type or application-type), determining the appearance of creative behaviour in a task, and determining whether tasks begin and end with the same type or a different type of entity. Through this scheme it is therefore possible to build a detailed understanding of the task behaviour of individual designers.

## 1.2 Stages of the Design Process

In addition to the coding scheme, it is necessary to categorise tasks as according to specific design stages. Developing from the work of Howard (2009) and Gero (1990) this coding scheme defines design stages as according to their focus on design function, behaviour and structure. Design stages are identified according to the foci of the tasks themselves, rather than by chronology of the process (such as within Pahl and Beitz (1984)), in which later stage tasks refer to those occurring at a later point in time; or system hierarchy (Suh, 1990, Ulrich and Eppinger, 2012), in which later stage tasks refer to those on a lower system level). Within this work, early-stage tasks are those concerned with task analysis and producing conceptual design descriptions or ideas; and later-stage tasks are those concerned with producing the detailed behaviour and structure of the system; those tasks that would typically be listed as belonging to embodiment and detail stages of engineering design process models.

**Table 2: Definitions of stages of design**

| Design Stage | | Definition |
|---|---|---|
| Early Stage | Analysis | Determine the desired and required functions of the system, for it to complete its purpose. |
| | Concept | Conceive the system functions in detail through preliminary description of system behaviour. |
| Late Stage | Embodiment | Design detailed system behaviour through preliminary description of system structure. |
| | Detail | Design and finalise system structure, and all aspects that may influence it. |

## 2 Methodology

The two studies presented here present two different methods of gathering data for the same purpose; Study 1 as a study of a longer term project analysed through the records kept by participants, and Study 2 as a direct observation of designers completing a specifically chosen design activity.

*Study One*

Study One followed the work of undergraduate engineers as they completed a single, 22-week project. Although completing different initial briefs, all participants were required to complete the same portion of the design process – from early task analysis to the production of a fully-functional proof-of-principle prototype. As example, projects included the development of a low-cost, hobbyist-level aerial photography rig, and a head support for patients with cerebral palsy.

*Study Two*

Study occurred through a direct observation of designers as they completed a four stage design process, designed to mimic the real life design process as described by Hales (1987), as presented in other research (Cash et al., 2013). The participants completed the study according to Figure 2 over a period of four hours, designed to mimic a complete design process as described by Hales (1987). Between each stage participants were permitted short, supervised breaks to prevent fatigue, during which they did not discuss the study.

| | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|---|
| | Information Seeking | Group Brainstorm | Detail Design (Area of Study) | Design Review |
| **Duration** | 50 mins | 50 mins | 90 mins | 50 mins |
| **Teamwork** | Individual | Group | Individual | Group |

**Figure 2: The structure of the study**

Throughout the study, the brief was to develop a remotely operated mount to be placed underneath a balloon for amateur aerial photography, and was consistent between designers. Within this study, analysis occurred only on the first and third stages The first of these prompted the designers towards task analysis, through a brief provision of background information and the task to: "*Using any means available to you search for and note down information that may help.*" The third stage stimulated the designers towards embodiment and detail design, through the instruction to: "*Develop an appropriate,* *feasible, dimensioned, detailed solution.*" This stage was based on work from the group brainstorm completed in stage two, and required the designers to develop a single idea that had been proposed as feasible. In addition, they were given a number of goals chosen to stimulate later-stage design activities, such as *"include all component dimensions"*.

## 2.1 Study Participants

*Study One*

Study One included seven undergraduate engineers from the University of Bath, UK, all completing a degree in mechanical engineering. Each participant had undertaken identical higher education and, of the seven, three had completed 12 months industrial experience.

*Study Two*

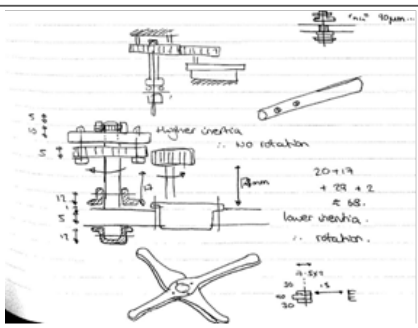
Study included twelve undergraduate engineers from the University of Bath, UK, completing a mechanical engineering degree. All participants had identical higher education, and an average of 10 months industrial experience.

## 2.2 Data gathering and coding process

Both studies followed similar data gathering and coding processes, with differences due to the data that could be collected. Data for Study One was collected in the form of the participants logbooks, which they were instructed to use as a working document and complete record of the design process, and also formed part of the assessment process. As such, the logbooks contained a substantial amount of data taking the form of, for example, lists and explorations of potential requirements and constraints, lists of suppliers, descriptions and analysis of competitive products, sketches of configurations, geometry and dimensions, lists and sketches of individual components, brainstorms and mind maps, assembly diagrams and detailed dimensioned drawings of components for production. As such, the logbooks contained a good record of the process followed; supported by research concerning logbooks as indicating chronology and completeness of data (McAlpine et al., 2006), the reliance of students on hand-drawn representation (Sobek, 2002), and the tendency for logbooks to capture a large portion of the expansive idea generation process (Currano and Leifer, 2009).


An *expansive* task performed by designer D, in which functional requirement (*information-type* input) is transformed into a collection of several working principles (*application-type* output). Task assignment:

**I → A; Expansive**




A *restrained* task performed by designer B, in which the a gear/shaft system layout (*application-type* input) is transformed into a dimensioned, detail layout (*application-type* output), in a decisive manner without consideration of options. Task assignment:

**A → A; Restrained**

**Figure 3: Example task assignment from real data**

Data for Study Two was collected using a webcam to record a front view of participants, another to record a wide view, Panopto recording software to capture computer screens (www.panopto.com) and LiveScribe (www.livescribe.com) notebooks and pens to capture real time, detailed logbook data.

This comprehensive method ensured that all actions and tasks completed by the designers were captured by multiple sources.

Data for both studies was coded according to the scheme presented in Section 1.1, with small differences due to data type. Figure 3 shows examples of task assignment from real data. Due to the length of the project undertaken in Study One, reliable recording of time of marking was unfeasible. Data was therefore coded on a page-by-page basis, with rules for task separation. As Study Two included a recorded time dimension to data, each source was synchronised and then coded on a minute-by-minute basis. For both studies, each participant was coded in a single sitting to ensure consistency in results, involving three individual passes through the data. These three passes were used to maintain focus and accuracy for each individual aspect of the coding scheme:

*Step 1* - Identification of occurrence of creative behaviour through expansion

*Step 2* - Identification of individual entities, and subsequent identification of tasks.

*Step 3* - Identification of design stage of each task.

The coding scheme and data type have demonstrated reliability in inter-coding testing to a value for Krippendorff's alpha (Hayes and Krippendorff, 2007) of $\alpha = 0.768$ (Snider et al., 2013), a value that is suitable for exploratory work of this form (Blessing and Chakrabarti, 2009).

# 3 Results

As listed in Table 1, there are several situational differences between early and later stage engineering design. However, as demonstrated by the data gathered within these studies, there are also evidential differences in the appearance of creative behaviour. Table 3 presents some general figures.

**Table 3: General task quantities**

| | Total Tasks | Percentage N/A | Early Stage Tasks | Late Stage Tasks |
|---|---|---|---|---|
| Study One | 1045 | 32.0 | 192 | 519 |
| Study Two | 219 | 0.00 | 100 | 119 |
| Overall | 1264 | 26.4 | 292 | 638 |

## 3.1 Focus of Design

Through the transition from early stage to later stage design, participants demonstrated a change in focus of their working from tasks focused on the development of information regarding the design to tasks focused on the application of such information to the physical design and the refinement of the physical design as an output (i.e. Study 2; 91.8% information early stage down to 24.5% information later-stage; Table 4).

**Table 4: Focus shift between early and later stage design (Studies 1 and 2)**

| | Design Stage | Task type (%) | |
|---|---|---|---|
| | | Information | Application |
| Study 1 | Analysis and Concept (early stage) | 82.9 | 17.1 |
| | Embodiment | 38.9 | 61.1 |
| | Detail | 36.6 | 63.4 |
| Study 2 | Early Stage | 91.8 | 8.23 |
| | Late Stage | 24.5 | 75.5 |

This shift in focus stands to reason; as the design process continues, there is a requirement for the focus of the designer to increasingly concern the actual design. In earlier stages, they may develop their knowledge of potential requirements, place in the market, and potential design opportunities (for example); while in later-stages they are required to produce and detail a functional system.

### 3.2 Creative Behaviour through Design Tasks

By analysing in relation to creative behaviour both the distinction between information and application type tasks, and between within-entity and cross-entity type tasks, some findings can be made regarding the appearance of creative behaviour through the design process.

**Table 5: Average proportions of each pair-wise category set**

| Task category | Early-stage proportion (%) | | Later-stage proportion (%) | |
|---|---|---|---|---|
| | Study 1 | Study 2 | Study 1 | Study 2 |
| Creative | 49.5 | 67.4 | 27.8 | 21.7 |
| Non-Creative | 50.5 | 32.6 | 72.2 | 78.3 |
| Information | 82.9 | 91.8 | 36.8 | 24.5 |
| Application | 17.1 | 8.23 | 63.2 | 75.5 |
| Within-entity | 67.8 | 86.2 | 47.8 | 64.2 |
| Cross-entity | 32.2 | 13.8 | 52.2 | 35.8 |

First, as shown in Table 5, there is a distinct drop in creative behaviour from early stages to late in both studies (49.5% to 27.8%, Study 1; 67.4% to 21.7%, Study 2). This is in tandem with a switch from information to application-type tasks (82.9% to 36.8% drop in information, Study 1; 91.8% to 24.5% drop in information, Study 2) and a drop in within-entity type tasks (67.8% to 47.8%, Study 1; 86.2% to 64.2%, Study 2).

Looking more specifically at the occurrence of creative tasks in conjunction within the other categories, Table 6 presents more detail. Within early stages of design, Study 1 in particular shows a reasonably even split of creative tasks in each category, with no more than 8.2% difference (47.2% creative information to 55.4% creative application) between creative occurrence in any two pairs. Study 2 however shows a significant difference, with creative information tasks occurring much more frequently than creative application tasks (56.5% to 5.23%) and creative within-entity tasks occurring much more frequently than creative cross-entity tasks (54.4% to 10.4%). This difference is thought to be methodological, see Section 4.3. Within later-stages of design, there are distinct differences in the appearance of creative behaviour. Within Study 1, the proportion of creative information-type tasks drops to 22.1%, while the proportion of creative application-type tasks drops to 31.7%, a value nearly 1.5x higher. Similarly for Study 2, the proportion of creative application type tasks is significantly higher in later-stages than in early (15.3% to 7.38%; 2x higher). This is a particularly telling result considering the very low proportion of creative application tasks occurring in early stages for Study 2; despite the overall tendency for creative tasks to decrease in proportion from early stages to late, this category increased. There is therefore a strong suggestion that designers are primarily creative in application-type tasks in later-stage design, a pattern that is not present in early-stage design.

**Table 6: Creative proportions of pair-wise categories**

| Task type | Creativity | Early-stage proportion | | Later-stage proportion | |
|---|---|---|---|---|---|
| | | Study 1 (%) | Study 2 (%) | Study 1 (%) | Study 2 (%) |
| Information | Creative | 47.2 | 56.5 | 22.1 | 7.38 |
| | Non-creative | 52.8 | 43.5 | 77.9 | 92.6 |
| Application | Creative | 55.4 | 5.23 | 31.7 | 15.3 |
| | Non-creative | 44.6 | 94.8 | 68.3 | 84.7 |
| Within-entity | Creative | 50.2 | 54.4 | 19.9 | 9.00 |
| | Non-creative | 49.8 | 48.6 | 80.1 | 91.0 |
| Cross-entity | Creative | 49.9 | 10.4 | 34.2 | 13.6 |
| | Non-creative | 50.1 | 89.6 | 65.8 | 86.4 |

There is also a distinct difference in the appearance of creative tasks by the within / cross-entity type category within later-stage design. For Study 1, although an even split occurred between creative within-entity and cross-entity type tasks in early stages, creative cross-entity type tasks occur 71.9% more frequently in later-stages (34.2% to 19.9%). Similarly for Study 2, the occurrence of creative cross-entity tasks is higher than creative within-entity tasks by 51.1% (combined significance of higher cross-entity proportion, $p=0.0032$, Wilcoxon signed rank test). This is interesting considering that this difference involved an increase in creative proportion from early-stage design to late-stage design. There is also therefore a strong suggestion that cross-entity type tasks are more frequently creative than within-entity type tasks in later-stage design; a pattern that is not present in early stages.

# 4 Overall Discussion

This paper presents two subjects for discussion – that of the typical focus of design, and that of the specific appearance of creative behaviour in early and late-stage design, and the differences between.

## 4.1 Typical focus of design

Considering the findings presented in Section 3, it is possible to make some statements of the flow of design behaviour from early-stage to later-stage, with particular thoughts on the focus of the designers and the typical appearance of their creative behaviour. As a general trend, there is a switch from a focus on information-type tasks to application-type tasks as the process continues. In more tangible terms, this demonstrates that typical tasks in early-stage design are concerned with the like of research and information gathering, while typical tasks in later-stage design are more concerned with the development of the actual output as an artefact. This is a logical transfer; earlier in the design process it is necessary to gather information in order to have the resources to put together a solution; later in design the resources are present, and it is necessary to produce the actual design output. This does not, however, preclude the appearance of application-type tasks in early-stage design or the appearance of information-type tasks in later-stage design. Throughout the early design process the designer is liable to attempt to form solution concepts to some detail, and throughout the late-stage process there is still potential to require the development of information, either for the sake of solving an issue or for the purpose of design refinement. Both of these examples are perhaps similar to research on designer solution strategies; the former to depth-based episodes in design, where a designer will go into detail on smaller elements for the purpose of scoping or evaluation (Ball and Ormerod, 1995); and both to co-evolution in design (Dorst and Cross, 2001), where an iterative process of production of a solution followed by re-assessment of the problem based upon its evaluation increases problem understanding.

In addition to this trend, there is a decrease in the appearance of creative tasks as the design process continues. There are a number of potential reasons for this, all of which form interesting directions for further research. The first concerns the necessity of creative behaviour, particularly in later stage design. Exploration by its nature involves the research and production of options and opportunities, whether or not they are followed. Given the highly constrained nature of later-stage design (McGinnis and Ullman, 1990), often focused more towards variant design processes (Howard et al., 2008), there is perhaps simply lower necessity for creative behaviour in later-stage design. The designer is more likely to be able to see a path to solution, and therefore able to follow it (see Ward, 1994); using a well-defined and non-creative schema (see Dym, 1994, Brown, 1996).

A second reason for the lower appearance of creative behaviour in later-stage design is perhaps in suitability to the design situation. Given the specific conditions, the process of exploration (required for creative behaviour) may prove undesirable when compared to following a well-defined process; for example, when under high levels of constraint or under strict time restrictions. As has been proposed by other researchers, the different requirements, priorities, and influences of complex design situations may require creativity of a different form (Eckert et al., 2012).

In a general case then, engineering design can be described as a transition from information to application-type tasks, during which the appearance of creative behaviour decreases. Consolidating findings, later-stage design can be described as primarily involving non-creative tasks that are for the purpose of producing the design output itself. This is not to assume, however, a reflection on a lack of necessity or potential benefit of creative behaviour. In cases either where progression has proven impossible or a designer identifies new opportunities, creative behaviour may occur throughout the entirety of the process of design.

## 4.2 The appearance of creative tasks in later-stage design

Placed in direct contrast to early-stage design, there are two identified features of the appearance of creative behaviour in later-stage design that indicate it as different.

The first of these is a higher occurrence of creative behaviour in application-type tasks during later-stage design. Considering the predominance of application-type tasks at this stage (those that focus on development of the actual output), this is not necessarily surprising. It does suggest, however, some thoughts on the necessity of creative behaviour in different task types in later-stage design. Considering the lower-proportion of creative information-type tasks in later-stage design, it seems that designers are less prone to explore or expand knowledge in later-stages, instead focusing on exploration of how the knowledge present may be used and the resulting form of the output. This is in contrast to early stage design, when designers are highly creative in both information- and application-type tasks. In early-stages, designers are willing to explore and develop knowledge creatively, and to form potential solution conjectures in a creative manner. There are some potential implications of this behaviour on design output. Particularly if the information and knowledge present in later-stage design is sub-optimal, there is a lower potential for a creative task to occur and identify new versions that will greatly benefit design output – the designer will complete creative tasks in the formation of the output from the resources they have available, but the resources will not necessarily be the best.

The second feature of creative behaviour that demonstrates a difference between early and late-stage design is in cross-entity type tasks (those that have a different *input* and *output* type). While within-entity tasks and cross-entity tasks are completed creatively in similar proportion in early-stage design, cross-entity tasks are most often completed creatively in later-stage design. Within-entity type tasks would typically be represented by examples such as clarification of information or gathering of further detail on a subject; or of refinement of dimensions and configuration design. Cross-entity type tasks would typically be represented by (for example) an exploration of solution concepts based on a set of requirements, or the evaluation of a part against its specification.

There may be, therefore, a link between the transformation from information input to application output (or vice-versa) and the requirement for exploration; which can be clarified through relating to the types of creative and non-creative behaviour of Dym (1994). When developing an entity into a more developed form of itself there is a clear conceptual link, in that the subject and form of the output can often be described directly in terms its relation to the input. For example, when completing dimensioning tasks, the designer is taking a component and finalising the sizes of each aspect – they take a geometrical input and develop it to a more detailed form of itself. In these cases, there is a well-defined schema available to the designer; they know their inputs, they know a sufficient amount about the form their output will take, and they know what must be done to transform one into the other. However, due to the transfer between information and application that occurs within cross-entity type tasks, there is potentially less indication of the result that the output will take. The disjunction between the input and output, which will be related but of a distinctly different form, creates a lack of clarity to solution. As it is not necessarily obvious how to form the output from the task input, there is wide potential for unprompted exploration in cross-entity tasks. The stimulation of cross-entity tasks then serves as a potential method for the support and enhancement of designer process. Should a creative process and creative result be desired, stimulating the designer to complete a higher proportion of cross-entity tasks could be the initiator. Similarly, should a creative process not be desired, stimulating a higher proportion of within-entity tasks could encourage non-creative behaviour.

## 4.3 Cohesion of studies

There are benefits from the comparative analysis of the two studies, which had both significant similarities and differences, as listed in Table 7. The similarity of results in each study despite differences in method therefore give confidence to results – for example, even though study 1 involved multiple project briefs and study 2 only one, similar task proportions appearaed in each. This suggests that project brief is not the primary influence in the types of task completed . Through the combination of these studies, there is scope to give higher confidence to results when analysis agrees.

One additional example of the benefit of this comparison is evident in a large difference in the results of the two studies. Amongst the results presented here, there is a far lower proportion of creative behaviour in application and cross-entity type tasks in early stage design in the results of study 2, than in the results of study 1 (Table 6). The reason for this is hypothesised to be a result of design situation. Both application and cross-entity tasks are in a general minority in early-stage design for logical reasons; it is important to develop a good base of information in early stages, and as a result there are fewer opportunities for cross-entity tasks. Considering then that Study 2 was highly time restricted, there is possibility that the need for a high rate of working restricted the appearance of creative behaviour for those participants. When application and cross-entity tasks are of lower importance, the designers may minimise exploration within them in order to increase their rate of working. Such thoughts cannot be proven here, but demonstrate the benefit of triangulation between multiple studies. In addition to the balance of strength and weakness shown in Table 7, comparison of the results of the studies suggests additional results that could otherwise not be implied.

**Table 7: Cohesion of the studies**

| Study One | Study Two |
|---|---|
| Weakness: Differing project briefs | Strength: Identical project briefs |
| Weakness: Lower number of participants. | Strength: Higher number of participants. |
| Strength: Realistic task completed by the designers. | Weakness: Lower realism in constrained setting |
| Strength: Longer-term experiment | Weakness: Short-term experiment |
| Strength: Un-intrusive data collection method | Weakness: Disruptive data collection method |

# 5 Conclusions

This paper has presented an analysis of two studies, both with a focus on creative behaviour throughout the engineering design process. Through comparison of the results of each, and hence through the use of 19 participants completing a variety of projects, this paper suggests several findings relating to design process behaviour. First, there is a distinct (and logical) transition from a focus in tasks that develop information and resources, to tasks that develop the actual design solution as the design process continues. Second, particularly within later-stage design, creative behaviour has a high focus on developing the actual output, to the neglect of the information and resources available for use. Third, tasks that take information and apply it to the actual output or study an output to gain additional knowledge are more often completed in a creative manner.

These findings suggest some considerations for support of creative behaviour in later-stage design that are to be explored in future work. Particularly if an increase in creative behaviour is desired, there is scope to do so through encouraging cross-entity type tasks. There is also an investigation to be made to the effect of encouraging creative behaviour in information-type tasks in later-stage design (which are typically in minority) and the effect on the output. Through exploration of the information available throughout the design process, there may be potential for signficant improvement of performance and creativity in the design outputs that are produced.

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