An Annotated Bibliography of Publications About Creativity and Innovation within Software Development

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Abstract

This annotated bibliography maps previous research on creativity and innovation within software development. The annotations have been analyzed and categorized to provide an overview of what the community currently knows and does not know, and allow developers and researchers to easily locate relevant knowledge about creativity and innovation within software development.

The main motivation for creating this bibliography is to help researchers focus towards areas where little research has been done.

Introduction

Couger, Higgins, and McIntyre [Cou90] states there is a need for more creativity and innovation within software development, because all the simple and straight-forward systems have already been developed.

Software development may seem as an inherently creative and innovative business area, because it is relatively new; but the methods which have been applied, traditionally, suggests otherwise. According to Pressman [Pre05], traditional software development is based on a plan-driven method, which means a heavily defined process, where every stage in the development is laid out in the beginning. The steps in the plan are sequentially linked and dependent upon each other. In plan-driven development, the plan has to be precisely described in advance and requirements to the product have to be specified early. This is not possible when there is great uncertainty about the end product, as is the case with creative and innovative products.

So it seems there is a controversy between the need for creativity and innovation within software development and the traditional way of developing software.

A search for the word "creativity" on Google Scholar results in about 417,000 publications. A similar search for the word "innovation" returns a warping 1,610,000 publications.

Even though there exists a lot of literature about creativity and innovation, we suspect that the extent of research on creativity and innovation within software development is limited. This is a problem as Miller, Couger, and Higgins [Cou93] concludes that the creative style of Information System personnel is significantly different to those in other occupations – it is much more experimental. If this is the case, then it means that tools, guidelines, and processes from other occupations can not be expected to be immediately applicable in software development.

This annotated bibliography maps previous research on creativity and innovation within software development. The annotations have been analyzed and categorized to provide an overview of what the community currently knows and does not know, and allow developers and researchers to

easily locate relevant knowledge about creativity and innovation within software development.

The main motivation for creating this bibliography is to help researchers focus towards areas where little research has been done.

Creativity and Innovation

The word *create* originates from the Latin word "creare", which means to bring into existence. *Creativity* is the ability to create, so the linguistic and historic definition of creativity is "the ability to bring into existence". *Innovate*, originally, comes from the Latin word "innovare", which means to renew.

Creativity and innovation are, however, two abstract concepts, which several people and organizations have tried to define. The many understandings have resulted in the two words being used rather arbitrarily and with some confusion in today's literature. To illustrate how differently the words are understood we present a few interpretations of the words in the following.

Our perception of *creativity* match the definition in Encyclopædia Britannica [Enc06]:

> "*...the ability to make or otherwise bring into existence something new through imaginative skill, whether a new solution to a problem, a new method or device, or a new artistic object or form.*"

Couger, Higgins, and McIntyre [Cou90] have examined different understandings of creativity and presents, among others, these three definitions:

1. Bruner [Bru68] have the simplest and widest definition. He defines creativity as:

   "*...an effective surprise.*"

We find this definition too subjective. An effective surprise can only be judged individually. It is, furthermore, not very informative. It does, e.g., not state how creativity is manifested.

2. Ciardi [Cia56] makes a narrower definition, he defines creativity as:

   "*...the imaginatively gifted recombination of known elements into something new.*"

Ciardi assumes that creativity occur from something that is already known and results in something new, e.g., a product, a design, or a mental model. We believe that creativity can also occur as a result of a specific state of mind and situation.

3. Keil [Kei87] has a completely different point of view describing creativity as more of a process:

   "*...a state of mind that is always alert and ready to turn any kind of stimulus into an idea. It is the ability to look at things differently.*"

Our perception of creativity is closest to a combination of the last two proposals. We do, however, not believe that these definitions cover the term completely, because they, e.g., do not bring up the subjects of how creativity occurs and whether creativity originates from an individual or in a group. Does creativity, e.g., occur by coincidence? Keil mentions the potential of a "state of mind", but we believe this potential is only visible when utilized to create an idea. In accordance with the previous definition from Encyclopædia Britannica, this idea can be in the form of a solution to a problem, a new method or device, or a new artistic object or form.

Our perception of *innovation* match Couger's [Cou94] definition:

> "*...the successful implementation of creative ideas in the organization.*"

Couger, Higgins, and McIntyre [Cou90] have similarly examined the use of the word innovation and have identified two common understandings:

1. The first understanding is supported by, e.g., Roberts [Rob88]. He defines innovation as:

   "*invention + exploitation.*"

Invention is basically the result of creativity. Creativity results in ideas, which usually have to grow into an invention. Roberts' definition of innovation is only supported by a minority, as invention is usually considered to be a separate activity, i.e., not part of innovation. It is, however, a common understanding that any innovation process involves some sort of exploitation.

2. Westwood and Sekine [Wes88] provides a definition which considers invention as an independent part of the innovation process; they define innovation as:

   "*...the process by which inventions are... transformed into a profitable product or system.*"

The second definition by Westwood and Sekine matches our perception of innovation well, but we do not think that an innovation always results in a profitable product or system. An innovation should add value of some kind, but not necessarily in the form of money; it could also be, e.g., moral or aesthetic value. An innovation may also not result in a product or system, it could, e.g., be an improved work process. Also, we do not like the word *invention* as it implies something radically new. An innovation may also be an improvement of something existing.

Bessant, Pavitt, and Tidd [Bes05] also discuss what innovation is, and present an understanding of the word based on six other definitions.

3. The definition of Bessant, Pavitt, and Tidd contains similar perceptions as Westwood and Sekine, but with a wider perspective:

   "*...a process of turning opportunity into new ideas and of putting these into widely used practice.*"

Instead of focusing on the profit of the innovation as Westwood and Sekine, the focus of Bessant, Pavitt, and Tidd is on the implementation of ideas as widely used practice in the targeted group or in larger parts of society. The definition is, furthermore, not limited to concern an innovative product, but instead uses the wider term "ideas". In fact, this definition provides a combination of both creativity and innovation by talking about the process from opportunity to idea, and even into practice.

To summarize; *creativity* refers to the production of ideas for the solution of a problem, whereas *innovation* refers to the composition of the ideas and conceptualization into a viable solution to the initial problem.

Types of Innovation

Instead of only using the generic term "innovation", Martinich [Mar02] has introduced some more technical variants of innovation, which are used throughout the rest of this annotated bibliography.

Innovation can refer to many areas in the creation and evolution of something. In overall terms innovations are either disruptive or incremental. *Disruptive innovations* are radical, meaning the innovation overturns the existing dominant technology or product in the market, or creates an entirely new technology or product. *Incremental innovations* improve existing technologies meaning, e.g., adding new functionality to, or increasing the usability of a product.

The kinds of innovations that are by far the most common, are product innovations and process innovations. A *product innovation* is a new and unique product or the evolution of an existing product, whereas a *process innovation* is a new way of developing or producing the product.

Product and process innovation can both be either disruptive or incremental. Typically, an innovative solution is initially being developed as a disruptive innovation. Afterwards, it is matured by several incremental innovations until the solution is obsolete, whereafter a new disruptive innovation must be introduced, and the cycle repeats. [Mar02]

Research Context

Research at the Department of Computer Science at Aalborg University in creativity and innovation in relation to software development is currently centered around two specific and relating projects.

The first project is called Software Innovation Research Lab (SIRL). *SIRL* is a complete software development environment and laboratory, as the name implies, in which experiments and research related to innovation can be carried out. What differentiates SIRL from other physical software development environments, is that there is much more state-of-the-art technology available. The laboratory does, e.g., have four 64-inch interactive white boards installed. [The07b]

The second project is a draft for a new agile-inspired approach which is intended to facilitate creativity and innovation, called Essence. *Essence*

presents fragments of a process to support the creative team in developing an innovative piece of software. The fragments can be seen as a sort of toolbox with tools, which can be employed in a specific project. The Essence framework consists of four views and three modes, which altogether is meant to cover the complete development of innovative software; from the initial idea to the release and beyond. The three modes are called Idea, Planning, and Growing, and split the process into three conceptual stages. This annotated bibliography is particularly relevant for Idea mode, as the purpose of this mode is to generate ideas. The four views are called Project, Product, Process, and People. The four views run in parallel on the four screens in SIRL and offers an interactive holistic view on the development at the current stage. Because Essence is built on agile principles we want to investigate if publications concerning creativity and innovation advocate an agile approach as well. [The07a]

The results and experiences acquired on the basis of the publications discovered in this annotated bibliography will be used to provide researchers with an overview over where more research is required.

Research Scope

Instead of looking at creativity and innovation in a wide perspective, this annotated bibliography focuses on creativity and innovation in software development. Generic creativity and innovation theory may not be applicable in software development, as previously mentioned, for which reason there is a need for locating creativity and innovation theory especially aimed at software development.

In accordance with the generic definitions of creativity and innovation provided earlier, *creativity in software development* refers to the ability to suggest a solution to, or contribution to a solution, of a specific problem that can be solved with software.

Innovation in software development refers to the composition of ideas and conceptualization into a viable new and unique product or the evolution of an existing product. It may also be a change in the software development process. The primary research scope with regard to innovation is on product innovations and process innovations which facilitates product innovations. Generic process innovations, popularly called Software Process Improvement (SPI), in itself is not covered in this annotated bibliography. As SPI does not aim to improve creativity or facilitate innovations. The following research is generally not included in this annotated bibliography:

- Research concerning software for supporting generic creativity or innovation, rather than creativity or innovation within software development.
- Research which focuses on traditional SPI, e.g., improving efficiency or reducing errors. These are process innovations, which are beyond the scope of this annotated bibliography. SPI, meant to facilitate creativity and innovation, is, however, included.
- Research dealing with the organizational ripples a finished software innovation creates, rather than the development of innovative software.

Research Method

Two research approaches have been used to locate publications; systematic search and opportunistic search.

Systematic search refers to an approach where a set of predefined rules are used to exhaustively search a predefined search space with the purpose of locating a large part of the publications in the search space.

The Institute of Electrical and Electronics Engineers (IEEE) Computer Society and Association for Computing Machinery (ACM) digital libraries have been searched systematically. These libraries were selected because they are the largest information system databases. Many of the publications in their databases have, furthermore, been through a review process by well-qualified and impartial reviewers, with the purpose of ensuring publications at a certain technical level with soundly-based arguments [Ass01, Ins06]. All publications from the ACM and IEEE Computer Society databases containing the keywords “software” or “information system” in combination with either the keyword “innovation” or “creativity” have been considered for the literature study.

Opportunistic search is a less systematic approach with a broader scope; meaning not directly

aimed at specific databases. The purpose is not to exhaustively search a predefined search space, but to search among as many publications as possible through as many sources as possible. The philosophy behind the opportunistic search is that the most relevant publications are well cited, and should appear no matter the search route.

We do not expect all relevant research to be published in IEEE or ACM. Opportunistic search has been used to locate possible fundamental research which has not been located in the systematic search due to the reduced search space. Sources utilized in the opportunistic search encompass, e.g., references in literature found using the systematic search method, the web site search engine *Google*, the *Google Scholar* scholarly search engine, the largest human-edited directory of web sites *Dmoz*, and the largest online web shop *Amazon*.

Research Findings

The systematic and opportunistic searches revealed a substantial amount of publications, but many of these did not deal with creativity or innovation within software development. A total of 69 publications were selected for a more thorough analysis. 51 of the 69 publications was found in the systematic search; 39 publications in the IEEE Computer Society database and 12 publications in the ACM database. The remaining 18 publications was found in the opportunistic search.

The more thorough analysis based on the three criteria stated in the *Research Scope Section* meant that the number of publications was reduced to 33 publications; 21 from the IEEE Computer Society database, 3 from the ACM database, and 9 from the opportunistic search.

The publications originates from North America, Oceania, and Western Europe, more specifically, USA, Canada, Australia, United Kingdom, Italy, Finland, and Denmark.

Researchers from University of Colorado in Colorado Springs, USA and City University in London, United Kingdom are involved in several of the publications, which may indicate that a substantial amount of research on the topic takes place in these locations. Most other institutions are only represented by a single publication.

Annotation Style

An annotated bibliography is a list of citations, where each citation is followed by at short annotation; a short descriptive and/or evaluative résumé of the source. There are four major types of annotation styles according to The Writing Center at the University of Wisconsin-Madison [Uni06]. These four styles are:

Indicative: This form of annotation defines the scope of the source, lists the significant topics included, and tells what the source is about. There is no attempt to give actual data such as hypotheses, proofs, etc. Generally, only topics or chapter titles are included.

Informative: This form of annotation is a summary of the source. It consists of the thesis, the arguments or hypothesis, a list of proofs, and the conclusion.

Evaluative: This form of annotation assess the source's strengths and weaknesses. It states why the source is interesting, or why it is not. The annotation does also list what kind of and how much information is given.

Combination: This form of annotation, usually, contains a few sentences describing the content of the source and a few sentences providing an evaluation. Most annotated bibliographies are of this type.

A list of annotations for our research findings can be found in the *Annotations Section* in the back of this paper.

The annotation style in this bibliography is of the combination type. Each annotation starts with an evaluation of how the source contributes to the topic presented in this annotated bibliography. It is followed by a short summary of the source, describing the focus and content.

Citation Analysis

The purpose of this section is to examine the publications and their authors respectively, i.e., more specifically:

- Connections between the authors in the form of co-authoring,

- Connections between the individual publications in the form of citations,
- Locate the most significant authors and publications.

Figure 1 shows authors which have worked together on creativity and innovation. The nodes represent authors and the edges represents collaboration. For the sake of clarity the figure does not include authors which have not collaborated with others, or isolated author pairs that have only written a single article together. The size of the nodes in Figure 1 illustrates how many times the author's publications have been cited, however, not including those which are not in this bibliography. The number of citations is based on data from Google Scholar; a search engine, which is used because it searches for scholarly literature across databases and has cross-indexes.

Two large clusters in Figure 1 stand out. The most conspicuous cluster consists of 10 authors and have Couger as the most cited author, with a total of 87 citations. The second conspicuous cluster consists of six authors and have Maiden as the most cited author, with a total of 46 citations.

The authors in the Couger cluster comes from the USA with the exception of a single author named Dengate from Australia and a single author from Finland named Ruohonen. Dengate is represented with a direct parent-child connection to Couger in Figure 1, which means that they have worked together. Ruohonen is a grandchild node to Couger in the figure meaning that they have not worked directly together; Couger has worked with Higgins and Higgins has worked with Ruohonen. The main institution in this cluster is University of Colorado represented by Couger, Higgins, and McIntyre. Research in this cluster mainly concerns how to measure and improve creativity in IS organizations.

The authors in the Maiden cluster are all from the United Kingdom. Most of them are associated with City University in London. They collaborate with J. Robertson and his wife S. Robertson from The Atlantic Systems Guild and Greenwood from National Air Traffic Services. Research in this cluster mainly concerns how to integrate creativity into requirements elicitation and engineering.

The impact on future research is an important indicator of the quality of a publication. By sorting the publications according to the number of citations to each publication, we can see how well-known they are; and the more well-known they are, the more likely they are to have an impact on other research.

Table 1 shows the number of citations to each publication found in Google Scholar. The most cited articles are [Cou93a] and [Giz01]. One of these articles are by Couger and the other is from the Maiden cluster, so it appears that both clusters have well-cited publications.

Recent publications will of course not be as cited yet, but Table 1 should still emphasize high quality publications.

Citations	**Publication**
16-20	[Cou93a], [Giz01]
11-15	[Cou90a], [Cou91], [Cou92], [Cou94], [Gre04]
5-10	[Ane04], [Bos93], [Cou93], [Giz04]
1-4	[Cou97], [Dea98], [Fra05], [Gla01], [Hig96], [Kak03], [Lob94], [Lob95], [Mai05], [McC98], [McL93], [Ven99], [Wal94]
0	[Amo95], [Ane05], [Cal91], [Gla06], [Hig97], [Hig98], [Mai06], [Mar02], [Nic05]

Table 1: Publications ordered by the number of citation to each publication.

Figure 2 shows how the publications in this bibliography cite each other. Each node represent publications and each edge represent a citation. The size of the nodes shows how many times a given publication is cited in total, i.e., both by the publications in this bibliography and other publications, based on data from Google Scholar. The publications are sorted by their publication year to make development visible.

Again, two clusters seems to stand out, even though they are weakly connected.

The first mainly consists of publications from the Center for Research on Creativity and Innovation at University of Colorado published from 1990 to 1997. Their research ends with a publication called

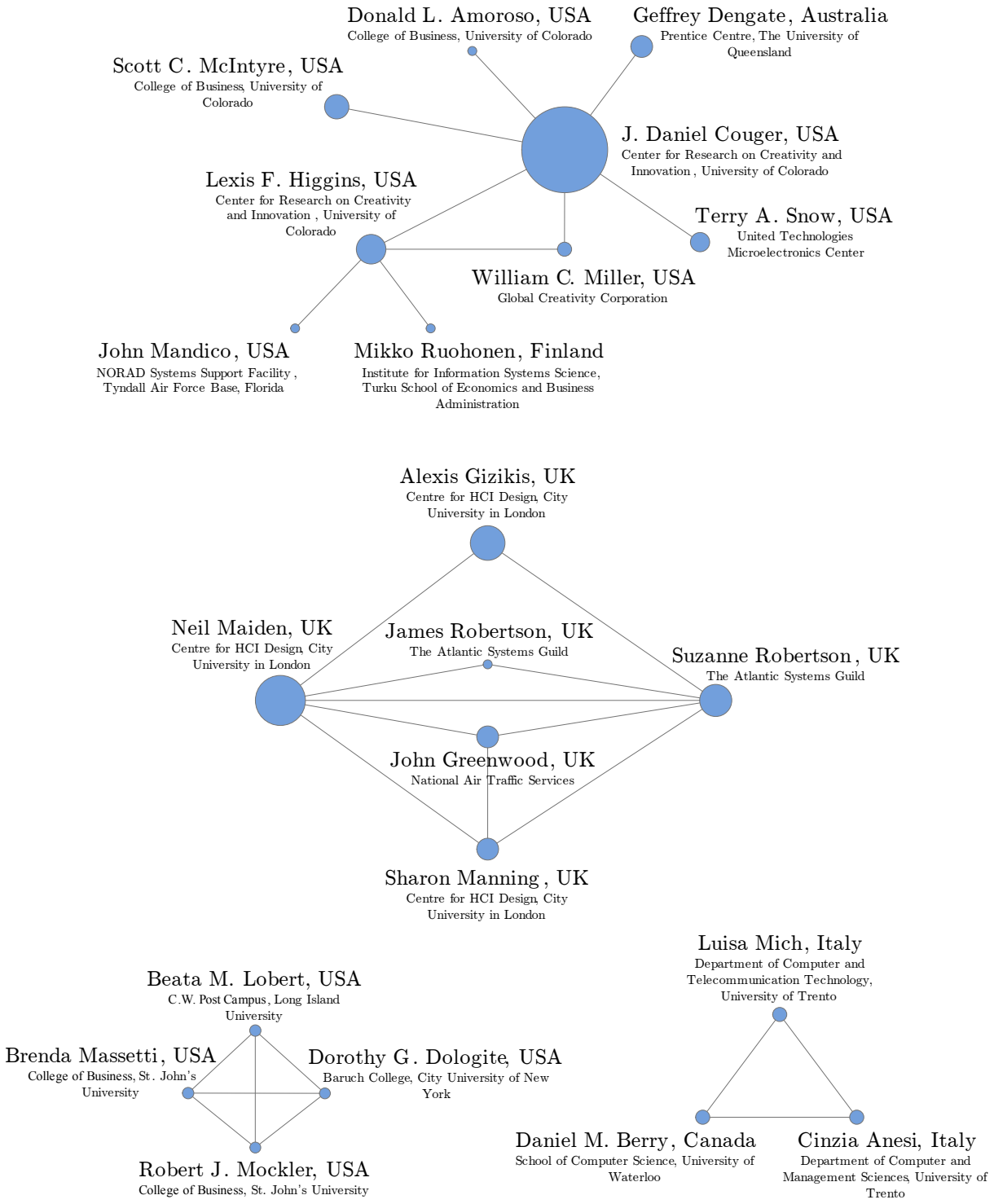

Figure 1: Network of collaboration between authors.

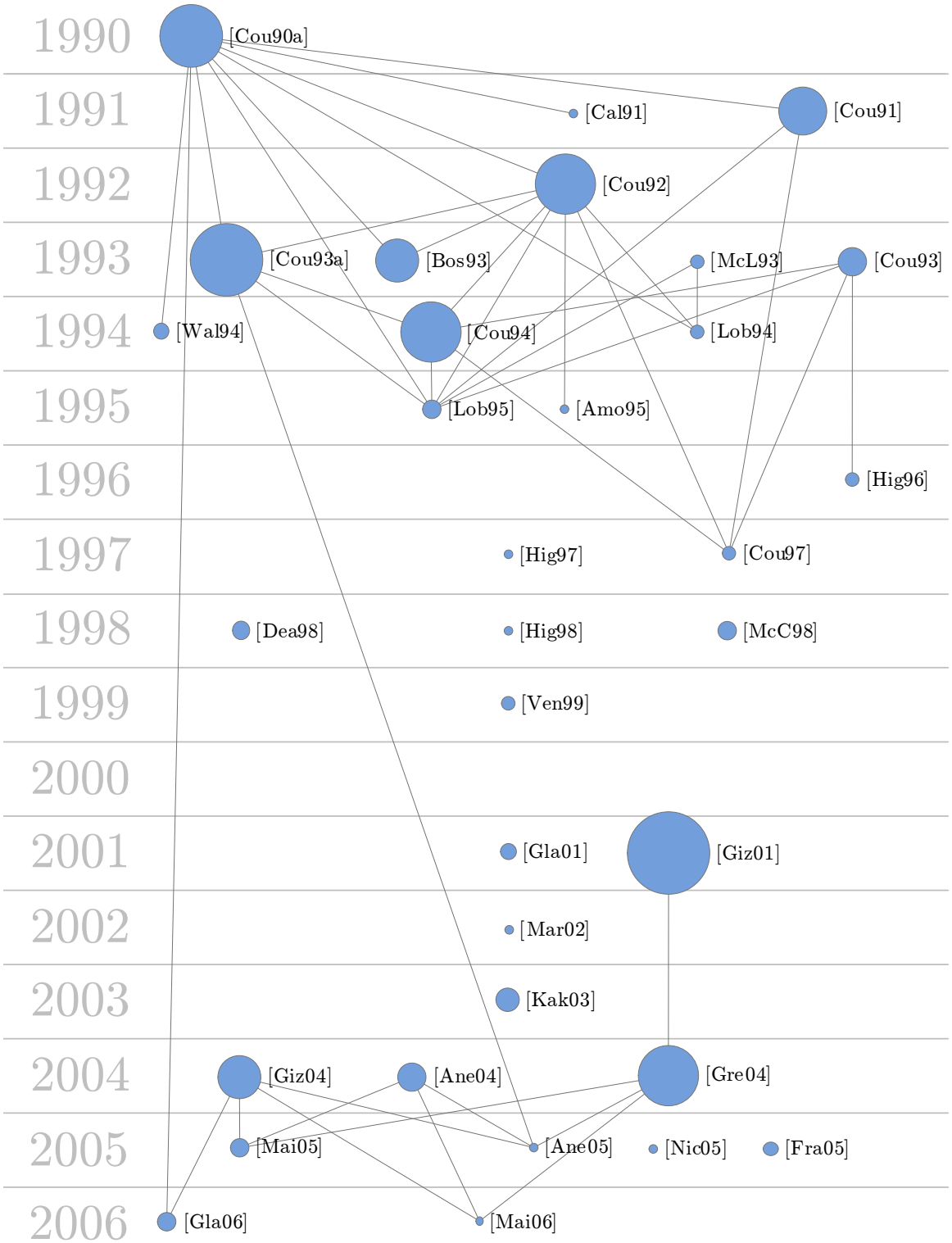

Figure 2: Network of citations between publications.

"Results of a Trans-Discipline Research Structure for Study of Creativity/Innovation in I.S." [Cou97] which summarizes their research. This is Couger's last publication on the topic as he passes away shortly after.

The second cluster is much newer and does mainly consist of publications from the Maiden cluster at City University in London, as shown in Figure 1. This cluster is almost completely separated from the previous research performed at the University of Colorado and marks a completely new line of research.

Categorization

This section provides an overview of publications on creativity and innovation within software development. The main purpose is to categorize publications in a manner which allows software developers and researchers to identify literature. As we described in the *Research Scope Section*, we will, furthermore, determine if the literature, in general, advocates an agile approach to facilitate creativity and innovation.

We have derived a framework for categorization of publications from the work of Couger. Couger's philosophy is positivistic. He believes that to improve creativity or innovation within software development one needs to be able to measure it. Because of this, the research of Couger concern ways of measuring creativity and innovation within software development. This is visible in Table 2 which shows publications that describe how to measure creativity or innovation within software development.

Measuring Creativity or Innovation
[Cou92], [Cou93], [Cou94], [Cou97], [Hig96], [Wal94]

Table 2: Publications which describe how to measure creativity or innovation.

Couger et al. actually appears to be the only ones who have done research about how to measure creativity and innovation within software development. The part of their research, which we have used to categorize publications, is a framework originally developed by Rhodes.

Rhodes [Rho61] specifies four aspects, that influence creativity – called the *4P's model* of creativity. The publications in Table 2 all suggest that these four aspects can be used to measure creativity in software development. The four Ps are:

Person: the personality, intellect, traits, attitudes, values, and behavior of those involved in the creative process.

Process: stages of thinking people go through when overcoming a problem or achieving a solution which is both novel and useful.

Press (work environment): the way people relate to their environment and theories about situations which are conducive to creativity.

Product: the characteristics of artifacts, new thoughts, ideas, inventions, designs, or systems.

A categorization by the 4P's model will allow researchers to locate research relevant to different aspects of creativity. Some publications do, however, not discuss any of the Ps and are therefore marked with *N/A* in the categorization.

The creativity aspects suggested by Rhodes does not differentiate between creativity and innovation. However, there is a distinction between the two concepts according to the definitions stated in the *Creativity and Innovation Section*. Therefore, we differentiate between publications concerning creativity and innovation.

Table 3 shows the publications categorized according to the 4P's model and creativity and innovation in a five by two matrix. The categorization is based on a subjective assessment and an interpretation of which aspects each publication deals with. Some publications discuss more than one of the Ps or both creativity and innovation and are therefore found in more than one of the cells in the matrix.

All 4P cells contain more than one publication in both creativity and innovation. However, many of the publications have the same topic, e.g., many of the Couger publications concern how to measure creativity. The matrix is dominated by Couger et al., as some of their publications elaborate on the 4P's model.

	Creativity	**Innovation**
Person	[Bos93], [Cal91], [Cou90a], [Cou97], [Fra05], [Gla06], [Hig96], [Hig97], [Hig98], [Lob95], [McL93], [Wal94]	[Bos93], [Cou93], [Cou97], [Gla06], [Hig98], [McL93]
Process	[Ane04], [Ane05], [Bos93], [Cal91], [Cou90a], [Cou91], [Cou93a], [Cou97], [Fra05], [Giz01], [Giz04], [Gla06], [Gre04], [Hig97], [Hig98], [Lob95], [Mai05], [Wal94]	[Bos93], [Cou93a], [Cou97], [Dea98], [Fra05], [Gla06], [Hig98], [McC98]
Press	[Bos93], [Cal91], [Cou91], [Cou94], [Cou97], [Fra05], [Giz01], [Hig97], [Hig98], [Lob95], [McL93], [Nic05]	[Bos93], [Cou97], [Fra05], [Hig98], [Mar02], [McL93], [Ven99]
Product	[Amo95], [Bos93], [Cou92], [Cou97], [Gla06], [Hig97], [Hig98], [Lob94], [Lob95]	[Amo95], [Bos93], [Cou92], [Cou97], [Gla06], [Hig98], [Kak03], [Mar02]
N/A	[Gla01], [Mai06]	

Table 3: Distribution of publications according to the 4P's model.

The research project Essence, which is meant to facilitate creativity and innovation within software development is built on agile principles. For that reason we investigate if publications concerning creativity and innovation advocate an agile approach as well. As can be seen in Table 4 this is generally not the case.

Agile	**Traditional**	**N/A**
[Gla06], [Kak03], [Mar02]	[Ane04], [Ane05], [Cou90a], [Dea98], [Giz01], [Giz04], [Gre04], [Mai05]	[Amo95], [Bos93], [Cal91], [Cou91], [Cou92], [Cou93], [Cou93a], [Cou94], [Cou97], [Fra05], [Gla01], [Hig96], [Hig97], [Hig98], [Lob94], [Lob95], [Mai06], [McC98], [McL93], [Nic05], [Ven99], [Wal94]

Table 4: Distribution of publications according to whether they suggest using an *agile approach*, a *traditional approach*, or do not discuss development paradigm at all (*N/A*).

Only three publications in Table 4 advocate an agile approach. Eight publications suggest the traditional paradigm, which is partially related to the fact that the agile manifesto was not introduced until 2001. Even though five of the eight publications were written in 2004 or later, these concern requirements engineering in the traditional paradigm. The last 14 publications are not related a specific paradigm and may, therefore, be used with an agile approach as well.

Requirements Engineering
[Ane04], [Ane05], [Dea98], [Giz01], [Giz04], [Gre04], [Mai05], [Mai06]

Table 5: Publications concerning creativity or innovation in requirements elicitation and engineering.

Almost all publications which suggest traditional development concern ways of changing the requirements phase to support a creative or innovative approach. Table 5 lists publications concerning creativity or innovation in requirements elicitation and engineering. Seven of the eight publications from Table 4 suggesting a traditional approach are found in Table 5. Five of these were not surprisingly authored by Maiden and his colleagues, as their main research topic is requirements engineering.

Discussion

We have discovered that the amount of published research concerning creativity and innovation within software development is very limited as our search has only uncovered 33 relevant publications on the subject. A lot of the research is, furthermore, sporadic without connections to previous research in the field. This came as a surprise to us, as we expected that researchers would examine previous research within their field before conducting their own research.

Research on creativity and innovation within software development does not appear to be an actual research branch yet. We have only identified two groups of research of a significant magnitude. These two groups include about half of the publications and the newest group does not utilize any of the research in the first group. The first group has, e.g., discovered over 20 creative problem solving techniques that prove especially appropriate for the information system field. We are convinced that these techniques could have been utilized by the second group in relation to their research.

The first group emerged in the early 90s around the Center for Research on Creativity and Innovation at the University of Colorado with J. Daniel Couger and Lexis F. Higgins as main contributors.

The declared goal of this group was to conduct research on ways to improve creativity in organizations and, additionally, to work in a consulting capacity with organizations that wants to improve the creativity of individuals and teams. Their publications are primarily about ways of measuring creativity within software development.

The philosophy of the first group is clearly *positivistic*. They fit well within the classical scientific tradition, since most of their articles are about objectively measuring something, in their case the level of creativity and innovation within software development. From a positivistic viewpoint, this is important because it is impossible to improve something without knowing how to measure it. So by devising metrics for creativity and innovation, they believe that they are solving their initial goal, which was to improve creativity in organizations.

The second group of research was published from 2001 to 2006 and was centered around City University in London. Neil Maiden, Alexis Gizikis, and Suzanne Robertson, among others, are in this group.

The declared goal of this group was to create an innovative process, with software tool support, for specifying requirements for socio-technical systems. This included innovative techniques for creative requirements engineering, designed to run at the beginning of the development process. The purpose of these techniques are to discover and surface requirements and design ideas that are essential for system modeling and use case authoring. The primary focus for the researchers has been on including creativity techniques into requirements elicitation and engineering in the form of two day workshops.

The philosophy of the second group is part of the *mechanistic* heritage. The researchers appear to have worked a lot with requirements engineering and traditional software development, which is based on a bureaucratic approach with formalizations and rules. They are motivated by a desire to bring creativity and innovativeness into something that they think needs creativity and innovativeness; namely requirements elicitation and engineering.

We believe that traditional requirements elicitation and engineering in its essence focus on discipline and routine much more than on creativity and innovation. In traditional plan driven development, plans have to be precisely described in advance and requirements to the product must be specified early. This is not possible when there is great uncertainty about the end product, as is the case with creative and innovative products. "Requirements" can not be requirements in creative and innovative products, they are requests, features, thoughts, ideas; something that may and probably will change quickly as the product develops. Therefore, it may be difficult or impossible to make requirements elicitation and engineering creative.

The researchers in the second group mainly suggest two day workshops for requirements engineering, but does this make sense? Requirements emerge continuously for creative and innovative products, so one workshop is not enough.

The best way to improve requirements engineering may be to not do requirements engineering at all. Agile development may be one answer. Requirements elicitation is tailored into agile development, which means that new ideas can be discussed and incorporated into the product as they appear. Creative problem solving techniques may also be applied in agile development. Agile development can adapt to changing ideas, concepts, and projects in an effective way. It would be interesting to verify this assumption through case studies or experiments where Couger's techniques for measuring creativity are applied to both traditional and agile development and compared.

If agile development is part of the answer, then why is it, that nobody has done significant research about agile development and creative and innovative products? We think this is mainly because the agile manifesto has only existed since 2001 and most of the publications on the subject are older. Those which are newer do, furthermore, focus on what we see as the counterpart to agile development, namely traditional requirements engineering and plan-driven development. Researchers often adhere to those software development approaches they are used to, and are not easily persuaded into using other approaches such as the agile. The future will hopefully bring more research on creativity and innovation within software development and agile development.

To conclude this article, we have located research about creative problem solving techniques, creativity enhancing group support systems, and organizational requirements. We believe that there is a need for a new large study of creativity and innovation within software development; one that pays attention to previous research on the fields. Specifically, we suggest a study on how creative problem solving techniques and group support systems can be incorporated into agile development and what this requires by the development organization. We do also suggest case studies and experiments to verify that agile development is indeed more creative than traditional development and creative requirements engineering, and leads to more innovative products.

Acknowledgement

We wish to thank Ivan Aaen who has contributed with several ideas for this bibliography.

Annotations

[Amo95] Amoroso, Donald L.; Couger, J. Daniel. *Developing Information Systems with Creativity Techniques: An Exploratory Study.* Proceeding of the Twenty-Eighth Hawaii International Conference on System Sciences, Volume 4, pp. 720-728, January 1995.

This article shows how the creativity of an IS product can be measured.

The article presents a method based on content analysis, to measure the creativity of an IS product. The literature is reviewed to identify keywords which are descriptive for innovative products. A total of 16 keywords which indicate novelty and value are located and evaluated. The keywords are used in an experiment to scan texts about information systems to generate descriptive statistics. The article concludes that the results of the method correlates with a set of independent reviewer's opinion on the texts with regard to innovativeness. It is concluded that there is sufficient evidence to support its inclusion as an important metric of creativity.

Classification: Creativity, Innovation, Product, Measurement.

[Ane04] Anesi, Cinzia; Berry, Daniel M.; Mich, Luisa. *Requirements Engineering and Creativity: An Innovative Approach Based on a Model of the Pragmatics of Communication.* Proceedings REFSQ'2004 Workshop, 2004.

This article is a previous version of another article. See [Ane05] for a description of the content.

This article contributes with the same as [Ane05].

Classification: Creativity, Process, Plan-driven, Requirements engineering.

[Ane05] Anesi, Cinzia; Berry, Daniel M.; Mich, Luisa. *Applying a Pragmatics-Based Creativity-Fostering Technique to Requirements Elicitation.* Requirements Engineering, Volume 10, Issue 4, pp. 262-275, November 2005.

This article suggests an idea generation technique that encourage the creative person. The technique makes use of an already exisiting technique called the Elementary Pragmatic Model (EPM), which is interesting because it requires only minor changes in an organization, which already makes use of EPM.

The article suggests a creativity fostering technique for requirements elicitation. The technique is based on EPM, a method for analyzing relational patterns of interaction among groups. The suggested model is called EPM Creative Requirements Engineering Technique (EPMcreate). EPMcreate uses 16 response patterns suggested by EPM as a base for 16 mini sessions. Two experiments shows that EPMcreate generates more ideas than normal brainstorming. The quality of the ideas generated with EPMcreate were, furthermore, assessed to be better.

Classification: Creativity, Process, Plan-driven, Requirements engineering.

[Bos93] Bostrom, Robert P.; Fellers, Jack W. *Application of Group Support Systems to Promote Creativity in Information Systems Organizations.* Proceeding of the Twenty-Sixth Hawaii International Conference on System Sciences, Volume 4, pp. 332-341, January 1993.

This article suggests how Group Support Systems (GSS) can be used to complement Creative Problem Solving (CPS) techniques. Furthermore, it explains the benefits and potential of GSS.

The article describes how Group Support Systems (GSS) can be used to promote creativity and innovation in IS organizations both with regard to individual creativity and on an organizational level. It is argued how all four Ps in the 4P's model can be improved by a GSS and Creative Problem Solving (CPS) techniques. The article states that a GSS can support four generic activities: generating, organizing, evaluating, and communicating ideas, comments, and judgements. One of the conclusions is that the efficiency of a GSS depends on its ability to handle the sheer magnitude of information and its ability to make individuals access the comments of others to stimulate their thinking. It is also concluded that the power of a GSS does not come from the number of built-in CPS techniques, but in the ability of the individuals to utilize the GSS system in combination with CPS techniques.

Classification: Creativity, Innovation, Person, Process, Press, Product.

[Cou90a] Couger, J. Daniel. *Ensuring Creative Approaches in Information System Design.* Managerial and Decision Economics, Volume 11, pp. 281-295, December 1990.

This article maps creativity techniques used in other disciplines to IS. It lays a foundation for research on creativity techniques within IS by looking at techniques used in other disciplines and assessing their relevance to IS development.

The article starts out by looking at some of the disciplines where methods to facilitate creativity are common and have been successful, e.g., art, science, and engineering. It is observed that the creative process has four phases which are named Preparation, Incubation, Illumination, and Verification, respectively. The article moves on to describe how to promote creativity in IS and the positive outcome of doing so. Furthermore, some of the techniques used in other disciplines are described and assessed for their relevance to IS development.

Classification: Creativity, Person, Process, Plan-driven.

[Cou91] Couger, J. Daniel; Snow, Terry A. *Creativity Improvement Intervention in a System Development Work Unit.* Proceedings

of the Twenty-Fourth Annual Hawaii International Conference on System Sciences, Volume 4, pp. 412-418, January 1991.

This article shows that it is possible to improve creativity in an IS development team. It does, furthermore, suggest how it can be done.

The article describes a case study concerning the effects of introducing creativity improvements into a systems development unit. Two approaches are applied to improve the creativity of a work unit. The first is improvements in the environment to enhance creativity. The second is training in creativity techniques. The improvements are divided into three phases which include creativity reinforcement, utilization of tools, and evaluation techniques. The case shows that the work unit improved their creativity significantly.

Classification: Creativity, Process, Press.

[Cou92] Couger, J. Daniel; Dengate, Geoffrey. *Measurement of Creativity of I.S. Products.* Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences, Volume 4, pp. 288-298, January 1992.

This article presents a framework for evaluating the creativity of an IS product by measuring the utility and novelty of the product.

The article states that the creativity of IS products can be assessed in terms of utility and novelty. The measurements of utility are well covered within the software quality research. Novelty can, however, not be measured using conventional methods. This article presents six software products which are evaluated according to their level of utility and novelty using a rating framework.

Classification: Creativity, Innovation, Product, Measurement.

[Cou93] Couger, J. Daniel; Higgins, Lexis F.; Miller, William C. *Comparing Innovation Styles Profile of IS Personnel to Other Occupations.* Proceeding of the Twenty-Sixth Hawaii International Conference on System Sciences, Volume 4, pp. 378-386, January 1993.

This article shows that the innovative styles of IS personnel is different to personnel within other business areas. It, furthermore, suggests that IS personnel can be made more creative by the use of roleplay.

The article describes how a method called the Innovation Styles Profile (ISP) instrument have been applied to gather data about the innovative styles of three IS personnel groups. The ISPs are compared to those in other occupations. An analysis of the data collected reveals significant differences between IS personnel and personnel within other business areas. The article, furthermore, encourages IS personnel to get acquainted with different innovative styles in order to get a wider perspective on creativity. It is suggested that roleplay can be used to get an insight into different innovative styles, that does not come natural to a specific person.

Classification: Innovation, Person, Measurement.

[Cou93a] Couger, J. Daniel; Higgins, Lexis F.; McIntyre, Scott C. *(Un)Structured Creativity in Information Systems Organizations.* MIS Quarterly, Volume 17, No. 4, pp. 375-397, December 1993.

This article presents a set of case studies showing how creativity techniques from other disciplines can be used in software development. Definitions of creativity and techniques to facilitate creativity are, furthermore, discussed.

The article presents a set of creativity techniques which have been transported from other disciplines to the IS field to help individuals and teams become more creative. Six case studies show how analytical and intuitive techniques were used to solve IS-related problems. The analytical techniques are progressive abstraction, interrogatories, and force field analysis. The intuitive techniques are associations/images, wishful thinking, and analogy/metaphor. The article describes when and where to use creativity techniques in information system activities. The article, furthermore, contains a

description of other techniques, which may be utilized to facilitate creativity. These techniques are called: attribute association, boundary examinations, brainwriting-shared enhancements variation, bug list, decomposable matrices, dimensional analysis, disjointed incrementalism, manipulative verbs, morpological analysis, nominal group technique, peaceful setting, problem reversal, SIL method, and wildest idea.

Classification: Creativity, Innovation, Process.

[Cou94] Couger, J. Daniel. *Measurement of the Climate for Creativity in IS Organizations.* Proceedings of the Twenty-Seventh Hawaii International Conference on System Sciences, Volume 4, pp. 351-357, January 1994.

This article argues that the creative environment in IS organizations is different than in other business areas. Some parameters are valued higher by IS professionals than by other prefessionals, and visa versa.

The article describes the Work Environment Inventory (WEI) survey instrument which can be used to measure the creative climate of an organization. A WEI survey is conducted in eight IS organizations and the results are compared to non-IS organizations. The comparison shows that IS professionals tend to use a modifying and experimenting style whereas other professinals tend to use an exploring and visioning style. The article uncovers the existence of parameters in IS organizations that are valued significantly higher than in non-IS organizations, with regard to the creative climate.

Classification: Creativity, Press, Measurement.

[Cou97] Couger, J. Daniel. *Results of a Trans-Discipline Research Structure for Study of Creativity/Innovation in I.S.*. Proceedings of the Thirtieth Hawaii International Conference on System Sciences, Volume 3, pp. 309-317, January 1997.

This article summarizes research from the Center for Research on Creativity and Innovation at the University of Colorado. It does, furthermore, summarize how creativity can be measured with regard to the 4P's model.

The article desribes how researchers at the Center for Research on Creativity and Innovation at the University of Colorado have used a horizontally oriented research approach to achieve a holistic view on creativity and innovation in IS projects. Over a period of eight years the center has developed a method to measure the four aspects of creativity in the 4P's model; Person, Process, Project, and Press. This article summarizes the results of the research with regard to measurement of each of the four Ps.

Classification: Creativity, Innovation, Person, Process, Press, Product, Measurement.

[Dea98] Dearden, Andrew; Howard, Steve. *Capturing User Requirements and Priorities for Innovative Interactive Systems.* Proceedings of the Australasian Conference on Computer Human Interaction, pp. 160-167, December 1998.

This article suggests a method for the maturing of an innovation in early stages of development. The method describes how requirements can be identified when the end-users are unknown and functionality cannot be extracted from existing similar products.

The article presents a method for creating requirements and priorities in innovative product development. This method focuses on the development of disruptive innovations. It consists of four phases, starting by a clarification of the innovation's nature, then finding potential users, then making scenario walkthroughs, and, finally, identifying the needs of potential end-users.

Classification: Innovation, Process, Plan-driven, Requirements engineering.

[Fra05] Fraser, Jennifer. *Inspired Innovation: How Corel is Drawing Upon Employees' Ideas*

for User Focused Innovation. DUX '05: Proceedings of the 2005 Conference on Designing for User eXperience, Article No. 40, 2005.

This article describes how Corel Corporation managed to support all individuals in the organization in contributing to new innovative product releases. Four software tools developed reflect four components needed to build a great idea. This article suggests software functionality to support creativity and innovation in software development.

The article discusses considerations with regard to an iterative implementation of an information system for enhancing innovation at Corel Corporation. The purpose of the system is to improve existing products (product evolution). The main result of the article is a central repository for ideas and tools and processes for maintaining and utilizing this repository. The article addresses the characteristics of an innovation-enhancing information system, ways of representing ideas, and ways of rating and evaluating ideas. It also discusses processes for mapping ideas into a list of requirements and how this impacts quality assurance. The conclusion of the article is that a diminishing atmosphere of innovation at Corel Corporation has been replaced with formalized processes and procedures for enhancing innovation, and that the system was still in use at the time of writing.

Classification: Creativity, Innovation, Person, Process, Press.

[Gal91] Galetta, Dennis F.; Sampler, Jeffrey L. *Individual and Organizational Changes Necessary for the Application of Creativity Techniques in the Development of Information Systems.* Proceedings of the Twenty-Fourth Hawaii International Conference on System Sciences, Volume 4, pp. 404-411, January 1991.

This article presents a stategy for adapting creativity techniques. It, furthermore, summarizes different creativity and problem-solving techniques suggested by other researchers.

The article focuses on the adaption of creativity techniques in software development organizations. The article identifies the different types of problems that both individuals and the organization may encounter. It analyzes these different barriers and suggests a strategy for infusing creative idea generation into the software development process by overcoming the barriers.

Classification: Creativity, Person, Process, Press.

[Giz01] Gizikis, Alexis; Maiden, Neil. *Where Do Requirements Come From?.* IEEE Software, Volume 18, Issue 5, pp. 10-12, September 2001.

This article suggests ways to recognize the importance of creative thinking in requirements engineering. The recommendations are based on convictions from a number of sources from the area of requirements engineering.

The article focuses on how creativity can be included in requirements engineering and how it is done at the time of writing. It points out convictions of a number of people which have examined different aspects of working with creativity in software development. These aspects comprise different types of creativity (exploratory, combinatorial, and transformational), different phases (preparation, incubation, illumination, and verification), and social contexts (domain, field, and person) of a creative process.

Classification: Creativity, Process, Press, Plan-driven, Requirements engineering.

[Giz04] Gizikis, Alexis; Maiden, Neil; Robertson, Suzanne. *Provoking Creativity: Imagine What Your Requirements Could Be Like.* IEEE Software, Volume 21, Issue 5, pp. 68-75, September 2004.

This article shows how workshops can be used to create new ideas.

The article describes an session of Requirements Engineering with Scenarios for

User-Centered Engineering (RESCUE), a requirements engineering process described in [Gre04] and [Mai05]. RESCUE is applied to a system which provides computer-based assistance to air traffic controllers. A reflection upon the process is given and improvements are suggested, e.g., random idea generation using what-if questions.

Classification: Creativity, Process, Plan-driven, Requirements engineering.

[Gla01] Glass, Robert L. *A Story about the Creativity Involved in Software Work*. IEEE Software, Volume 18, Issue 5, pp. 96-97, September 2001.

This short article shows that creativity is an abstract concept that needs to be clarified.

The purpose of the article is to examine if software development requires creativity. The results of observing a number of students doing systems analysis is, however, fuzzy. Glass observes a lot of inactivity or "thinking", but an analysis of this does not result in any conclusion, because there is different opinions of what creativity is and what it is not.

Classification: Creativity.

[Gla06] Glass, Robert L. *Software Creativity 2.0*. developer.* Books, November 2006.

This book suggests various techniques to encourage creativity. The book, in general, looks at the topic from different viewpoints.

This book by Glass provides a good but incomplete overview of creativity within software development. The main point is that software construction is a highly complex problem-solving activity, which requires creativity. The importance of creativity is discussed based on research and personal experiences, and possible solutions or optimizations are suggested. The book relates to at least three of the four Ps in the 4P's model; person, process, and product.

Classification: Creativity, Innovation, Person, Process, Product, Agile.

[Gre04] Greenwood, John; Maiden, Neil; Manning, Sharon; Robertson, Suzanne. *Integrating Creativity Workshops into Structured Requirements Processes*. Proceedings of the 2004 Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques, pp. 113-122, 2004.

This article presents a process for generating requirements using creativity workshops.

The article concerns RESCUE, a requirements engineering process. The process introduces workshops in the requirement phase of plan-driven software development projects, which consists of a divergent exploratory phase and a convergent focusing phase. The objective is for the stakeholders to have a common system model in the beginning of the workshop, which is then explored and developed into a modified system model.

Classification: Creativity, Process, Plan-driven, Requirements engineering.

[Hig96] Higgins, Lexis F. *A Comparison of Scales for Assessing Personal Creativity in IS*. Proceedings of the Twenty-Ninth Hawaii International Conference on System Sciences, Volume 4, pp. 13-19, January 1996.

This article reviews three methods for assessing personal creativity in IS. It does, furthermore, provide an assessment scale for measuring personal creativity in IS, which is based on the main characteristics of the three reviewed scales.

The article starts by reviewing research conducted in the area of assessing creativity in general. The article uses the 4P's model (Person, Product, Process, and Press) and focus on the Person aspect. Afterwards, three creativity assessing methods used in IS are reviewed and compared. The outcome of the comparison is a new scale for assessing personal creativity based on the main characteristics of the three creativity assessment methods.

Classification: Creativity, Person, Measurement.

[Hig97] Higgins, Lexis F.; Mandico, John. *Integrating the 4 P's of Creativity in an IS*

Project: An Ethnographic Example from Hewlett-Packard. Proceedings of the Thirtieth Hawaii International Conference on System Sciences, Volume 3, pp. 298-308, January 1997.

This article integrates the 4P's model into a creativity project, and studies interactions between the four Ps. It suggests a model which describes the 4P's model as a cause and effect model, where Product is caused by the other Ps.

The article describes a project at Hewlett Packard with the purpose of conceptualizing and implementing a new interactive marketing tool. The team uses "participant observation", where the project manager and a consultant are observing the team in order to relate the work of the team to the 4P's model of creativity. A structural model is suggested that sees the three of the Ps; Person, Process, and Press, as exogenous variables. Product is the endogenous variable and is seen as a result of the other Ps.

Classification: Creativity, Person, Process, Press, Product.

[Hig98] Higgins, Lexis F.; Ruohonen, Mikko. *Application of Creativity Principles to IS Planning*. Proceedings of the Thirty-First Hawaii International Conference on System Sciences, Volume 6, pp. 382-390, January 1998.

This article uses activity theory to examine the interplay between creativity and IS planning. Based on an analysis of the use of creativity principles in IS planning in the last 35 years, the future implications for IS planning are stated. The 4P's model of creativity is used to indicate how each of the Ps interacted with IS planning.

The article identifies the impact of creativity on IS planning. The evolution of IS planning is divided into three periods; from 1960 to 1980, from 1980 to 2000, and from 2000 and beyond. Each period is analysed with activity theory in order to ascertain which creativity aspects are needed during each stage of evolution.

Classification: Creativity, Innovation, Person, Process, Press, Product.

[Kak03] Käkölä, Timo. *Software Business Models and Contexts for Software Innovation: Key Areas for Software Business Research*. Proceedings of the Thirty-Sixth Hawaii International Conference on System Sciences, January 2003.

This article outlines business, design, and development strategies for software innovation in software ventures.

The article focuses on software ventures and innovative organizations. The influence from different kinds of ventures on software innovations are discussed. Different design and development strategies are presented with special focus on the business part of the strategies, e.g., design a software product for multiple markets concurrently, design with modularity in mind, and run design iterations of different versions of the same product in parallel.

Classification: Innovation, Product, Agile.

[Lob94] Lobert, Beata M.; Dologite, Dorothy G. *Measuring Creativity of Information System Ideas: An Exploratory Investigation*. Proceedings of the Twenty-Seventh Hawaii International Conference on System Sciences, January 1994.

This article suggests a model for measuring the creativity of ideas based on a number of criteria stated by expert judges. The criteria are generated from a few IS project with a few academicians as judges.

The article suggests a model for measuring the creativity of ideas at an early stage of an IS project. The model is based on another model for evaluating the creativity of computer-aided design projects. The original model was revised based on suggestions from expert judges, and tested by comparing results from the model with the opinions of the expert judges.

Classification: Creativity, Product, Measurement.

[Lob95] Lobert, Beata M.; Massetti, Brenda; Mockler, Robert J.; Dologite, Dorothy G. *Towards a Managerial Model of Creativity in Information Systems*. Proceedings of the Twenty-Eighth Hawaii International Conference on System Sciences, January 1995.

This article presents a managerial model for creativity in IS organizations. The organization's outputs are highly influenced by input from the creative thinking inside the organization. Thus, management of creativity in IS organizations can be very important to assure competitive product outcomes.

The article proposes a model for managing creativity in IS organization. The model builds on four inter-connected managerial areas: Organizational Inputs, Creative Processes, Creative Outputs, and Organizational Outcomes. Organizational Inputs affects the Creative Processes, the Creative Processes affect Creative Outputs and so forth. The four areas are described in detail and shows the critical factors of the IS organization's influence on creative processes. The article states that the creative outputs are related to organizational outputs.

Classification: Creativity, Person, Process, Press, Product.

[Mai05] Maiden, Neil; Robertson, Suzanne. *Integrating Creativity into Requirements Processes: Experiences with an Air Traffic Management System*. Proceedings of the 2005 13th IEEE International Conference on Requirements Engineering (RE'05), pp. 105-114, September 2005.

This article suggests adjustments to the practical use of the requirements engineering process RESCUE, e.g., to introduce workshops adjusted to the specific project.

The article focuses on experiences with a requirements engineering process called RESCUE in the development of an air traffic management system. The practices of RESCUE are described and reflected upon, and suggestions to adjustments of the practical use of RESCUE are proposed based on the amount and quality of ideas.

Classification: Creativity, Process, Plan-driven, Requirements engineering.

[Mai06] Maiden, Neil; Robertson, James; Robertson, Suzanne. *Creative Requirements: Invention and Its Role in Requirements Engineering*. Proceeding of the 28th International Conference on Software Engineering, pp. 1073-1074, May 2006.

This article is a sort of tutorial for integrating creativity techniques, guidelines, tools, etc., into requirements engineering.

The article describes how to bring creativity into the current practices of requirements engineering. The authors argue that little requirements engineering research has addressed creative thinking directly. They argue that requirements analysts need to be inventors in order to create a more competitive product or business. This article is a draft for a tutorial on the 28th International Conference on Software Engineering in Changhai, China, 2006. The tutorial tries to fill the creativity gap in engineering practices.

Classification: Creativity, Requirements engineering.

[Mar02] Martinich, Leslie. *Managing Innovations, Standards and Organizational Capabilities*, IEEE International Engineering Management Conference, Volume 1, pp. 58-63, August 2002.

This article describes different management, engineering, marketing, and operation capabilities that are needed to make a successful innovation. It furthermore explains when these capabilities should be used.

The article starts by introducing three different types of innovation: product, process, and conceptual innovations. Every technology innovation typically follows a specific pattern of behavior. This includes four phases: the innovation phase, the chaos and commercialization phase, the standards phase, and the maturity phase. The article describes the different management, engineering, marketing, and oper-

ation capabilities needed in the individual phases.

Classification: Innovation, Press, Product, Agile.

[McC98] McConnell, Steve. *The Power Of Process.* Computer, Volume 31, Issue 5, pp. 100-102, May 1998.

This article presents an alleged optimal model for weighting the software process.

The article examines how effort is distibuted among different tasks in software development projects. This article focuses, especially, on the importance of controlling the process. Models are given for what happens if there is no attention paid to the process, if the process is not properly controlled, if the process is managed too late in a project, and if the process is handled correctly. The argument is that if the process is properly controlled, creativity will appear automatically.

Classification: Innovation, Process.

[McL93] McLean, Ephraim R.; Smiths, Stanley J. *The I/S Leader as "Innovator".* Proceeding of the Twenty-Sixth Hawaii International Conference on System Sciences, Volume 4, pp. 352-358, January 1993.

This article suggests how IS leadership should structure the organization and take initiatives to facilitate innovation.

The article discusses how an IS leader can be a key innovator. It presents a model of leadership, consisting of the technologist, manager, innovator, and strategist roles. The article states that up to 45 percent of an organization's performance can be explained by executive leadership and that effective IS leadership requires a focus on both technology and people. The challenges of an IS innovator is to create and sustain an internal environment that facilitates innovation and to re-engineer the business functions of the overall organization; because of this, the article presents several enviromental conditions that facilitate innovation. The article does, furthermore, state that IS leaders can stimulate innovation by articulating a vision of the changes technology can make to the core fuctions of the organization, by using creative tension to create a climate for innovation, and to foster early adoption of technology.

Classification: Creativity, Innovation, Person, Press.

[Nic05] Nichol, Sophie. *Creative Geeks..? Facilitating the Creative Growth of Computer Science Students Using Engaging Environment.* Proceedings of the 19th Conference of the Computer-Human Interaction Special Interest Group (CHISIG) of Australia, pp. 1-5, November 2005.

This article suggests that the environment is a key factor for creativity.

The article focuses on Press (environment) from the 4P's model. The claim is that the environment has strong influence on creativity in software development, this applies to online as well as physical set-ups. However, the study reports from ongoing research, so the claim has not been proven yet.

Classification: Creativity, Press.

[Ven99] Vendelø, Morten Thanning. *The Politics of Software Innovation.* Portland International Conference on Management of Engineering and Technology, Volume 1, pp. 401, July 1999.

This short article suggests an alternate view on innovation based on political power perspectives.

The article states that innovations are required for a software firm to stay alive. Innovations do, however, cost a lot of money and require a lot of time, which is a problem because it is impossible to forsee if an innovation is good or bad. The article sees the creation and implementation of innovations as power strugles. Individuals or groups of individuals pursue different interests and the step-wise implementation of an innovation becomes a race between subjective opinions and ressource allocations; it is a trial and error game before the innovation is completed.

Classification: Innovation, Press.

[Wal94] Walz, Diane B.; Wynekoop, Judy. *Creativity and Software Design: Is Formal Training Helping or Hurting.* IEEE International Conference on Systems, Man, and Cybernetics, Volume 1, pp. 842-846, October 1994.

This article illustrates how training in traditional software development techniques does not necessarily degrade the level of individual creativity.

The article examines if the formal methods taught in IS makes software developers more or less creative. This is done in two studies including MBA students with the use of a tool called the California Psychological Inventory Adjective Check List. The first study compares the creativity of 75 students majoring in the IS field with 111 students majoring in other fields. It can be concluded statistically that the IS students are significantly more creative than the other students. The second study compares IS seniors to new IS majors with regard to creativity. It can be concluded that the students entering an IS degree program are no more or less creative, on average, than those finishing the program. The article notes that the creativity of IS students are not especially different from the general population – the difference may occur because the students which are majoring in other business areas may be less creative.

Classification: Creativity, Person, Process, Measurement.

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