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Transforming knowledge through mentor-supported cognitive apprenticeship learning methods

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Abstract: *This paper discusses how findings from a research study into how cognitive apprenticeship learning methods applied by building designers acting as mentors may be implemented in classroom settings. Three elements of an approach to learning using authentic problem solving supported by cognitive apprenticeship teaching constructs are explored as part of a model for classroom implementation. This research suggests that cognitive apprenticeship methods can be used effectively for classroom-based student learning in the building design discipline. It showed that having expert building designers as mentors facilitated student learning in ways that utilise information and employ heuristic problem solving strategies as practiced in authentic situations typically encountered in the building design and construction profession. To achieve this, learning should take place in a learning environment that replicates the conditions and practices typical of the commercial design office situations used in this research. The learning tasks used should be based on authentic projects and be implemented using the kinds of resources and methods that emerged from this study as typical of those used by expert building designers in their everyday culture of practice activities.*

Keywords: *Cognitive apprenticeship; mentoring; authentic learning.*

Introduction

This paper discusses how findings from a study of student learning in design office situations organised using cognitive apprenticeship methods incorporating task-based authentic activities can be applied to classroom based learning.

Findings from a research study about the learning experiences of a group of students working on authentic design projects, in real design office settings, with expert building designers acting as their mentors using cognitive apprenticeship (Collins, Brown, Newman, 1989; Carver, 2001) teaching strategies underpin this discussion. Data collected from multiple sources concerning the same events when analysed facilitated triangulation of emergent findings thus adding rigour to the validity of the study. The mentors' use of the key cognitive apprenticeship teaching strategies of modelling, coaching, scaffolding and fading, articulation, reflection and exploration in their work sessions with the students formed a major part of this research. The theoretical framework that underpins this study has at its roots cognitive apprenticeship constructs as used by Collins et al. (1989) and numerous others in a variety of studies. This research studied students undertaking authentic projects, with the aid of mentors using cognitive apprenticeship teaching methods, over the final two years of a Building Design course.

Real design projects undertaken by the students were organised by expert building designers, acting as mentors, to replicate their usual professional practices. The projects were conducted in real design office settings in the context of the discipline domain. This approach utilised a learning situation structured in accordance with principles suggested by Schőn (1983) who contends that learning occurs as professional practitioners engage in every activity of their everyday world. The authentic nature of the design office situations studied through this research meant that students worked in settings where professional designers applied specialist knowledge and sophisticated mental models in the social and cultural context of their usual practices. This allowed students to construct their domain expertise, in ways similar to that suggested by Hennessey (1993).

The professional building designers who acted as mentors in this study were regarded as having good communication skills and interactive working practices as typically found in commercial design office settings. Their use of tacit knowledge to support and encourage student learning through cognitive apprenticeship methods presented findings similar to those reported by Casey (1996, p.73) who notes that cognitive apprenticeship is heavily dependent on the ability of an expert to interact with the learner by: "modelling expert practices, observing student performance, supporting performance through scaffolding and fading of support as performance improves." This was clearly evident in data collected in this research.

Data collection and analysis in this research

Data used in this study were collected over a fifteen-month period using a variety of methods including interviews, observation of student-mentor work sessions, reflective journals, video recordings of student-mentor work sessions, and questionnaire survey tools. Analysis of data took place in ways that included triangulation of data from different sources about particular events and work practices. This facilitated rigour in data collection and analysis, which ensured reliability of the research methods, and validity of the research findings (Ryan & Bernard, 2000).

Findings

From the outset of this study, most of the mentors gave designer status to the students, rather than student status. Working in this way meant that in all of their design office interactions, the students experienced authentic design office culture of practice events in ways typical of the mentors' usual practices. This approach is in keeping with that proposed by Resnick (1987) who contends that authentic learning must involve situations where actual cognitive processes are involved rather than simulated processes as found in many classroom situations. Authentic experiences used as the basis of design tasks in this research study setting were thought to facilitate student enculturation (Collins et al., 1989) into the mentors' culture of practice through real design activities and social interaction (Wilson, 1993).

The study situation used supported learning through cognitive apprenticeship methods by making visible to the students the largely tacit knowledge possessed by the mentors about design and problem solving procedures. Emergent findings suggest that some of the mentors approached their work with the students by taking them on a guided journey of discovery. This, some mentors said, assisted students to deal with authentic tasks in the context and culture of everyday design office practices.

Most of the mentors commenced their work with the students by introducing them to typical design office methods for assembling resources appropriate to the design project described by the client brief. The mentors then modelled for the students their own design methods, and went on to coach the students as they applied those methods to authentic design projects, often using Computer Aided Design (CAD) methods (Baird, 1997). By working in this way, the students were provided with experience based learning situations in which they used self-evaluation and reflection when defending their design endeavours. The authentic experience-based learning situation allowed students to construct their knowledge about expert practices in ways modelled by the mentors (Kaufman, 1996; Carver, 2001).

This study found that the cognitive apprenticeship situations developed in the design offices provided mentor support for progressive transfer of responsibility to the students for their own learning in ways similar to that found in a different study by Palinscar and Brown (1984). Collaboration between the students and the mentors also provided situated learning opportunities in which the students had critical opportunity to observe, engage in, or invent expert strategies in context (Brown, Collins, & Duguid, 1989; Pieters & de Bruuijn, 1992; Hennessy, 1993). The students then applied strategies they had learned to authentic tasks with the aid of mentors, in the design office culture of practice of the study settings. In this way, the students became engaged in authentic, meaningful real work design project tasks thereby using a constructivist manner of learning (Biggs, 1995).

Undertaking design projects in this way facilitated student development of design expertise within a cognitive apprenticeship framework, implemented using collaborative mentor/team-based office activities (Brown et al., 1989; Pieters et al., 1992; Hennessy, 1993). It also facilitated their development of personalised ways for solving design problems and helped them to acquire declarative and procedural knowledge of design methods. This took place through activities situated in the usual context of their use by mentor supported "learning-through-guided-experience on cognitive and metacognitive, rather than physical, skills and processes" (Collins et al., 1989, p. 457).

What has emerged from this research?

This study sought to determine the learning outcomes for students in a cognitive apprenticeship situation. It also sought to understand what kinds of knowledge were acquired by those students, what heuristic strategies were learnt, and what was it in the study situation that facilitated student learning. In the Collins et al. (1989) model, some learning content is considered as strategic or tacit knowledge and this underlies an expert's ability to make use of concepts, facts and procedures to resolve problems emerging from authentic tasks. It also includes problem solving strategies and heuristic strategies used by experts when solving emergent problems in the context of their usual practices and when exploring new concepts (Collins et al., 1989; Collins, Hawkins, & Carver, 1991).

In this research the domain knowledge of the expert building designers, acting as mentors, was grounded in the discipline of their practice. This included explicit factual knowledge and procedures used by them to solve problems in the context and manner of their usual culture of practice activities. Heuristic design strategies gave students discipline specific ways of dealing with problematic situations that emerged from the real work design project. These were used by the mentors in the manner of "tricks of the trade" (Collins et al., 1989, p. 478) that had been tacitly acquired by them through professional experience in the domain. Much of what was observed as mentor use of heuristic design strategies here pertains to managing problem solving in building design. This occurred through reflective work practices and the sequencing of design tasks as scheduled by the mentors. Use of this approach gave structure and formality to the development of cognitive processes by setting the strategies in the context of the domain, thus making them purposeful through student application, which enhanced their understanding of their role (Choi & Hannafin, 1996).

Knowledge transfer in the cognitive apprenticeship situations used in this research was thought to take place mostly through a cycle of modelling, coaching, and scaffolding, represented here in Figure 1. The knowledge transfer cycle shown in Figure 1 is nested in Phase 2 of the proposed three-phased theoretical framework represented in Figure 2 (later in this paper). It forms an integral part of knowledge development, communication, and the culture of practice experiences (as shown in Figure 2) that together represent a learning cycle based on mentor supported cognitive apprenticeship learning methods using authentic projects in real settings.

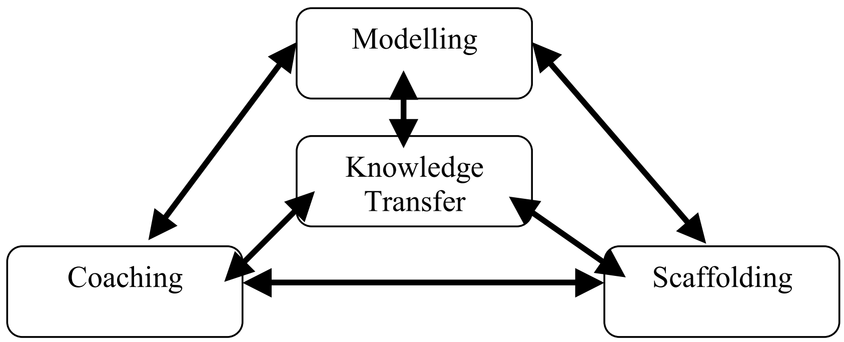

Figure 1: Knowledge transfer using Modelling, Coaching and Scaffolding

Phases of learning activities observed in this study

Findings from this study suggest that student learning in the authentic design office situations studied is characterised by three phases. These were shaped by activities and experiences that provided students with entry to the culture of practice, knowledge of the discipline domain and ways for using design strategies. The three phases are represented graphically in Figure 2, but may be summarised as follows:

- **Phase One - Entry to the design office situation**
  This involves bonding with the mentor and establishing links with others operating in the domain.
- **Phase Two – Acquisition of knowledge and skills in the domain of practice**
  This phase is constructed around a three-part cycle of learning focussed on:
  (a) *Culture of practice* activities with the mentor and other experts in the broad spectre of the design industry;
  (b) *Knowledge Acquisition*, including *Declarative knowledge* (explicit), *Procedural knowledge* (design processes and procedures), *Tacit knowledge* (experience based strategies and understanding); and
  (c) *Communication:* the use of *Discussion, Articulation and Sketching* to express visualised design concepts using industry language and vocabulary.
- **Phase Three - Development and application of metacognitive ways for creating, visualising and resolving design concepts**
  This phase is constructed around a three-part cycle of learning focussed on:
  (a) *Development of Creativity and Innovation* – using knowledge and design tools; and
  (b) *Testing and Defending* design ideas for acceptance or rejection – applying evaluation procedures.
  (c) *Exploration and Reflection* – using metacognitive ways to create, explore and refine design ideas by reflecting on multiple potential solutions

This proposed theoretical framework is represented graphically in Figure 2 with arrows used to show the interdependence of the cycles of learning activity within and between Phase 2 and Phase 3.

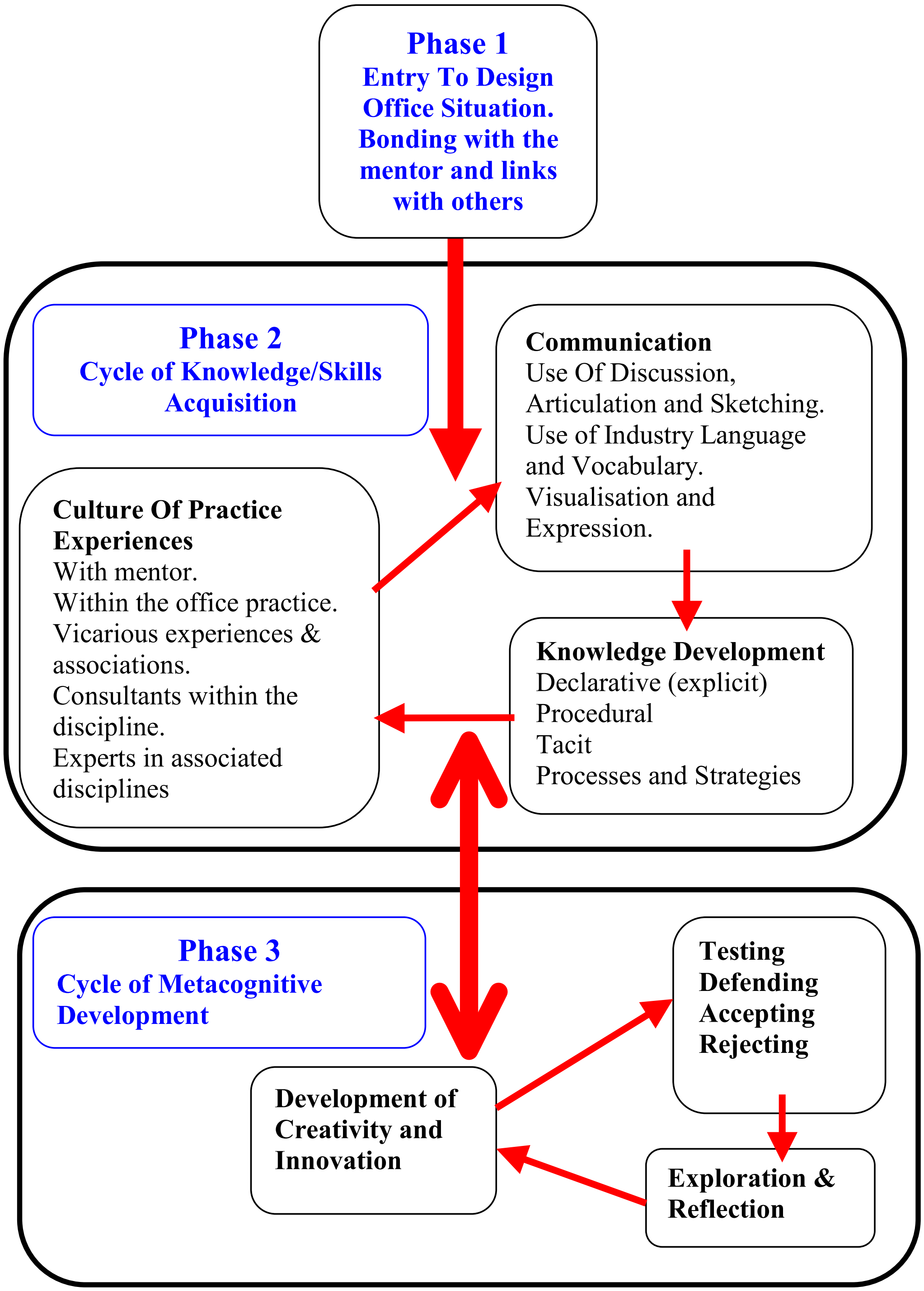

Figure 2: Learning phases in this study

Implementation of cognitive apprenticeship methods in a classroom

Findings from this study indicate that mentor use of the teaching strategies proposed by Collins et al., (1989) in their cognitive apprenticeship approach to learning can provide a successful means for teaching building design in the situations studied. Using authentic activities, the students developed skills during their social interaction and collaboration with expert building designers acting as mentors. This took place in the context and culture of practice of the mentors usual design activities. The combination of the creativity based design domain with the technically based construction and documentation domain makes the learning environment complex, much more so than a traditional classroom setting. Many aspects of student learning with the mentors in this situation involved overlapping activities, ongoing activities and metacognitive processes to resolve problems (Fowler, Armarego, Allen, 2002). Students were often required to use creative design skills and technical procedures with construction detailing methods.

Throughout multiple work sessions with mentors, the students were observed to gain confidence in their use of design knowledge and fundamental problem solving procedures. They went on to work in more independent ways to apply heuristic design strategies to resolve design problems and to defend their solutions. Many of the students were also observed to undergo a transition from simply using information and procedures to resolve design problems, to using heuristic design strategies in creative, innovative ways. This is consistent with findings reported in other studies (Berryman, 1991; Hennessy, 1993; Carver 1995; Jarvela, 1995; Cash, Behrmann, Stadt, & Daniels, 1997; Carver, 2001) about using a cognitive apprenticeship approach to learning and supports the Collins et al. (1989) contentions about students attaining mastery of knowledge and skills modelled by experts.

Having first attained mastery of the methods used by expert designers, the students then mostly applied their knowledge and design skills in creative and innovative ways to explore and reflect different design ideas as they refined and developed new design solutions, with personal style elements. Findings here have shown that using the six teaching strategies of a cognitive apprenticeship approach to learning (modelling, coaching, scaffolding, discussion, reflection, and exploration) provided a successful means for learning building design when implemented with authentic tasks in a design office setting. They also indicate that student learning was enhanced through having a well-defined learning situation and authentic activities structured to address specific aspects of practice.

This research suggests that cognitive apprenticeship methods can be used effectively for classroom-based student learning in the building design discipline. It showed that having expert building designers as mentors facilitated student learning in ways that utilise information and employ heuristic problem solving strategies as practiced in authentic situations typically encountered in the building design and construction profession. To achieve this, learning should take place in a learning environment that replicates the conditions and practices typical of the commercial design office situations used in this research. The learning tasks used should be based on authentic projects and be implemented using the kinds of resources and methods that emerged from this study as typical of those used by expert building designers in their everyday culture of practice activities.

Findings about the three phases of student learning (see Figure 2) that emerged from this study, and the manner in which cognitive apprenticeship (Collins et al., 1989) teaching methods were used by the mentors, suggested that a particular structure was needed to optimise student learning opportunities. It is proposed here that student learning in the building design discipline can be facilitated by cognitive apprenticeship teaching methods in conjunction with a four part structure that incorporates teaching activities and authentic tasks that together replicate everyday design office culture of practice operations (Baird & Fetherston, 1999).

It is also proposed here that for teaching building design students in classroom settings, the six teaching strategies of a cognitive apprenticeship (Collins et al., 1989) learning approach can be effectively implemented in such a learning environment if structured using the four elements outlined below.

A structure for implementing cognitive apprenticeship teaching methods for building design students

Learning environments in which a cognitive apprenticeship approach might be successfully applied to teaching building design students should incorporate the following elements:

The mentors

The mentors must be expert in the building design discipline as well as having expertise in the use of the teaching strategies of a cognitive apprenticeship approach to learning. The mentors classroom activities must be organised using a team-based approach with academic staff so as to provide industry based knowledge and skills within sound educational delivery practices and curricula. Where possible teaching teams should include multiple experts, each of whom might contribute specific key knowledge and skills to a collective model for student learning. Having multiple experts, each of whom bring a different perspective and expertise to the learning situation, may enhance student learning by supporting a community of learning as suggested by findings in this study.

The learning environment

The learning environment should incorporate the following aspects:

- A classroom situation that replicates the working environment of a typical design office with individual work stations and equipment arranged for one-on-one tutoring, as well as for group interaction;
- Have available industry based consultant designers to support the classroom teacher on an as-needed basis to mentor, advise and assess the students according to industry standards of design and presentation;
- Provide access to experts in associated disciplines having multiple perspectives, design styles, working practices and alternative approaches to resolving design problems
- Provide within the classroom a diverse range of resource materials including archival office-set (project drawings) documents of authentic commercial projects produced by recognised expert designers, student projects, books, magazines, technical publications, codes and regulations, computer equipment, telephone/fax, photocopier, and other similar items as used in commercial design office settings;
- Include in the classroom environment the kinds of dress codes, behaviour, language use, and design office facilities and services such as music and refreshments to replicate the social working situation present in most commercial design offices;
- Create a team-based classroom environment in which students from different course levels work in collaborative teams on different projects in the same general work-space, so that peer mentoring and incidental assistance and learning may take place in a environment that presents a broad picture of design endeavour;

- Provide "after hours" access to all of the classroom facilities, including access to expert advice and support from rostered staff, or consultant experts, either face-to-face or via the telephone or e-mail; and
- Arrange for students to participate in building site visits involving experts from associated disciplines to introduce multiple perspectives of each design situation, and to explore multiple solutions.

The learning activities

The learning activities should include:

- Teaching methods that encourage student self confidence and anxiety-free expression of innovative ideas;
- Modelling and coaching in the use of sketching and discussion methods typically used by experts in the building design discipline when exploring, debating and defending design ideas;
- Support for using collaborative team-based work practices based on exploration, reflection, and evaluation of ideas to resolve complex design tasks in the manner of commercial design office practices;
- Support for an inquisitive approach (to design) with a sense of excitement and inspiration;
- Modelling of methods used by expert designers to match patterns of design problems and solutions, shown to occur frequently in authentic building design situations, to elements of student design projects;
- Integrate into design practices the use of rich descriptive articulation of personal design ideas and problem solving methods as part of visualisation and exploration of proposed designs, along with sketching and over-sketching of formal or CAD based drawings;
- Incorporate the overlaid drawing office-set approach into all design projects along with detailed notes and explanatory reporting of the methods and rationale behind design decisions and branching of design elements explored, evaluated, and accepted/rejected in the final presentation;
- Introduce industry standards to the assessment of design presentations by having industry experts evaluate student works, or contribute to benchmarks for teacher assessment of the students' work;
- Create design teams similar to the student mentor collaborative teams, within the classroom each working on different projects, but able to interact with others by contributing to their works as consultants;
- Place emphasis on developing collaborative relationships between students within groups, with other groups at different development levels, and with teaching staff;
- Encourage a communicative and supportive approach with all class members using rich explanations and highly visual presentation of their design methods and outcomes as developed for the authentic design tasks;
- Place the emphasis in design on it being a guided journey of discovery with clear communication by the students of their design development path showing their exploration of all ideas using sketching and notes, backed up by open forum articulation of the reasons why they accepted or rejected the ideas presented; and
- Provide positive reinforcement of student design ideas throughout project development.

The learning tasks
The learning tasks should be arranged to:

- Use authentic projects that replicate broad based design office commissions using design situations where teacher guided analysis of the design brief can readily define key elements as linked to replicable design processes and procedures that can be implemented through small stages of design development;
- Implement small staged design procedures of increasing complexity and difficulty typical of design office working practices;
- Address particular aspects of design or design situations, for which authentic commercial design office-set drawings are available that show how similar problems to those in the student projects, were addressed by professional designers. Include multiple design industry disciplines and real links to regulatory bodies and municipal approval agencies; and
- Provide sufficient challenge in their diversity and degree of difficulty to promote student striving to achieve excellence in creative, innovative design solutions.

Application of the study findings to other discipline areas

Although this study focussed on learning in the building design profession, findings reported here have wider application in education and training in other discipline areas. Some aspects of what this study has shown have application to any profession where there is a demand for creativity in visualising and resolving problem situations through the use of replicable procedures and heuristic strategies that may be used for dealing with multi-factor influenced situations. The dual domains of creative design and technical knowledge of construction methods required of a building designer have similarities with other professions such as engineering, surveying, cartography, dental technicians and web-page design, as some examples. The following elements of this study can be applied to any similar discipline using learning situations constructed around a cognitive apprenticeship approach to learning:

- all tasks must be authentic and true to the usual demands of the discipline;
- all of the participants must be willing to contribute to the collaborative activities required by modelling, coaching, scaffolding, articulation, reflection and exploration;
- students need to have at least elementary skills in the discipline in order to commence their collaboration with a mentor at a level that does not require the mentor's total attention at all times;
- mentors are best selected (as volunteers) from expert practitioners who have shown:
  - excellence in their professional practices;
  - have established communication skills;
  - have at least elemental experience with teaching or mentoring in the commercial sector or tertiary institution; and
  - have an awareness of the teaching strategies and nature of a cognitive apprenticeship approach to learning, either formally acquired or intuitive.
- the mentoring situation needs to be typical of the environment and culture in which the expert practitioner usually operates in order to replicate the context and culture of the domain of practice; and
- the learning situation needs to be fully resourced in the same manner that the students might encounter when entering professional practice in a commercial setting.

Conclusion: Using cognitive apprenticeship for learning building design

The use of a learning situation that incorporates the working environment, activities, and tasks presented in the four-part structure outlined above, in conjunction with the teaching strategies of a cognitive apprenticeship (Collins et al., 1989) approach to learning can be an effective way to teach building design students. Such an approach is essentially constructivist. Findings to emerge from this research show that the complex demands of the building design profession, with its need for creativity and technical know-how, were successfully addressed using the methods and learning situation described here. It is the view of this writer that application of a similar structure and teaching methods to a classroom setting can potentially facilitate student learning in ways similar to those observed in the design office settings of this study.

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