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Four PPPPerspectives on Computational Creativity

Anna Jordanous [1]

Abstract. From what perspective should creativity of a system be considered? Are we interested in the creativity of the system's output? The creativity of the system itself? Or of its creative processes? Creativity as measured by internal features or by external feedback? Traditionally within computational creativity the focus had been on the creativity of the system's Products or of its Processes, though this focus has widened recently regarding the role of the audience or the field surrounding the creative system. In the wider creativity research community a broader take is prevalent: the creative Person is considered as well as the environment or Press within which the creative entity operates in. Here we have the Four Ps of creativity: Person, Product, Process and Press. This paper presents the Four Ps, explaining each of the Four Ps in the context of creativity research and how it relates to computational creativity. To illustrate how useful the Four Ps can be in taking a fuller perspective on creativity, the concepts of novelty and value explored from each of the Four P perspectives, uncovering aspects that may otherwise be overlooked. This paper argues that the broader view of creativity afforded by the Four Ps is vital in guiding us towards more encompassing and comprehensive computational investigations of creativity.

1 Introduction

A practical issue arises when considering the evaluation of a computational creativity system: from what perspective should creativity of a system be considered? Are we interested in the creativity of the system's output? The creativity of the system itself? Or of its creative processes? Creativity as measured by internal features or by external feedback?

The computational creativity community has traditionally considered creativity from the perspective of the creative output produced by a system, or the processes employed within creative systems (with notable exceptions, such as Saunders [48]). The call for this ICCC 2014 conference invites papers addressing the 'Process vs. product: addressing the issue of evaluating/estimating creativity (or progress towards it) in computational systems through study of what they produce, what they do and combinations thereof.'

This paper argues that to consider process and product is not enough; computational creativity should be considered and explored from four different perspectives, known as the Four Ps: the creative Person, Product, Process and Press (or environment) [43, 26].

The Four Ps have long been prevalent in creativity research relating to humans[2] and enable a more inclusive and encompassing approach to the study of creativity and accommodating multiple relevant perspectives. Here the Four Ps are presented and considered in the light of how they are relevant to computational creativity researchers.

1.1 The product/process debate in computational creativity evaluation

> 'As a research community, we have largely focussed on assessment of creativity via assessment of the artefacts produced.' [8, p. 1]

As illustrated by the ICCC 2014 call for papers, one important debate in computational creativity is about whether evaluation of a creative system should focus exclusively on the output produced by the system, or whether the processes built into the system should also be taken into account. Should both product and process should be included in evaluation [39, 8, 20], or should evaluation concentrate solely on the product of systems [45]? Ritchie [45] stated that examining the process is unimportant for creativity, arguing that humans normally judge the creativity of others by what they produce, because one cannot easily observe the underlying process of human creativity. Ritchie therefore advocated a black-box testing approach, where the inner program workings are treated as unknown and evaluation concentrates on the system's results. Later, however, Ritchie [46] conceded that it can be important to consider a system's 'mechnisms' in the case of 'more theoretical research'[46, p. 147].

While it is true that we can only use the material we have available to form an evaluation, evaluation experiments [36, 19] show that people often make assumptions about process in their judgements on product. As Hofstadter pointedout, '*covert mechanisms* can be deeply probed and eventually revealed merely by means of watching *overt behaviour* ... [this approach] lies at the very heart of modern science.' [15, quoted in p. 10, [39]]. Pearce & Wiggins [36] discussed how our interpretation of how something was produced is important, even if the actual method is unknown, and that such an interpretation can be derived if people are repeatedly exposed to the compositional systems (human or computational) that they are evaluating. Collins [6] discussed how making reasonable assumptions can assist the reverse-engineering[3] of program code from output, in scenarios where white-box testing (evaluation with access to the program code) is not possible.

Colton [8] acknowledged Ritchie's arguments but quotes examples from art to demonstrate that process is as important as the end product when evaluating creativity, at least in the artistic domain. As evidence, Colton cites conceptual art for details on conceptual art in the context of this debate, where the concepts and motivations behind the artistic process are a significant contribution of the artwork. Sol LeWitt defined Conceptual Art [25] as an art form where 'the

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[2] Variants of these *Ps* also arise in slightly different guises in non-related areas, such as software project management [16] or education [2].

[3] Reverse-engineering is the process of identifying and perhaps replicating how a product is made, through analysis of that product.

idea or concept is the most important aspect of the work. ... The idea becomes a machine that makes the art.' Two examples are Tracey Emin's controversial exhibit *My Bed* (1999) and Duchamp's Fountain (1917). Jordanous [20] makes similar arguments for creativity in musical improvisation, finding that the process of improvisation is often seen as more relevant for creativity than the end result.

If assessing how creative a piece of conceptual art or a musical improvisation is, solely by evaluating the product, then there are two negative consequences:

1. The primary intentions of the artist/musician are ignored (their focus is on how the creative work is made rather than the end result).
2. The level of creativity presented will probably be underestimated, especially if the creative process results in producing something that might seem commonplace outside the context of that art installation/musical performance.

Colton [8] also posed a thought experiment that considers two near-identical paintings presented at an exhibition. In the first painting, the dots are placed randomly, whereas in the second, the dots' locations represent the artist's friendships with various people. Colton argued that the second painting would be more appealing to purchase than the first, though the end product is very similar, due to the process by which it was created. Colton's thought experiment illustrates how process can impact on our judgement of creative artefacts, though one could question if the experiment explores perception of creativity, or of quality/appeal.

The thought experiment described by Ventura [54] gives further evidence (perhaps unintentionally) on how knowledge of the creative process affects how we evaluate creativity. Two creative systems, the RASTER and iRASTER systems, were designed by Ventura to be decidedly non-creative. If these systems were implemented and their generated images were given to people to evaluate without telling the evaluators how they were produced, the evaluators may well rate the creativity of the system highly. Supplying the evaluators with details of how a program works, though, could have a detrimental impact on the subsequent evaluations [11, 8].

One issue with creativity is analogous to the adage that a magician never reveals their secrets. This adage is based on the fact that tricks do not appear so impressive once you have found out how the magician performed the trick. Similarly things can appear to be less creative when you know how they were produced:[4]

> 'it is not unknown for critics of AI to refuse to accept programs as creative (or intelligent) once the mundane mechanistic nature of the inner workings are revealed' [44, p. 4]

Colton [8] intentionally sidestepped this issue by reporting on his artistic system in high-level terms only, rather than giving details of the program [8, p. 8].

Until recently, computational creativity evaluation methodologies mainly looked solely at a system's *products* [45, for example] or at a combination of the *products* and the *process* [39]. Recently it has been acknowledged that there is more to creativity than process and product, with the Creative Tripod [8], whose evaluative framework is influenced by how an audience perceives the creativity of a system, SPECS [20] which requires the researcher to investigate what creativity means in the context of their system, and the FACE/IDEA models [9] which consider various aesthetic features and interactions between audience and system. Work on computationally creative societies has also developed in the last few years [48, is a significant example].

Along a similar broadening of perspectives, the next section brings in work from the wider creativity research community, examining further viewpoints - the creative *person* operating in a *press*/environment - and relating these viewpoints to a computational creativity standpoint.

2 The *Four Ps* of creativity

One major approach in creativity research is to break down creativity into four perspectives, commonly referred to as the *Four Ps* [43, 51, 34, 26, 49, 53, 35]:

- Person: The individual that is creative.
- Process: What the creative individual does to be creative.
- Product: What is produced as a result of the creative process.
- Press: The environment in which the creativity is situated.

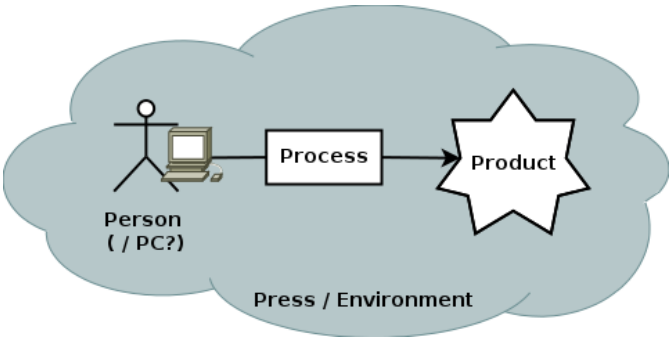

Figure 1. A simplified view of how the Four Ps fit together in creativity

Rhodes [43] was perhaps first to identify the four P perspectives. Rhodes collected 40 definitions of creativity and 16 definitions of imagination. The '*Four P*' dimensions of creativity emerged from analysis of these definitions.[5] Several people seem to have independently identified four similar themes of creativity [26, 51, 34, 35], boosting the credibility of the Four Ps.

Plucker, Beghetto & Dow [41] conducted a literature survey investigating the use (or absence) of creativity definitions in creativity research. As part of this review, Plucker et al. used their analysis to derive their own definition by identifying reoccurring themes and forming these into an inclusive definition which happens to account for each of the Four Ps:

> 'Creativity is the interaction among *aptitude, process, and environment* by which an individual or group produces a *perceptible product* that is both *novel and useful* as defined within a *social context*' [41, p. 90]

In reviewing Four Ps research, Kaufman [23] described addendums that have been suggested for the Four Ps: persuasion [49]

[4] If the inner workings of a program are very impressive, complex or novel, then we may still be impressed by the program, but this is a different perspective to whether or not we think the program is creative.

[5] As Rhodes' work appeared in a relatively unknown journal, many later advocates of a 'Four Ps'-style approach to creativity seem unaware of Rhodes' contribution (e.g. Odena, 2009, personal communications), so fail to cite him.

and potential [47]. In general, however, the Four Ps have been adopted as they were originally conceived by various researchers [43, 51, 34, 26].

2.1 The Four Ps: Person

This perspective addresses human characteristics associated with creative individuals or groups of people. Encouraged by Guilford's call in 1950 for studying the creative person, an abundance of different personal characteristics have been associated with creativity [43, 51, 24, 53, 35], ranging from personality traits, attitudes, intelligence and temperament to habits and behaviours (for example curiosity, persistence, independence and openness). Some of these are closely related; others are contradictory. Rhodes mentioned the relevance to creativity of people's personality traits, attitudes and habits, physique and intelligence and the identifiable features of creative people, as well as referring to people's temperament, habits, self-concept, value systems, defence mechanisms, and behaviour [43, p. 307].

Empirical studies up until 1968 were summarised by Stein [52] and were combined into a list of 18 distinct personality characteristics of a creative person, including aspects such as curiosity, persistence, independence and openness. Stein used these characteristics to identify creative individuals for study. There is a risk of circularity here, as the selection criteria for creative individuals chooses people to be studied, then the study involves examining those characteristics and criteria. Stein's work has not stood the test of time, with few current citations.

Several researchers subdivide the 'Person' category into finer-grained groups. Three sub categories of the 'pupil' perspective emerged during Odena & Welch's work [35]: personal characteristics of the pupil, their individual learning style (either adapting to new information or deriving new information themselves) and the influence of the pupil's background. Koestler [24] described three types of creative person: the *Artist*, the *Sage* and the *Jester*. Through Tardif & Sternberg's review of definitions of creativity, three main categories were identified with which to describe creative people: cognitive attributes, personality attributes/motivation and developmental influences. Tardif & Sternberg suggested three resultant modes of study of human creativity: cognitive psychology; psychometric testing; and study of human development.

These discrepancies and the sheer quantity of attributes together place an obstacle in the way of compiling a definitive list of attributes of a creative person and instead provoke disagreements on exactly which cognitive characteristics should be attributed to creative people. Tardif & Sternberg's review showed that as of 1988, different authors highlighted a variety of characteristics, with no general consensus and no characteristics common to all reports [53, Table 17.1, p. 434].

2.1.1 The Person in Computational Creativity

In computational creativity, the creative person could be analogous to the computer, or perhaps more accurately, to the computer program, software, or to a creative agent within a multi-agent system. Here the machine is the hardware hosting the creative agent, much as we might distinguish between physical and functional characteristics of a 'Person'.

Interesting work has been done on modelling creative agents, for example by Saunders [48], although the emphasis in computational creativity software tends to be on product generation and to some extent, process modelling, rather than on the modelling of characteristics of a creative Person in computational format. This is because computational creativity systems tend to be oriented towards a particular goal or domain, rather than being generally creative, as we can see by the plethora of domain-specific systems (as opposed to modelling of creative personal characteristics) in the various proceedings of ICCC conferences (International Conference on Computational Creativity). As argued in [20], different types of creativity require domain specific skills to some extent, so domain-specific computational creativity systems tend to be built around the most prominent necessary skills for that domain.

In terms of evaluating creative systems, Colton's Creative Tripod [8] emphasises the need for systems to demonstrate skill, imagination and appreciation before they can be considered as a candidate creative system, all three of which are alluding to personal characteristics.

Features, traits and aspects of the creative system can be studied, and it would be fascinating to explore how general creative personal characteristics could be specifically modelled within creative systems (see the *Process* section, next). Computational modelling of characteristics that encourage creativity could help us progress our systems to be able to be creative in more than one system which they were originally designed for; this would be significant progress in our pursuit of modelling creativity as a phenomenon which transcends different types of creative activity.

The 'Person' could also entail the individual(s) interacting with a creativity support system or co-creative system which interacts with people[27, 22]. Another possible interpretation of the 'Person' in computational creativity would be to acknowledge the role of the programmer(s), tester(s), researcher(s) and peers involved in shaping the project.

2.2 The Four Ps: Process

The creative process has been broken down into a series of sequential or cyclic stages occurring over time [42, 55] or subtasks [35].

In their work on student creativity in school music lessons, Odena & Welch [35] broke down the creative process into subtasks, identifying various types of process (e.g. different activities, group process, the structuredness or otherwise of a process and composition by improvisation) rather than tracing a linear progression of subprocesses.

It is often stressed that creativity is not just the first flash of inspiration, but is also the activity that validates, develops, and refines that first idea; rather than occurring at one point in time, creativity develops over a period of time [55, 42, 53]. Tardif & Sternberg [53] questioned whether creativity is a social or an individual process. The social view of creativity has notably been promoted by Csikszentmihalyi [12].

2.2.1 The Process in Computational Creativity

In computational creativity, the creative process might be that employed by a single piece of software, or the interactions between multiple machines or programs, or the interactions between machine and human users. As described above, the computational creativity community has given some attention to the concept of creative processes employed within computational creativity, with growing attention paid to this aspect in recent years. For example, the FlowR framework [5] is designed to facilitate creative computational workflows by chaining together processes in a linear pattern, and from personal communications with members of the project team, there are plans

to consider non-linear chains of processes as well. Additionally, the work by Joanna Misztal on poetry generation [31] specifically focusses on the processes required to generate poetry, at various levels of abstraction.

The generate-and-test [30, 38] or engagement-reflection approach [40] specifically models the creative process as a cycle of generating artefacts then improving the generation process via evaluating the generation phase. This is an approach which deserves broader adoption within computational creativity; evaluation is a critical part of the creative process [42, 12]. In terms of post-implementation evaluation, the FACE model for evaluation of creative systems [9] places importance on computational systems being able to report on the creative process (this report is referred to in the FACE framework as a *Frame*).

There are multiple theories about how human creativity processes are structured (see for example [42, 12, 23, 14]). Computational creativity research can provide a test-bed for these psychological theories and allow us to explore if implementing the theories result in creative behaviour. Conferences such as the Creativity and Cognition series showcase work that links between theory and practice to some extent, but further activity along these lines would emphasise the validity of computational creativity research, allowing computational work to contribute to human creativity research and vice-versa.

2.3 The Four Ps: Product

Many authors advocate that *proof* of creativity is necessary to be considered creative [21, 53, 41, 44]. The product-centric view adopted by computational creativity researchers such as Ritchie [45], that creative products are both necessary and sufficient for creativity, was present in earlier human creativity research [21]. But, inspired by Guilford's seminal 1950 address on creativity research, emphasis in human creativity research shifted from identifying creative individuals post-production of creative work, to predicting future potential for creativity in individuals. This change in emphasis is illustrated in the proliferation of psychometric tests [23, 19] within creativity research.

Tardif & Sternberg [53] considered the creative product more briefly than the other three 'Ps' in their review, deciding that while a creative product is essential for creativity, it is not enough merely to generate a product; the product should also be considered in a domain-specific context.

Computational creativity research has long acknowledged the importance of the output or artefacts generated by creative systems, as described above. To borrow a metaphor from human creativity research, it has been common (until recently) for computational creativity to follow the product-centric approach to creativity as advocated by Kagan: '*Creativity* refers to a product, and if made by a man, we give him the honor of the adjective' [21, p. viii].

2.3.1 The Product in Computational Creativity

Generating creative products has been an area of significant success for computational creativity. To see examples, one just needs to consult any year's proceedings of the International Conference on Computational Creativity where there are multiple examples to be found of systems which are reported in terms of the products they generate. The success of systems is often reported in terms of what kind of artefacts they generate, as noted in [18]. Some systems have been evaluated using Graeme Ritchie's empirical criteria [44, 45], which exclusively focuses on evaluating the products of computational systems without considering any of the other three Ps.[6]

2.4 The Four Ps: Press/Environment

The Press perspective encompasses a bidirectional perspective between the environment which influences the creator and receives the creative work, and the creator who publicises their work and is given feedback on what they produce. Tardif & Sternberg [53] considered both creative domains themselves and the social environments in which creative people are influenced as they employ creative process, advertise their creative products and receive feedback. Rhodes [43] concentrated on the role that the environment plays on a person during the creative process, rather than how the creative produce is judged by the external world after being created. Rhodes reflected on how everyone is different, so everyone perceives the world in a unique way and processes ideas according to their own contexts.

Of the Four Ps, this is the perspective that is often neglected when one takes an individualistic view of creativity. In general creativity theorists do however acknowledge the influence of the environment in which creativity is situated [49, 13]. If one concentrates on an individual's creativity, however, the Press perspective is often neglected, even if unintentionally. For example, although stating that '[t]o be appreciated as creative. a work of art or a scientific theory has to be understood in a specific relation to what preceded it' [3, p. 74], Boden's treatment of creativity mainly focused on different cognitive processes of creativity, rather than a detailed examination of social or environmental influences.

2.4.1 The Press in Computational Creativity

Some computational creativity researchers are starting to highlight the importance of the environment in which a creative system is situated [50, 17, 37, 48], with some of this work influenced by the DIFI (Domain-Individual-Field-Interaction) framework [12]. Social interaction between creative agents and their audience is an area which has been neglected by all but a few groups of researchers: for example nearly 75% of papers in the 2014 International Conference on Computational Creativity failed to make any reference to social or interactive aspects of creativity. But creativity cannot exist in a vacuum. A recent increase in development of the interactivity of creative systems (especially where this affects the way these systems works) is pleasing to see and deserves further attention [10].

There is a separate point to acknowledge regarding Press in computational creativity. As computational creativity researchers, we should stay aware of any potential biases that may be introduced, should an audience be aware that the creative agent of interest is computational rather than human [32, 19].[7]

2.5 Interaction between the Four Ps

Simonton [49] saw discrepancies between combining the Four Ps in theory and in practice:

> 'Now, in an ideal state of affairs, it should not matter which one of the four p's our investigations target, for they all will converge on the same underlying phenomenon. ... But reality is not so simple, needless to say. The creative process need not

[6] Recently proposed evaluation methods such as [8, 9, 19] place more emphasis on the other three 'Ps'.

[7] Many thanks to the anonymous reviewer who noted this point.

> arrive at a creative product, nor must all creative products ensue from the same process or personality type; and others may ignore the process, discredit the product, or reject the personality when making attributions about creativity.' [49, p. 387]

From this, one conclusion which seems to follow naturally is that an accurate and comprehensive definition of creativity must account for the (potential) presence of all four aspects, in order to be complete. Simonton, however, concluded that '[i]f we cannot assume that all four aspects cohesively hang together, then it may be best to select one single definition and subordinate the others to that orientation' [49, p. 387], with his natural research inclination leading him to focus his work on *persuasion*, his term for the Press/Environment aspect.

The mysterious impression often associated with creativity [56, 3, 23] can be explained to some extent when one or more of the Four Ps are not accounted for:

> 'Each strand [of the Four Ps] has unique identity academically, but only in unity do the four strands operate functionally. It is this very fact of synthesis that causes fog in talk about creativity and this may be the basis for the semblance of a "cult".' [43, p. 307]

Rhodes argued that creativity research should follow a specific path: 'from product to person and thence to process and to press.' [43, p. 309]

> 'Objective investigation into the nature of the creative process can proceed in only one direction, i.e. from product to person and thence to process and to press.' [43, p. 309]

Such a statement makes Rhodes's contribution less useful. For example, the Press (environment) in which one is creative has some influence on the creative Process, so one may prefer to study how Press and Person interact before looking at Process issues. Simonton viewed creativity as how a person's ideas emerge as influential when that person, by chance, has new ideas and promotes them to influence others. Creative people would not be equivalent to lucky people, by this interpretation, but chance would intervene in their success. Simonton refers to this as the 'chance-configuration theory' that 'outlines the general conditions that favor creativity' [49, p. 422].

Tardif & Sternberg [53] treated each of the Four Ps individually, 'as these really are separate levels of analysis, and it is from comparisons within levels that coherent statements about our knowledge of creativity can be made' [53, p. 429]. Tardif & Sternberg's summary is weakened somewhat by this as it does not make comparisons across the Four Ps, despite highlighting Simonton's emphasis on the interactions and relations between these four views [49]. In contrast Mooney [34] argued that the four approaches should be integrated in a model of creativity, proposing a model that 'puts together the four approaches by showing them to be aspects of one unifying idea' [34, p. 333]. While Mooney's claims become rather grandiose at points, Mooney's more specific contributions on creativity match neatly with the four Ps approach identified elsewhere at that date [43, 51]

2.5.1 Interaction between Four Ps in Computational Creativity

This paper argues that we can make significant progress in computational creativity by considering all four Ps in our computational creativity work. Tony Veale's tagline for the ICCC'2012 conference sums up current aspirations of computational creativity well; Veale characterises computational creativity research as 'scoffing at mere generation for more than a decade'. Generation of creative products is only a quarter of the full picture of creativity, only one of the Four 'Ps'. Granted, we have achieved much success in product generation, as exemplified by exhibitions, concerts and other demonstrations of creative products reported in various papers on computational creativity systems [18]. However, the more mature work and exciting potential comes from the incorporation of the other three Ps, at least to some extent, such as in [40, 48, 31].

3 Applying the Four Ps: examples of *novelty* and *value*

Novelty (originality, newness) and value (usefulness, appropriateness) form key parts of creativity [28, 3, 45, 20], often being identified as the two main aspects of computational creativity [39, 45, 4, for example].[8] Work in computational creativity illustrates both novelty and utility from each of the Four P perspectives, although some perspectives are represented more plentifully within computational creativity than others. To illustrate the discussions above, we can discuss novelty and value in computational creativity from each of the Four P perspectives. Considering novelty from each of the Four Ps:

Product Novelty is well associated with system outputs and products: how novel are the generated artefact(s)? The novelty of artefacts generated by computational creativity systems is a key consideration in Ritchie's empirical criteria for evaluating creative systems [45].

Process A creative process can take a novel approach or be implemented in a novel way, perhaps employing new algorithms or techniques or different approaches. Efforts at trying new processes and combinations thereof are being encouraged by systems such as the FlowR framework [5], which focuses specifically on enabling us to chain different processes together for creative purposes.

Person Creativity can be performed by a new creative entity, which demonstrates or uses novel characteristics relevant to that creativity. As is often encountered in computational creativity work, implementing or running a creative system on new hardware or in different software may also impact upon the system's performance and may have unexpected results. The number of new systems presented each year at the International Conference on Computational Creativity exemplifies how novel creative entities continually arise in computational creativity research.[9] (Also, the novelty of unexpected results is often unintentionally exemplified when live demos of these systems are attempted in unfamiliar computing setups.)

Press The creativity demonstrated by a system can be noted as being novel in a particular environment, even though it may be commonplace in other environments. The system may also exploit the surrounding press in previously unexplored ways. This was demonstrated neatly by the combination of two systems in [33], where a textual annotation system interacted with a system that generates emotion-driven music. The combination resulted in novel interpretations of fairy tales; such results would not have arisen were the systems operating in isolation.

Considering value from each of the Four Ps:

[8] It should be clarified that for this author, creativity consists of considerably more than novelty and value, though these are two key components of creativity. See [20].

[9] See `http://www.computationalcreativity.net/conferences`.

Product Value is also well associated with system outputs and products: how valuable or good are the generated artefact(s)? This is a highly current area of concern within computational creativity, with much evaluation concentrating on the quality of output [18].
Process The creative processes being incorporated within creativity can be useful in themselves for learning or studying how certain approaches and techniques work or for cross-application to new areas. Systems with an emphasis on modelling process, such as Misztal and Indurkhya's poetry generator [31] bring added utility by what they reveal about the processes being modelled.
Person Some creators become more valuable than others as a contributor in their field, based on their personal characteristics, experience and influence.[10] The same can be noted for creative systems to some extent; some are cited more often than others, for example Simon Colton's HR mathematical discovery system [7] (which provides a useful example of creativity in a non-artistic domain).
Press If creative activities benefit the external world in some way, then they have value to the press. As example, Harold Cohen's AARON colouring system has received much external attention, from media discussions [29] through to inspiring a screensaver for personal computers via `http://www.kurzweilcyberart.com`.

These above lists are not intended to be a full and conclusive portrait of novelty and value within computational creativity. What these lists illustrate is the different viewpoints that can be uncovered using the Four Ps as *signposts* with which to guide our thinking around computational creativity. The breadth of issues mentioned above shows aspects of novelty and value within computational creativity which may not always be accounted for if taking a product/process-oriented viewpoint; however it is argued here that those perhaps-overlooked aspects give us a closer rendition of creativity, guiding us away from incomplete viewpoints of creativity in the context of our computational work.

4 Summary

The difficulty of understanding what creativity is should not discourage us from such an attempt [43, 41, 8]. In creativity research, the *Four Ps* construct ensures we pay attention to four key aspects of creativity: the creative Person, the generated Products, the creative Process and the Press/Environment hosting and influencing the creativity. This framework helps us to consider creativity more broadly.

For example, if viewing *novelty* and *value* from the perspectives of *product*, *process*, *person* and *press*, we uncover various interpretations of these two key concepts within computational creativity which may otherwise have been overlooked. The *Four Ps* framework helps to highlight different perspectives on creativity, to portray creativity in a fuller context.

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[10] This has been found, for example, in the recent Valuing Electronic Music project `http://valuingelectronicmusic.org` [1], where some people's endorsements can have a greater influence on the perceived value of an electronic musician and their work.

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