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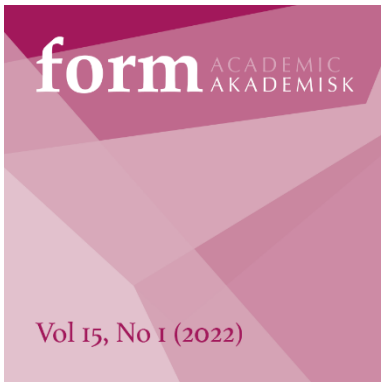

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ABSTRACT
It seems relevant for designers who are dealing with complex societal issues to be able to assess whether they appreciate the complexity of the design task sufficiently before the stages of the design and production process are reached, as these require informed decisions before committing substantial resources. We put forward that the 'richness' of intermediate results in a design process can be used as at least part of this assessment. The purpose of this paper is to explore the use of richness as a multi-level defined construct, to create a shared language for such an assessment. We created a three-part definition and tested its workability and value for designers. The results demonstrate the workability of considering richness as a multi-level defined construct. Its value for designers, then, is that assessing the richness of intermediate results can help to get a sense whether they are capturing the complexity of the design task. If not, this could be an explicit sign that more work is needed before moving towards the more resource-intensive stages. This first exploration can be built upon in various ways.

Keywords:
richness, assessment, multi-level defined construct, complexity, shared language

APPRECIATING COMPLEXITY OF DESIGN TASKS

Complex design challenges and introducing richness

There are different ways in which people in general and also designers might respond to a challenge that they consider to be complex. We will not go into a full-length discussion on all possible definitions of 'complex' because it is not the main focus of this paper. For now, we define it as a situation or 'system'

with many elements, which are connected in different obvious and less obvious ways, causing this whole 'system' to display behaviour that is fundamentally unpredictable (Kramer & de Smit, 1979). One reason for the (current and future) behaviour that we observe to be unpredictable is that it is also influenced by factors that, possibly inadvertently, are not considered to be part of the system. Creating (mental) boundaries that prevent actively seeking out such factors is the often-unconscious consequence of having a dominant perspective. This is inherently unavoidable because of the 'bounded rationality' of humans (Simon, 1969).

One possible and often-occurring response to a contemporary complex challenge is to simplify early on; for example, focus on a particular user group in order to (re)gain control and establish an overview of an overwhelmingly complex situation (Backx et al., 2017; Mundy, 2010). In any design process, such simplification, that is, making choices, always occurs. However, the question that we put forward is *how early* in the process simplifications can be made without undermining the *rich* analysis that is required to address contemporary challenges. In other words, particularly when confronted with a complex design challenge, it might be necessary to ask a few more questions before moving to critical and resource-intensive stages of the (design and production) process in a way as informed as possible. For example, should the common focus on a particular use case during the first stages of a design process, as is encouraged, for example, for human-centred design (Norman, 1988), perhaps be extended to more potential use cases? In other words, is early focus on one use case effective or, particularly when faced with complex challenges, might a *rich* design space (Sevaldson, 2008) that also includes other considerations be more in order? Further, how might such richness then be defined?

Dominant views regarding richness

Richness is a term that is far from alien to designers. Several authors (Checkland, 1981; Leenders et al., 2007; Sevaldson, 2017) refer to richness in the sense of using different media and thereby intentionally layered and therefore not oversimplified visualisations that allow the displaying of many different (types of) connections between elements of the system under consideration. Such visualisations and work-spaces are for example called rich pictures (Checkland, 2000), rich design spaces (Sevaldson, 2008) or synthesis maps (Jones & Bowes, 2017). As Lewis (1992) remarks, such visualisations should not be seen as a primary goal, but are a valuable result of an intentional *process of appreciating the complexity* of the system or situation under consideration. A similar attitude is voiced by Montuori (2011) when he talks about '…the web of interconnections that weaves complexity'.

The interpretations of richness in terms of multi-media and/or multi-layered visualisations are supplemental to mostly intuitive notions (Verganti, 2017; Kahneman, 2011). Both are very valuable. Multi-layered visualisations and a nourished but mostly implicit intuition of 'richness' may in fact distinguish designers' ways of working from those of non-designers (Lindgaard & Wesselius, 2017; Sevaldson, 2017). There is, however, reason to wonder whether this notion of richness can be developed further. The main reason for this desire is our observation that more and more design challenges are complex. The designerly way to deal with this complexity is to engage in more systemic analysis (Jones, 2014; Jones & Bowes, 2017; Jones & VanPatter, 2009) and encourage creation of multi-media and/or multi-layered visualisations to map the landscape of the challenge (Sevaldson, 2017b). This is valuable beyond doubt. Still, as designers, we may also inquisitively wonder whether we could do even more to capture the richness that is, consciously or not, embedded in complex (design) challenges.

Creating a shared language

In particular, we put forward that the potential of the aforementioned visual tools might be leveraged even more if we could manage to create a more explicit shared language, one that turns 'soft' individual opinions into 'harder' more comparable assessments that therefore lend themselves better to somewhat objectified departure points for subsequent, qualitative discussion. Without the intermediate shared objectified language, such discussions are ultimately difficult. Therefore, this intermediate step adds value to both the intuitive expert notions of richness and different visualisations in the conceptual and physical design spaces. The shared language can then strengthen the *dialogue* on what is to be or has been visualised. Thereby, a more solid basis is present to inform decisions in the

design process. Such dialogue would be in line with the aforementioned necessity of appreciating the interweaving web of complexity (Checkland, 1981; Lewis, 1992; Montuori, 2011) and might, in fact, make design analyses more accessible to non-designers. This, in particular, could be the case if these dialogues are generative, that is, deeper than the cognitive level, creating a relationship between people in the dialogue and providing a new perspective (Bushe, 2013).

For our purposes, we see a 'design space' mostly as conceptual. It roughly covers the period from problem identification to embodied designs. Getting from one to the other obviously does not occur in a straight line and typically involves many iterations and evolving views on how the problem at hand might best be addressed, and whose perspectives to use for it. Further, the more complex or wicked a problem is, the less one should think in terms of 'solutions'. Still, product designers want to contribute to improving a situation and therefore mostly think in terms of products (and/or services). The actual physical space or physical manifestations (i.e., visualisations, prototypes) during these activities are part of and basis for this process but not the focus of this paper. Others to whom we refer throughout this introduction have already covered these topics well.

An extra argument as to why we feel that this more explicit shared language makes sense is that we have reasons to believe that it can facilitate an accepted intersubjective assessment and ensuing deeper discussion of intermediate design results. Such discussion can help designers, and their principals, to at least get some sense of whether the complexity of the design task is apparent in their intermediate results. Early detection that this is not the case can then be taken as a sign that it is already necessary to move back in the process in iteration. Such iterations are, of course, common practice, but now there would be an actual tool to gauge the necessity of such an iteration before much time is wasted on overly simplistic efforts. Typically, more resources are required in later stages of the process, so there is value in detecting that it would not be a good idea to take the decisions that would lead to investing such resources.

Before this paper was written, we experienced that design experts, when asked to assess the richness of design concepts, managed to do so but used different implicit definitions of this notion. By their own admission, using different definitions without realising does not facilitate an effective discussion. See the following main section for more on this.

Purposes and outline of this paper

This brings us to the purposes and goals of this paper:

1) Investigate, by combining insights from literature and practice, what could be a *shared definition* of richness as a multi-level defined construct.
2) Test, i.e., assess, such a definition on *workability* and *added value for designers* by asking and collecting information to answer the following questions:
    a) Can the definition indeed be *used to assess richness* of design outcomes? How do design experts *react* in using the definition as opposed to expressing richness by means of a compressed intuition-based opinion?
    b) How much *distinction* does the definition allow? Do different design inputs result in different assessment scores? If very different design outcomes are roughly assessed as being equally rich, the used definition might not be helpful as an assessment tool that productively feeds dialogue with and between designers.
    c) What new insights for this topic are created by doing this test?
3) With the results as input, discuss the possible implications for designers. This might include the types of design outcomes for which these exercises might make the most sense.

To pre-emptively clarify and prevent potential confusion: the paper reflects abductive research to generate novel insights. It does not test a fixed hypothesis or focus on parametric analysis. The numerical information that is presented in the form of assessment scores is intended to *feed a qualitative discussion* on the presence, or absence, of patterns in these scores, and the implications thereof. More details on the assessment scores are provided in the section on the research design.

The next section first covers the *literature review* on richness in design and the related literature and first experiments on capturing this characteristic with designers. This preparation results in the aforementioned suggested formulation of a multi-level defined construct. Testing the use and value of this construct is the core of the rest of this paper. The *research setting, design and specific questions* that governed that test are described in the third section. The main *findings* in the fourth section describe the main non-parametric patterns, based on the assessment scores for the different parts of the three-part definition by different assessors for different design outputs. The assessment results are included in the Appendix. Further *discussion* is added on the validity of the results and the limitations of this particular research set-up, bearing in mind that it was intended as an initial exploration, not full-blown large-scale research. Finally, *conclusions and suggested next steps* are offered in the last section.

LITERATURE REVIEW AND MULTI-LEVEL DEFINITION

In this section we examine literature on richness. By combining interpretations from different design practices, we arrive at a three-part working definition of richness as a defined construct at the end of the section. This is a necessary basis to explore whether it is workable at all and whether it adds any value, that is, whether the different parts to assess are distinctive enough for separate assessment and if so, whether that helps such an assessment, as opposed to using an intuitive unarticulated definition and averaging the different parts into one number.

Warm-up: Notions of creativity

To ease into the topic of richness, we first take a quick, non-exhaustive look at the phenomenon that is closer to home for most designers: creativity. Most creativity assessment methods revolve around a combination of the concepts of novelty (Dorst & Cross, 2001) or a combination of usefulness and novelty (Sarkar & Chakrabarti, 2011). Usefulness might also referred be to as *effectiveness in meeting the constraints*. Novelty could, for example, be broken down further into originality and rarity (Gonçalves, 2016) or complemented with how surprising ideas are or how much enthusiasm they invoke (van der Lugt, 2003), preferably assessed by different stakeholders. The criterion *surprise* appears to be intended to weed out obvious outcomes that are also rare because experts would already have identified them as too common earlier in the process.

While many additional approaches to position creativity exist, as do indicators to assess it, this paper does not intend to excavate that topic fully. For now, it is interesting to note that all these well-known methods do not, explicitly, revolve around the notion of capturing the aspect of *connections between elements in a system* but focus more on the individual qualities of a particular design outcome. We have argued in the introduction that recognising the importance of (hidden and visible) relations is core to working with complexity. When discussing with design experts what would be an appropriate way to capture this aspect, the term ‘richness’ emerged repeatedly.

Exploratory test to assess interpretations of richness

As mentioned in the introduction, the construct of richness was used in a first experiment, and design experts were then asked to assess richness of design results in the way they saw fit, without yet providing a definition. While they indeed were able to assign an overall richness score between 1 and 10 to design concepts, they also commented that they would have liked at least some guidance on how to interpret this very multi-faceted term (Kersten et al., 2016). Furthermore, they felt that being allowed to assign only one overall score did not allow them to capture the nuances of underlying considerations that they felt were very relevant to interpret their numerical assessment correctly.

The main implicit interpretations that they had used, as they revealed after the test, were in a sense quite different. The implicit definitions that they used, as revealed *after* providing the numerical assessments of the design concepts, interpreted a concept to be richer if:

a) it can conceivably be used in different contexts;
b) it refers to a ‘deeper thought’ in relation to end-users or beneficiaries;

c) it is holistic;
d) it displays internal consistency;
e) it demonstrates creativity; and
f) it conveys some sense of being feasible.

As is clear from this list, the possible interpretations cover a broad range of interpretations that are not fully in line with each other. Therefore, the experts' discomfort in having to give one overarching assessment, that is, only one number between 1 and 10, was understandable. Reduction of an assessment to one number in terms of feedback to designers to assist them in the next steps is likely to obscure many relevant nuances. Supported by that experience, this topic seemed worthy of further exploration, with the aim to determine whether more guidance for assessors can be created. Such guidance could then help to create a more shared language for assessing and discussing intermediate design results to jointly explore whether the result sufficiently represents the complexity in the design challenge. The earlier documented results revealed that such discussion would begin on a false start without such shared language.

Literature review on richness

As a general statement, when we examined academic literature about richness, we observed that it contains only a few clues as to how richness of design concepts might be assessed, based on something other than an intuitive notion. Most literature that mentions richness seems to implicitly refer to it as an intrinsic quality without much further explanation. This results in many authors calling something richer or less rich than something else simply because 'it is'. As Schön (1984) identified, they dismiss the need for elaborate reflection by simply referring to terms like 'creative' and 'intuitive' and leave it at that. Deeper discussion on this is included elsewhere (Kersten, 2020).

Some usefulness can be found in the definition as hinted at by Oades-Sese and Esquivel (2011): a rich concept displays elements from multiple views either culturally or domain-wise, and Sevaldson (2009, 2017a) who suggests that richness equals inviting dialogue, that is, should be generative. Another contribution from Sevaldson (2009) would be that a design is richer if it conveys more *'an element of art'* instead of just 'commercial appeal'.

In previous work, Sevaldson (2008) described the aforementioned concept of rich design research spaces, which revolve around *interaction of inputs* from *multiple* media *sources* in *one physical space*, building on existing work by Daft and Lengel (1984) on comparison between rich media (face to face, suitable for resolving equivocal situations) and lean media (e.g., a memo, exchanging unequivocal messages). The practices in these rich design spaces, like Gigamapping (Sevaldson, 2011, 2017b) and synthesis maps (Jones & Bowes, 2017), heavily build on work by Checkland (1981, 2000), who talks about rich pictures. All these ways of discussing richness revolve around the visual notion. This is certainly an interpretation and category of tools that resonates with designers.

Weick (2007) actually describes richness, and even he simply quotes from the dictionary, defining 'rich' as 'above average' on the dimension that makes sense for the particular object that is considered. We would therefore still need to determine a dimension for such an assessment. Secondly, his remark '…it [i.e., richness] feeds on itself in ways that enlarge our understanding of the human condition' might be translated as 'holistic thinking'. In that interpretation, it is similar to Koffka's statement (Koffka, 2013): 'The whole is other than the sum of its parts'. Similarly, Sevaldson (2008) talks about 'intuitive synthesis'. This is appealing but still begs the question of how it might be properly and consistently assessed.

Gonçalves (2016) suggests the concept of intentionally sourcing in semi-related information when she states that designers tend to hijack their own inspiration process if they go for the most readily available stimuli, and that a more conscious and deliberate search process will lead to more creative results. Both findings seem to point to the relevance of a rich search space. The richness of that space is, according to her, helped by using stimuli that are neither too obvious (e.g., coming from one context), nor too far removed (have no discernible relation to the topic). This is similar to the concept of 'the adjacent possible' as criterion for innovative ideas being actually adopted (Johnson, 2011).

Finally, similar to the visual multi-layered design research spaces and gigamaps, in Kratzer et al. (2010), 'richness' is referred to in the context of using a variety of communication channels. The interpretation again seems to be that different communication media can express different types of depth. It is somewhat similar to the one referred to earlier (Daft & Lengel, 1984): e-mail is low on richness, and face-to-face communication scores high on richness because of layering of sensory input like intonation, facial expression, body language, etc. Based on that interpretation of interplay between layers, we might extract as a crucial element of richness that it 'displays connections between elements'. This seems to be in line with the interpretation of 'holistic' above.

Conclusion with regards to a working definition

Combining and triangulating the expert input from a previously reported experiment (Kersten et al., 2016) with the literature overview, a three-part definition emerged. To assess the richness of a (tentative) result in the design process, one needs to look at the extent to which it:

1) represents multiple views;
2) is generative (i.e., opens dialogue instead of closing it);
3) refers to a *connection* between elements instead of just elements themselves.

Many authors who have talked about richness do—often implicitly—refer to one or more of these aspects. We aim to explore what added value might be created by making these aspects explicit and considering them in a joint fashion. We expect that added value lies in creating a shared platform for discussion of intermediate design results before deciding to continue with the design process.

To quickly test whether the three-part definition might be workable, we asked the experts from the first experiment to assess two design concepts and now use the three-part working definition to provide assessment scores. They were able to do so and expressed that they felt positive about the possibility of providing a guided, but multi-dimensional assessment. This provided a sufficient basis to continue with a more elaborate test.

RESEARCH SETTING, DESIGN AND QUESTIONS

Setting

To increase the chance that the assessment units vary in richness, we identified two main options: using the same assignment and putting different groups of junior designers to work with different levels of awareness on 'richness' and then assessing and comparing the results, or using one group and giving them a succession of assignments, encouraging different levels of awareness of the concept of richness. In both cases, we were then likely to get results that could be internally compared with one main variable, that is, the conscious level of awareness of richness, while the assignment and the designers remained the same. For practical reasons, we chose the latter.

The whole exercise was an attempt to explore whether what might be called 'soft data' (individual assessment opinions using implicit own definitions) could be turned into 'harder' data, based on explicit provided definitions. These 'harder data' can then be compared and these results can then be more easily used as basis for subsequent qualitative reflection and discussion.

We chose a setting where we had the opportunity to first let the designers experience two comparable cases (C1, C2) in which they were not nudged with regards to the potential relevance of creating a rich design space. Next, they were introduced to a third case (C3) on the same topic, but this time they were nudged about the potential relevance of 'creating a rich design space' to benefit their results, without giving away what 'rich' is or how it might be defined. More importantly, the designers were not even told that there would be an assessment of richness in the first place. By subsequently assessing the results of all cases using the three-part definition, the results could be well compared in terms of their level of richness according to the three-part working definition.

The specific assignment concerned biomass gasifier stoves in an Asian country. The first case (C1) referred to the countryside, a rural context. In the second case (C2), the gasifier was intended to

be used in an urban context. In the third case (C3) the gasifier was intended to be used in both. Case C3, therefore, represented the more complex real-life situation, compared to the other two. Differences between the cases that were foreseeable included, for example, the main fuel source (wood for rural case, coal for urban case and therefore a mix for the combined case, C3). It is not difficult to see that a stove design optimised for one person's fuel preference is likely to be different than one that needs to be able to work with more fuel sources. Case C3 is more complex than the other two, and therefore is relevant to detecting whether that complexity is being grasped by the designers before they (iteratively) progress to the more resource-intensive stages.

Figure 1 shows some basic differences between the two starting contexts, Rural (C1) and Urban (C2). The names in the bottom-right refer to researchers who collected specific insights in the rural context.

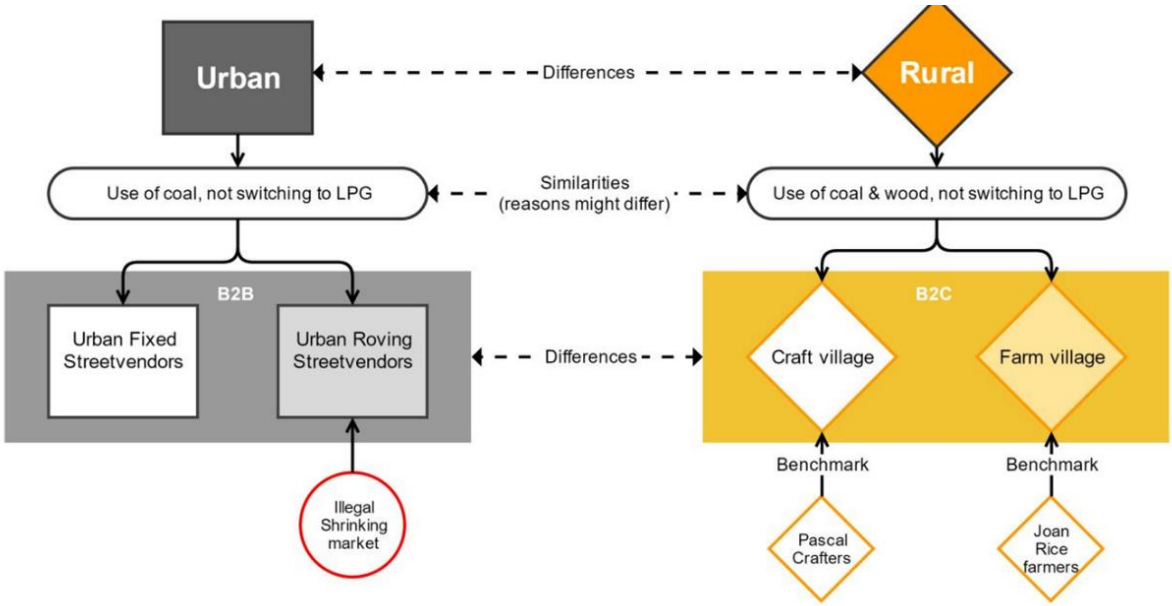

FIGURE 1. Some similarities and differences between the two main contexts.

The research design of the detailed test

The assessment unit that we used was twofold: individual 'insights' and 'set of insights'. An insight is more than a fact; it is a deeper understanding of one or more facts combined, a clear or less clear inference from existing evidence (Klein & Jarosz, 2011). By extension, the 'set of insights' that we also used as unit of assessment is the collection of insights that refer to the same case. All sets were related to one specific design challenge. In general, an insight is intuitively richer than a fact. The latter is more 'atomic' and less debatable and therefore a less generative piece of knowledge. Facts are therefore not very useful to assess in terms of richness. Several insights taken together, like the set of insights mentioned above, then in practice feed into directions for design concepts and later towards developed design concepts, like prototypes. Using this type of output as an assessment unit was, however, a step too far for this first exploration and impractical because assessing full design concepts requires a large initial effort in terms of duration of the process and would involve the development of multiple prototypes for comparative assessment. This would have been too costly. The intermediate results of *insights* and their grouping in sets of insights was therefore both a practical and justifiable decision.

We show a few examples to clarify the difference between facts, insights and next steps. All examples are obtained from observations in real-life cases, not hypothetical:

1. Two *observed facts* were that husbands are responsible for the financial decisions in a household, while wives are the ones who mostly use the purchased household items. An insight

(inference) then could be that product features need to appeal both to men in a financial sense and women in terms of features.

2. Two *researched facts* might be that a particular age range is the largest demographic segment in a context and this segment is currently hardly represented in the current customer landscape. An insight might then be that this provides much room for market growth, as long as people in this target group feel they are experiencing a problem that the company can solve.
3. Both examples show that an insight goes much deeper than a fact while not prescribing specific conclusions yet. Insights, therefore, do not yet necessarily convey specific features of a design concept (direction); they are valuable input for the step to work towards these directions.

The assessors whom we chose were a design team consisting of four Master's (MSc) students (henceforth referred to as 'team') who were executing the assignment under consideration and two detached design experts (referred to as 'DE1' and 'DE2'). Detached means they were not actively involved in the project of the students in any role, but they still had sufficient specific contents knowledge to value the quality (and richness) of the provided insights. They were from the same faculty, but since they had no involvement with the students nor with the principal of the project, were not made aware of the identity of the students and did not have any vested interest in any particular outcome, they could safely be labelled as 'detached' as well as 'experts' for the purpose of this test. None of the assessors has seen the assessment results of the others, so they determined their scores independently.

As mentioned, the assessment units were 'insights', further compiled into 'set of insights', each containing about 10–11 single insights. Two of the four students developed the insights from a rural perspective (resulting in a set of insights labelled as I1); the other two students developed them from an urban perspective (I2). For this step, they were free to use any (design) method they wanted and were free to explore broadly as long as their insights were relevant to their context. Finally, as a team they spent time on creating 'shared insights' (I3) by bringing together their combined intelligence. This is shown visually in Figure 2.

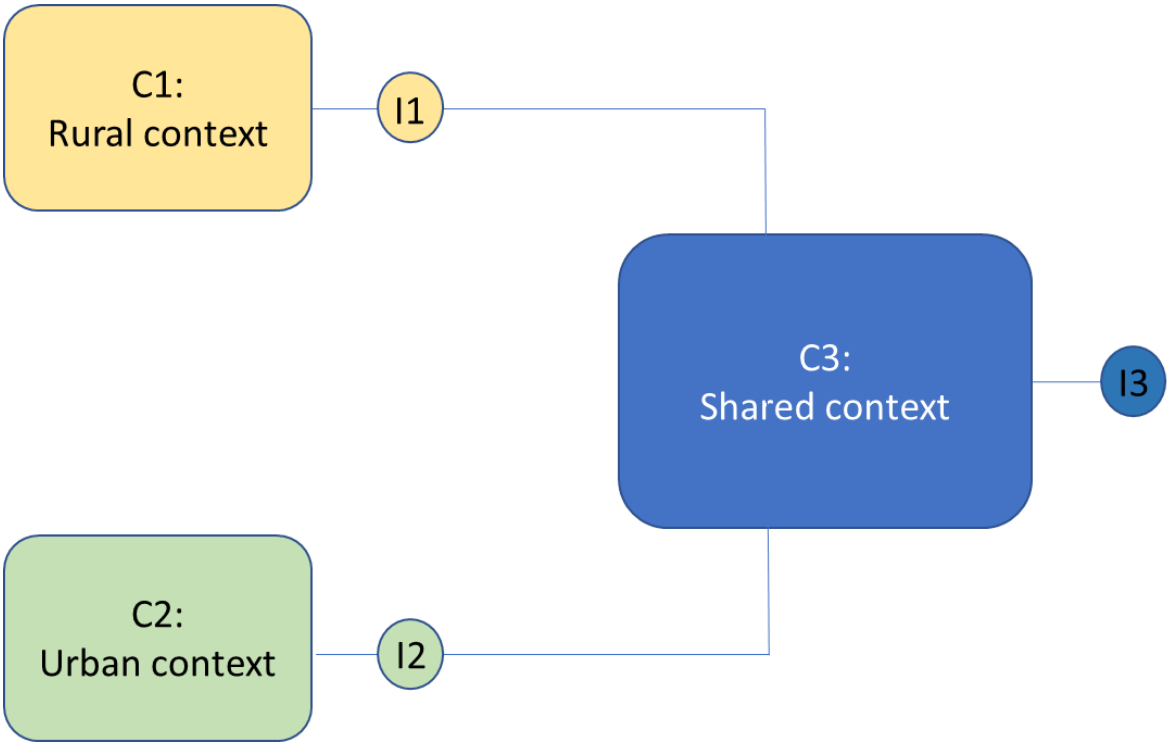

FIGURE 2. Sets of insights I1, I2, I3.

Different ways of using the full team's resources to create insights are shown in Figure 3. The option that was used here is the one shown on the far right. Context 1 could be considered the red process, Context 2 the light blue and Context 3 the shared light green space.

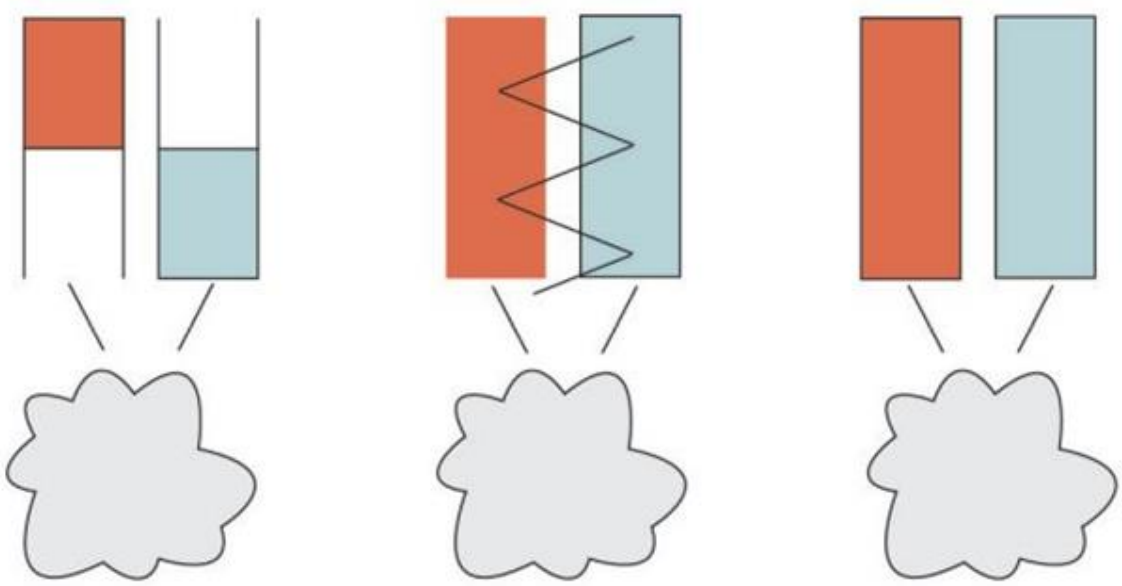

FIGURE 3. Using sub-teams to create insights.

For this step, as mentioned above, the team was primed slightly in the sense that it was suggested to them that *combining and working with all of their case-specific knowledge* instead of merely adding up their intelligence (i.e., insights) might have 'rich' results. However, they were not told what rich might mean, as this was for them to discover themselves. The team as a whole could then decide which set of insights they would use to develop the actual gasifier concept since there was only time to do so for one concept. That step is, however, beyond the direct scope of this paper.

Assessment, that is, generating what might be called 'hard data', occurred by letting all assessors (Design team, DE1 and DE2) score each of the three aspects of the working definition (multiple views, generative, representing connections) of each insight on a 1–5 scale, based on the instruction that 1 displays none/very little of this characteristic and 5 displays very much of this characteristic. In total, there were 31 insights to be assessed, times three aspects, creating 93 assessment scores per assessor.

Again, as stated previously, this method of assessment and subsequent presentation of results were not intended to imply any level of statistical significance or even analysis. It is the primary means through which we could explore whether, when given the option, assessors assign different scores to different aspects and different insights. Until now, a notion of richness, when scored, was in practice only captured in one overarching number that averaged out and therefore removed all nuances.

Research questions relevant for this test

For now, assuming that 'richness' of the design space is a relevant concept in contemporary design challenges, we explore whether turning it into a defined construct, that is, creating a common language around this concept, can help designers. Based on extensive literature search and interpretation, we therefore developed the three-part working definition as an essential first step to be able to ask the questions:

Is this three-part definition workable and does it add value when discussing/comparing/assessing design process results? Subsequently, what can we conclude from these results that is useful for designers, and what do the results add to existing theory on richness in design spaces?

The goal of answering these questions is achieved by means of assessing and discussing this workability and added value based on the following criteria:

- Workability. Do the results of the assessors point in one direction: Do the different assessments create a pattern or very scattered results? The more scattered the assessment results are, the less workable the definition seems to be as a construct, with the possible conclusions that either the working definition does not suffice, or the attempt of defining richness as a defined construct is not useful.
- Completeness of the definition: Based on qualitative reflection, is the current three-part definition good enough or are elements missing or redundant?
- Added value: Consider the horizontal and vertical ranges of assessment scores: when the different elements (parts of the definition) in the same assessed unit are assessed, do we see (large) differences per element (vertical range)? Similarly, when considering the full set of insights, do they receive different assessment scores (horizontal range)? The reason for looking at the assessment results in this way is to identify whether the ranges are small (0–1 points) or not. The smaller these delta ranges are, the more doubtful the added value of providing this level of granularity compared to allowing only one overall score. The larger these ranges, for example, larger than two points, the more valuable it seems for an assessor to have this level of granularity.

FINDINGS

In this section we refer to the clinical results of the assessments, being the full set of assessment scores by the different assessors of the tentative design process results. These are shown in the Appendix. In this section we share direct observations based on these results. In the Discussion section we interpret these results in light of the research questions.

The results per assessor for all insights, structured into the three sets of insights I1 (Rural), I2 (Urban) and I3 (Shared), can be investigated on the level of individual insights, and more systemically on the level of total set of insights. Besides the individual scores for each insight, the overview also contains the vertical averages (with 1 decimal for better distinction) per insight per assessor, the horizontal averages (also with 1 decimal) for each aspect per set of insights for that assessor, the delta ranges per row (part of the working definition) and column (insight) in each set. This combination of data provides a 'rich' picture that can be used to identify and then discuss non-parametric patterns.

The results in the Appendix can be considered the data that we will now interpret. To assist readers who desire to go into the data in detail, a short 'reading guide' in the form of examples is provided in the Appendix itself.

Looking at all combined assessment results, the following non-parametric patterns are easy to observe:

1. When comparing the assessment scores on the same part of the definition and/or same insight across the assessors, on the level of individual insights, an undeniably chaotic picture can be seen. Hardly any insights receive the same score from all assessors. Examples of this are discussed in Section 5. There is no discernible pattern, with the exception of the team of students systematically assigning higher assessment scores than the experts.
2. However, when zooming out to the 'set of insights' level (I1, I2, I3), we see one clearly dominant pattern, being that the average assessment scores of the third set of insights I3, Shared insights, is consistently the highest for all assessors (Team, DE1 and DE2). Additionally, the highest assessment scores per set (I1, I2, I3) per assessor are all from set I3. We thus observe that set of insights I3, for which the designers were made more aware about the existence of the notion

of 'richness', was consistently assessed as being richer. This is a relevant result because the designers were not informed how richness might be defined. In other words, they were not primed to an extent that turns this into a suspicious result, but they were primed of something like 'richness' being 'a thing', and apparently this stimulated them to consider their observations and formulations to become richer.

3. The delta ranges per set of insights, both vertical and horizontal, are considerable, indicating differences between the different assessors on the level of individual insights. The theoretical range goes from 0 (no difference) to 4 (maximal difference) and quick inspection reveals that most *average* delta ranges hover around 2.0.
4. When looking at the maximal differences, these are—by definition—even larger: the difference between the lowest and highest scores per assessor per insight (vertical delta range) are between 2 and more than 3 (out of a maximum of 4). Differences between the lowest and highest score for an aspect for all insights (horizontal delta range) within any set (I1, I2, I3) show a similar picture.
5. In practical terms, all of this means that within the assessment unit of 'set of insights', the same assessors scored different aspects (parts of the working definition) of the same insight quite differently, as well as the different insights for the same aspect. In short, when given the possibility to distinguish different parts of the assessment unit, assessors do use this opportunity. In this test, they had the opportunity to distinguish between the different insights, and between different aspects of insights, that is, the three parts of the working definition. This allowed distinctions resulting in a much more diverse set of scores than what would have been possible by simply assigning one number. This observation is far from trivial when interpreting the results and might be considered the main justification for why the presentation of the findings had to be done in this way and not in a simplified way, for example, by merely presenting one single assessment score per assessor. In the way the data are currently presented, they are comparable on different levels and thereby much more informative for producing an extensive and, one might even, say 'rich' analysis of these results.

DISCUSSION: INTERPRETING THE RESULTS IN LIGHT OF THE RESEARCH QUESTIONS

In this section we discuss the findings as seen through the lens of the research questions and highlight some limitations of this specific test set-up.

Workability and added value

In relation to the first part of the research question at the end of the third section, is the definition workable in the sense of providing a meaningful result? When examining the level of set of insights, the answer is affirmative: one clear dominant pattern can be found. On the level of individual insights, the opposite is the case: no clear pattern was present. We argue that the former level is the most relevant one because ultimately it is the whole that we want to draw conclusions about, and not individual elements (insights). It is very noteworthy that this is fully consistent with the essence of complexity and systemic thinking: patterns and connections that represent a complex system need to be considered not on the level of individual data points, in this case all the assessment scores of individual insights, but on sets of data points, in this case the overall results for sets of insights.

With regards to the second part, is the working definition complete? In informal reflections with the designers and the experts, the question of whether the working definition covers what they consider to be relevant or whether elements are emphasised too much, or missing, resulted in replies that implied that this working definition 'covers the bases'. In particular, the emphasis on valuing connections instead of singular elements in a design result, even an intermediate one, was considered to be very positive.

In relation to the third part of the research question, whether a defined multi-level construct *adds value*, the question is in fact whether the possibility to specifically assess aspects (parts of a definition) and then compare the results adds something to a discussion about (tentative) design results.

Based on the results that were shown, and ensuing brief discussion with all assessors, it became clear that when using a shared definition that does allow room for nuance because it considers three aspects and allows zooming in on the insight level as well as considers the total result for the entire set of insights, the assessment discussion itself becomes much richer. Even though the results on the level of individual insights (the individual data points) are chaotic, the pattern on the more 'systemic' level (sets of insights) is clear. This provides a common frame of reference to base the next parts of the design process on. Even if there are differences of opinion, these can now also be identified and articulated more clearly because of the common language. For example, the results might score high on being generative but much less high on referring to connections Then, it is clear what the discussion with and between designers can focus on. This would not be the case if the only way to express the richness was one single score or qualitative assessment. This more elaborate assessment toolbox and associated language facilitate choices, decisions and direction of the next steps in the design process. The question of what this deeper insight into and common language for richness adds to designers in terms of their final results is the next one to address.

In relation to the question of what these results add in practice for designers and current thinking and literature, we note the following. As stated, the intention was to explore whether making richness more explicit (and therefore less ambiguous) might have a positive effect on quality of design results. Beyond mapping, visually or otherwise, through the richness itself, when using the defined construct option, we can also achieve an enhanced shared understanding of what the map means. The activity of creating a rich set of shared insights can surely be seen as example of what Checkland (1981) and Lewis (1992) call 'appreciating the complexity of the situation', and keeps in mind their warning not to obsess with creating a visualisation as proof of that understanding. Creating the actual contents version of that understanding also makes much sense in that perspective. This is similar to the GiGAmaps (Sevaldson, 2011, 2017, 2017b) and synthesis maps (Jones & Bowes, 2017), which are a visual representation of the richness of a conceptual design space. By using a common language to talk about these maps, discussion is likely to create an even better shared understanding of them. In summary, the multi-level defined construct complements and strengthens the visual notions of richness that come more naturally to designers.

Limitations

What are limitations of this particular study? We briefly discuss the two main ones. Firstly, the findings mostly hinge on one case with three assessors. Obviously, the generalisability of this case is not yet high. However, as a first step to explore whether this is a fruitful way forward, it suffices. The total number of data points is close to 300 (3 * 93). This is by no means intended to give the impression of statistical significance, but it provides a firmer basis for conclusions than if only overall scores, that is, one score per set of insights, would have been provided.

Secondly, the level of design outcomes that was assessed was the level of insights. Insights is not a very common level of assessment, and insights are not yet design concepts or prototypes, so what does this experiment say about the quality of the concepts? This has been assessed informally, but left out of this paper in order to maintain focus. In practical terms, developing full-fledged concepts from all three cases would have involved much extra work, for which insufficient resources were available. This suggests the relevance of one obvious next step, that is, to design and find resources for a full chain of activities, up to the prototype level, so results can be compared on that level as well. This includes exploring whether richer insights also lead to richer, higher-quality prototypes. In Figure 4, a rough set-up is shown for such a test where not just sets of insights (I1, I2, I3) would be rated but also the quality of the design concepts (DC1, 2, 3).

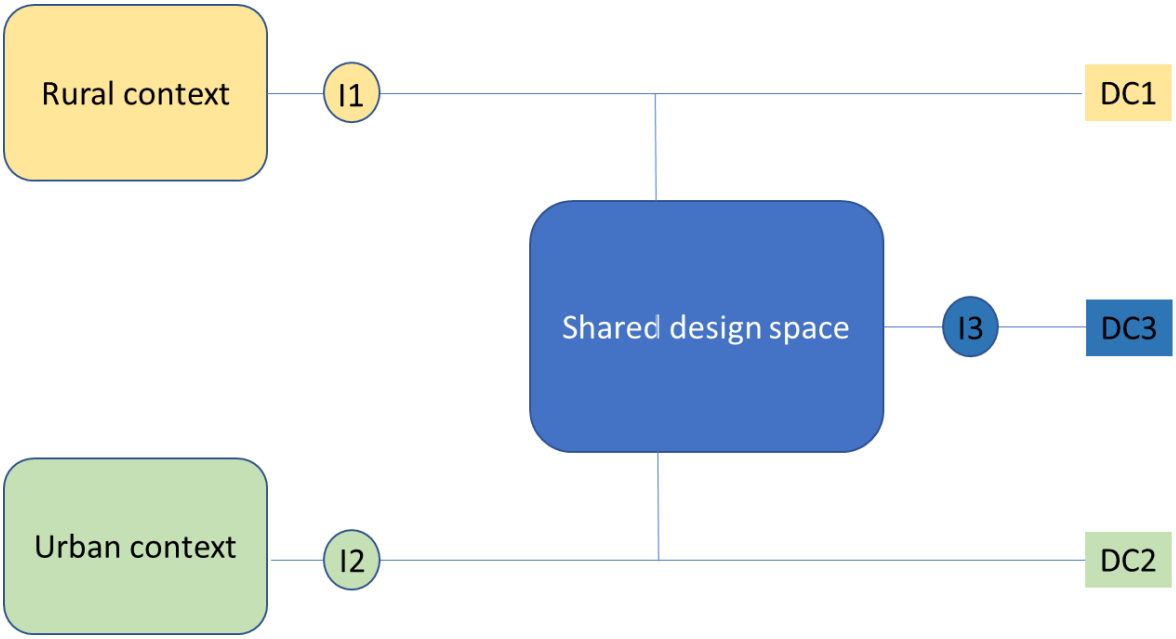

FIGURE 4. Rating richness of insights vs quality of design concepts.

This is not essential for this paper, but mainly to provide some concrete idea of how the design concept DC3 was turned into a prototype, and hereby a representative visual of this so-called slow cooker.

FIGURE 5. Actual end result of the design process.

CONCLUSIONS AND SUGGESTED NEXT STEPS

The aims of the exploration were to gain more insights into 1. whether introducing richness as a multi-level defined construct can work at all and 2. whether it adds value to designers. Building on the discussion above, we argue that the former is for now answered affirmatively if one looks at a more systemic level, in this case, set of insights as opposed to individual insights. Interestingly and very promisingly, this—at first sight ambiguous—result rather is in fact a perfect reflection of the statement 'observing emerging higher-level order out of lower-level chaos' that is so central to complexity (Johnson, 2002; Stacey, 1996). Furthermore, it corresponds with the notion of emergent properties (Moon & LaRock, 2017), that is, a property on the system level is more than the sum of its parts.

What this means in terms of the second aim, the added value for designers, depends on the attitude of the person asking the question. The more fine grained the overview of the richness 'performance' of an intermediate design result, the more fuel for discussion is provided, and thereby input for dialogue between designers and with non-designers. This is true even if intermediate design results (like sets of insights) are not scored; simply discussing intermediate results based on the shared three-part working definition is already likely to create more useful, specific input for decisions of whether to move back in the design process or, more confidently and in a more informed way, move forward. As stated in the introduction, by having this shared language as a basis, designers can detect early on and with some level of confidence whether their results display a satisfactory level of 'richness'. If not, in light of recognising that they are dealing with a complex design challenge, this might be considered as an explicit sign to turn back to previous steps in the process before moving forward to producing the final design process results. Without having a shared language, such discussions and therefore decisions in practice can occur but there is no objective basis on which to do so.

What could be next steps in terms of research? The following suggestions come to mind:

- After this successful step, the working definition might be tried out in more settings, possibly varying the number of assessors and types of cases. Replicating the test might provide a more thorough picture of the added value. Varying the types of assessors might reflect the ambition to feed a generative dialogue, particularly with non-designers.
- From the reflection by the assessors, we derive that the current working definition resonates sufficiently with expert designers. To further enrich the definition of richness, we might take the discussion outside of the design domain, as the previous point also hinted at. Inviting non-designers to reflect on the definition might provide new insights. If this reflection resulted in a modification, the workability would need to be tested again before being used in practice.
- Another line of development is to change implicit awareness to more explicit awareness. The current test revealed that even a limited higher a-priori awareness of the *notion of richness* had a positive effect on the richness of the insights. Next, tests could explore whether *knowing* the multi-level definition influences the assessed richness compared to the situation where designers have no or only fleeting notions of the definition.
- Finally, tests can be set up that explore whether high scores on richness of intermediate design results indeed are the preamble to final higher quality design *results*. These results can be prototypes or design concepts as suggested before (Figure 4).

APPENDIX: ASSESSMENT SCORES

The tables in this Appendix show the assessment scores by all assessors (Team, DE1, DE2). To facilitate the reader's interpretation of the table we provide a few arbitrary examples:

- To know how Team assessed the first of the Rural insights look at column #1 of set (I1) of the uppermost table and observe that Team scored 2, 4, 4 for the respective aspects.
- When we want to know how the other assessors scored this insight, we look at column #1 of set I1 and observe scores of 1, 3, 3 by DE1 and 2, 4, 2 by DE2.
- When we want to know the average scores for insight 5 of set I2 for all assessors, we observe a score of 2.0 (team), 2.3 (DE1) and 3.0 (DE2) respectively.

Richness Scores by the design team

Scores for set Rural Insights (I1)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		**TOTAL**	**AVG**
Representing multiple views	2	3	2	1	3	4	4	3	5	3		30	3.0
Be generative (open dialogue iso closing)	4	2	4	2	4	4	5	3	4	4		36	3.6
Refer to connections between elements	4	3	2	1	3	3	2	1	1	2		22	2.2
Total	10	8	8	4	10	11	11	7	10	9		88	8.8
Average (Avg)	3.3	2.7	2.7	1.3	3.3	3.7	3.7	2.3	3.3	3			2.9
Delta Range	2	1	2	1	1	1	3	2	4	2			1.9
Scores for set Urban insights (I2)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		**TOTAL**	**AVG**
Representing multiple views	2	4	3	5	2	5	2	5	3	3		34	3.4
Be generative (open dialogue iso closing)	5	4	3	4	3	4	3	5	4	4		39	3.9
Refer to connections between elements	3	4	2	2	1	2	1	2	2	2		21	2.1
Total	10	12	8	11	6	11	6	12	9	9		94	9.4
Average (Avg)	3.3	4.0	2.7	3.7	2.0	3.7	2.0	4.0	3.0	3.0			3.1
Delta Range	3	0	1	3	2	3	2	3	2	2			2.1
Score for set Shared insights (I3)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**TOTAL**	**AVG**
Representing multiple views	4	5	4	4	4	4	4	4	4	2	2	41	3.7
Be generative (open dialogue iso closing)	3	4	3	4	5	3	4	5	5	5	3	44	4.0
Refer to connections between elements	4	4	2	2	4	2	3	5	5	3	2	36	3.3
Total	11	13	9	10	13	9	11	14	14	10	7	121	11.0
Average (Avg)	3.7	4.3	3.0	3.3	4.3	3.0	3.7	4.7	4.7	3.3	2.3		3.7
Delta Range	1	1	2	2	1	2	1	1	1	3	1		1.5

Richness Scores by detached Design Expert 1 (DE1)

Scores for set Rural Insights (I1)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		**TOTAL**	**AVG**
Representing multiple views	1	4	1	1	3	2	3	2	2	4		23	2.3
Be generative (open dialogue iso closing)	3	4	3	1	2	1	3	1	1	3		22	2.2
Refer to connections between elements	3	3	1	1	4	3	4	1	2	3		25	2.5
Total	7	11	5	3	9	6	10	4	5	10		70	7.0
Average (Avg)	2.3	3.7	2.7	1.0	3.0	2.0	3.3	1.3	1.7	3.3			2.3
Delta Range	2	1	2	0	2	2	1	1	1	1			1.3
Scores for set Urban insights (I2)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		**TOTAL**	**AVG**
Representing multiple views	3	3	1	1	1	1	1	2	1	1		15	1.5
Be generative (open dialogue iso closing)	4	5	1	3	1	1	1	3	1	1		21	2.1
Refer to connections between elements	3	3	1	1	5	1	1	2	1	1		19	1.8
Total	10	11	3	5	7	3	3	7	3	3		55	5.5
Average (Avg)	3.3	3.7	1.0	1.7	2.3	1.0	1.0	2.3	1.0	1.0			1.8
Delta Range	1	2	0	2	4	0	0	1	0	0			1.0
Scores for set Shared insights (I3)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**TOTAL**	**AVG**
Representing multiple views	2	2	3	4	1	2	3	5	4	2	5	33	3.0
Be generative (open dialogue iso closing)	4	4	5	4	1	2	5	5	4	5	5	44	4.4
Refer to connections between elements	2	1	4	2	3	4	4	5	4	1	3	33	3.3
Total	8	7	12	10	5	8	12	15	12	8	13	110	10.0
Average (Avg)	2.7	2.3	4.0	3.3	1.7	2.7	4.0	5.0	4.0	2.7	4.3		3.3
Delta Range	2	3	2	2	2	2	2	0	0	4	2		1.9

Richness Scores by detached Design Expert 2 (DE2)

Scores for set Rural Insights (I1)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		**TOTAL**	**AVG**
Representing multiple views	2	2	1	1	2	1	4	1	1	2		17	1.7
Be generative (open dialogue iso closing)	4	5	4	1	4	5	5	1	1	3		33	3.3
Refer to connections between elements	2	3	2	1	4	2	3	1	2	2		22	2.2
Total	8	10	7	3	10	8	12	3	4	7		72	7.2
Average (Avg)	2.7	3.3	2.3	1.0	3.3	2.7	4.0	1.0	1.3	2.3			2.4
Delta Range	2	3	3	0	2	4	2	0	1	1			1.8
Scores for set Urban insights (I2)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		**TOTAL**	**AVG**
Representing multiple views	1	1	1	1	1	1	1	2	1	1		11	1.1
Be generative (open dialogue iso closing)	2	3	3	4	3	1	3	4	1	3		27	2.7
Refer to connections between elements	4	2	2	2	3	1	4	3	3	3		27	2.7
Total	7	6	6	7	7	3	8	9	5	7		65	6.5
Average (Avg)	2.3	2.0	2.0	2.3	2.3	1.0	2.7	3.0	1.7	2.3			2.2
Delta Range	3	2	2	3	2	0	3	2	2	2			2.1
Scores for set Shared insights (I3)													
BASIS FOR SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**TOTAL**	**AVG**
Representing multiple views	1	1	1	4	1	1	1	5	1	5	2	23	2.1
Be generative (open dialogue iso closing)	3	3	1	3	5	1	3	4	4	4	4	35	3.2
Refer to connections between elements	3	2	1	1	3	5	3	4	2	3	3	30	2.7
Total	7	6	3	8	9	7	7	13	7	12	9	88	8.0
Average (Avg)	2.3	2.0	1.0	2.7	3.0	2.3	2.3	4.3	2.3	4.0	3.0		2.7
Delta Range	2	2	0	3	4	4	2	1	3	2	2		2.3

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