Article

Reframing a Novel Decentralized Knowledge Management Concept as a Desirable Vision: As We May Realize the Memex

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Abstract: Proposing a major (though envisaged synergetic) shift in the knowledge management (KM) paradigm needs to convince a skeptical audience. This article attempts such a feat and motivates its conceptual considerations by fusing a wide scope of theoretical KM-related foundations in response to current KM unsustainabilities and emerging enabling technologies. The envisioned workflows, infrastructure, affordances, and impact resulting from the progressing design science research and prototyping efforts are consolidated and reframed, guided by a five-step visioneering process and twelve triple-criteria-clusters combining innovative, technological, and vision-related qualities. Inspired by Bush's "Memex", a desirable vision never realized since its suggestion three quarters of a century ago, the novel KM system (KMS) pursues the scenario of a mutually beneficial co-evolution between individual and institutional KM activities. This article follows up on the unsatisfactory and unsustainable state of current KM affairs suffering from accelerating information abundance, invisible work, structural interdisciplinary holes, lacking personal tools, and widening opportunity divides. By portraying a potentially transformative and game-changing technology, the crafting and drafting of a desirable, sustainable, and viable KMS vision assures transparency and can be more easily shared with a critical mass of stakeholders as a prerequisite for creating the respective future KM reality. The drafting of the "Desirable Sustainability Vision" is envisaged to assist a currently accepted KMS start-up project and investment.

Keywords: knowledge management; personal knowledge management; knowledge vision; sustainability vision; visioneering; quality criteria for visions; general-purpose-technology; disruptive innovation; opportunity divides; memex

1. Introduction

The year 2020 marked the 75th anniversary of publishing an inspired technological vision never realized. The Memex, envisaged as a mechanized private file/desk/library-device was supposed to serve as an intimate supplement to individuals' memory, to facilitate storing, recalling, studying, and sharing the "inherited knowledge of the ages" and to also enable contributing one's own ideas and trails of interests, all easily accessible and sharable with the "Memexes" of acquaintances [1].

Over forty years before the term "Knowledge Management" (KM) was even coined by Karl Wiig [2], Vannevar Bush, at the time President Truman's Director of Scientific Research, was frustrated with the "generations-old" methods for diffusion and review deemed "totally inadequate for their purpose" of tackling a steadily "growing mountain of research" [1]. Although his Memex is recurrently remembered for its desirable potential [3–8], it has not yet led to a viable knowledge management system (KMS) implementation.

Over the last years, related design science research (DSR) and prototyping aim for a Memex-inspired KM concept and system. As traditional KMSs continue to follow centralized, top-down, costly, prohibitive, enterprise-based approaches, the proposed concept and prototype of the novel personal KMS (PKM/PKMS) suggest a grass roots, bottom-up, affordable, accessible, personal alternative. It anticipates a mutually beneficial co-evolution between individualized and institutionalized KMSs where the synergetic

potential extends across all the three archetypes (resource, process, and product-oriented) of—what has been termed—digital entrepreneurship ecosystems (DEE) [9], which will be alluded to later.

However, introducing a digital system with novel affordances successfully into market spaces, depends on realizing significant adoption rates and network effects. It requires sharing the potential prospects with a critical mass of stakeholders as a prerequisite for creating the respective reality of a—in this case—decentralized, collaborative, and generative KM scenario. This article aims, consequently, for re-framing the novel PKMS's design features and affordances by molding them into what has been termed as a "desirable, plausible and sustainable vision" [10] in order to assist the PKMS's sustainable viability.

As an important tool to guide technology foresight research processes, these kind of shared visions "do not study only the future of a given phenomenon [but also] reference the present or a past situation" [11]. By focusing on projecting, visions are used in the contexts of sustainable technological trends and development paths, including their potential technical, organizational, social, environmental, economic, and personal impact on society [12]. In using the Memex as the point of departure (past), this article portrays the unsatisfactory and unsustainable current KM state (present) to depict an innovative KMS technology (future) as a potentially transformative and game-changing solution (impact). It repurposes prior research and findings as evidence to meet established visioneering and vision quality criteria and compares the ensuing qualities of the envisaged Memex with the novel personal KM system approach.

The methodology applied is DSR. The DSR research paradigm has been comprehensively presented and justified in the PKM-related context (design as an artefact as well as a search process) in a prior article [13] which has served as evidence of the PKM project's compliance with established DSR guidelines seeking to ensure problem relevance and utility, research rigor and contribution, design evaluation, and publishability in information systems (IS) research outlets [14]. DSR's aim is to supplement the reactive behavioral (natural) science paradigm with the proactive design science paradigm to provide a roadmap for conducting, and criteria for evaluating design science research in IT. In this process, DSR undertakings are based on problem statements which, usually, are not framed as hypotheses and research questions since the focus is on design and development.

This article—by utilizing three established visioneering frameworks [15–17]—further extends prior publications and contributes to the PKM's objective in regard to validating the DSR process and anticipated DSR outcomes, covering the innovative PKM concept and system (PKMS) as well as its projected implementation (start-up). It benchmarks key PKMS features against recommended visioneering process steps and twelve proposed vision quality criteria. To provide further transparency, the assessment is applied to the novel PKMS as well as to Bush's Memex which has inspired the innovative PKMS development. The research question can, thus, be stated as:

RQ. How can we create and utilize a sustainability vision to structure the logic and logistics of a pioneering Personal KMS concept and to articulate and communicate novel affordances and potential barriers to improve its viability and desirability?

In line with best DSR practices, the article also aims to further quality-assess/assure the PKMS design and prototype implementation and to contribute to the cumulative development of IS knowledge through design theories. Recent exploratory IS and KM studies regarding the latter expressed particular concern about the paucity of follow-up research that test or extend the IS design theories investigated [18] and the minor share of conceptual contributions (versus empirical works), addressing artefacts in the KM field which further lacks cumulativeness and consistency [19].

The DSR paradigm [14] together with its notion of theory effectiveness, expect designs to be purposeful, both in terms of utility (content) and communication (presentation) to an audience [20]. Complex DSR projects, hence, typically embody "longitudinal streams of research" where varied contributions need to be presented and published at appropriate times "in terms of the continually evolving artifacts and design theories, [including report-

ing on] early visions of technology impact [and] studies of [applied] technology impact on users, organizations and society" [21]. The PKMS conceptualizing and prototyping project falls into this category with currently twenty-nine scopus-indexed prior publications and references to over five hundred external sources, prompting the need to cite and summarize prior findings to avoid reiterating considerable detail in this article. As the prototype development is still in progress, the further aims of this article are:

- To reflect—for the benefit of a desirable, plausible, collaborative, and sustainable KMS vision—on Bush's Memex to furnish a more successful visioneering approach; while not aiming to present a polished self-contained vision statement, the novel core PKMS elements are to be aligned to the guiding visioneering levels.
- To respond to the call by the authors for further validating their original visioneering methods.
- To provide complementing thoughts and content for institutional knowledge vision developers, KM policy makers and practitioners (including the vision's knowledge asset management and knowledge technology sections [22]).
- To assist developers of digital artefacts engaging in and knowledge workers benefitting from similar visioneering and collaborative KMS design contexts.

The next section (Section 2) provides a brief recapitulation of traditional KM models versus the presented PKMS approach. Section 3 introduces visioneering and visions in the context of current and potential future KM states and explores sustainability as related to system visions and utopian ideas (Section 3), followed by mapping the development stages of the novel KMS approach to a recommended knowledge-based five-level-visioneering-framework (steps 1–5, Figure 1) and by pointing out the visionary shortcomings of the Memex (Section 4), by presenting the core PKMS functionalities (Section 5) and by applying the innovative-technology and vision-quality criteria (step 6, Figure 1) to the envisaged KMS's impact (Section 6), and, lastly, the concluding remarks (Section 7).
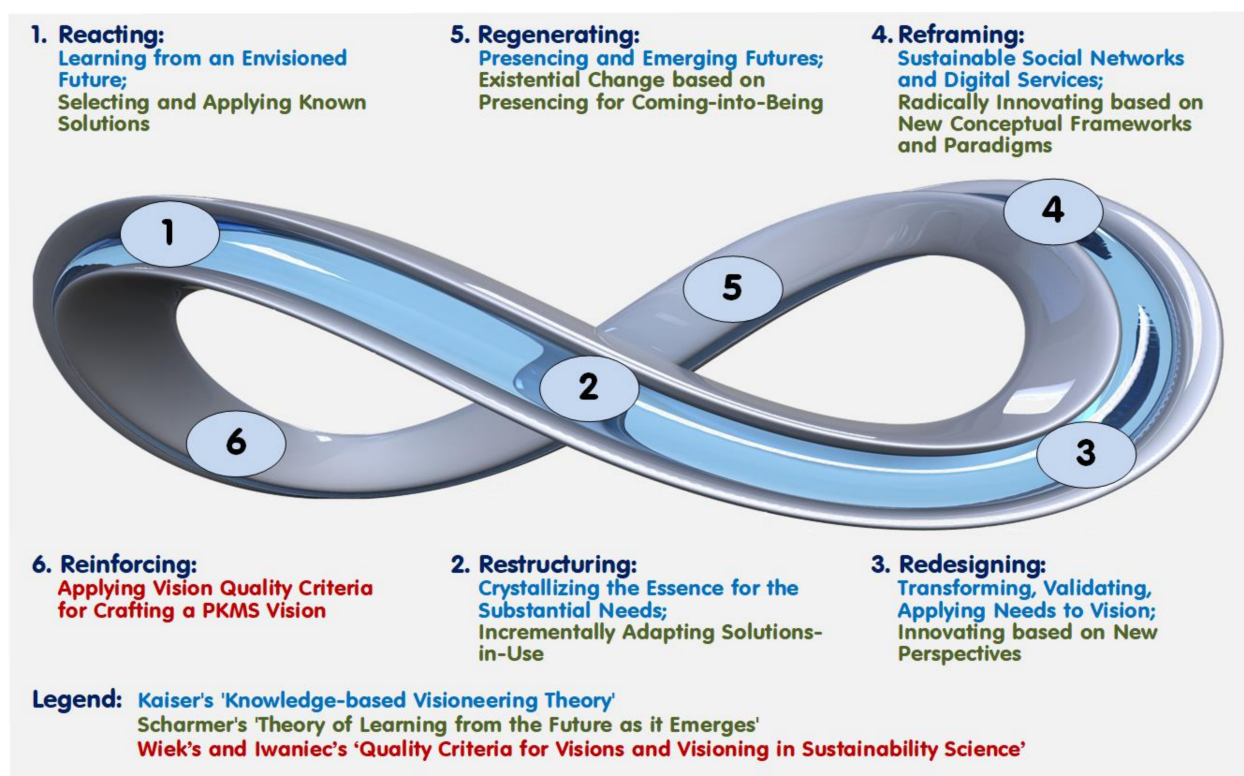

1. Reacting:
Learning from an Envisioned Future;
Selecting and Applying Known Solutions

5. Regenerating:
Presencing and Emerging Futures;
Existential Change based on Presencing for Coming-into-Being

4. Reframing:
Sustainable Social Networks and Digital Services;
Radically Innovating based on New Conceptual Frameworks and Paradigms

6. Reinforcing:
Applying Vision Quality Criteria for Crafting a PKMS Vision

2. Restructuring:
Crystallizing the Essence for the Substantial Needs;
Incrementally Adapting Solutions-in-Use

3. Redesigning:
Transforming, Validating, Applying Needs to Vision;
Innovating based on New Perspectives

Legend: Kaiser's 'Knowledge-based Visioneering Theory'
Scharmer's 'Theory of Learning from the Future as it Emerges'
Wiek's and Iwaniec's 'Quality Criteria for Visions and Visioning in Sustainability Science'

Figure 1. Structure of the paper following personal knowledge management system (PKMS) project's six visioneering phases [15–17].

2. PKMS's Role in Integrating and Expanding Current Dynamic KM Models and Practices

Traditional theoretical lenses guiding current organizational approaches have been explored in a recent article [23] covering twelve renowned KM models of knowledge creation (Figure 2).
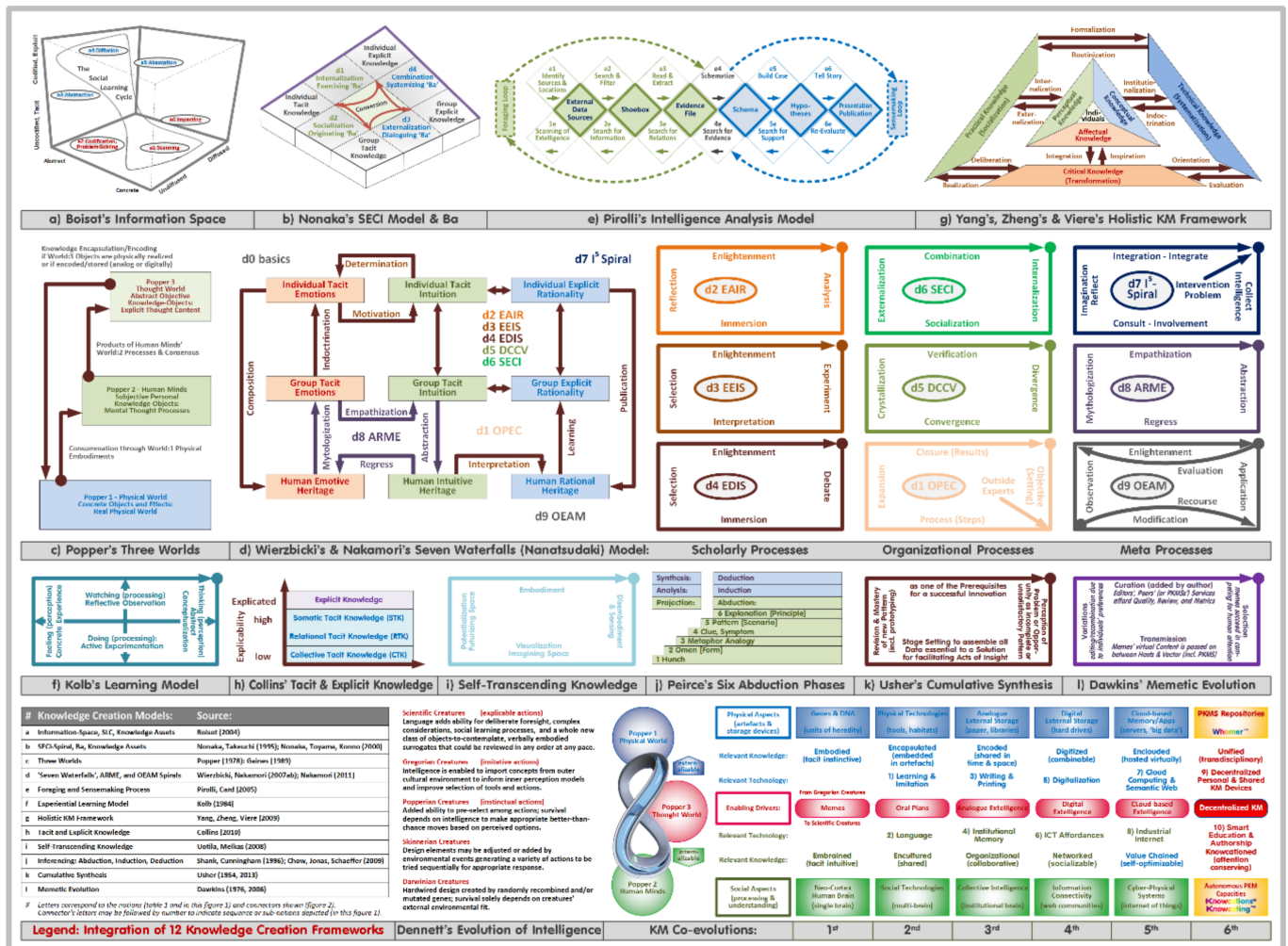

Figure 2. PKM concept's integrated twelve dynamic knowledge creation frameworks [23,24].

Rather than elaborating on the models' particular differences, the prior article focused on the complementing features and visualized them in a three-dimensional dynamic "public-transport-like" map (Figure 3) [23], an expanded version of Boisot's three-dimensional information or I-space [25]. The purple circle marks a position where an individual knowledge worker resides and where the cycles of the diverse dynamic KM models start and end, offering transparency of which alternative paths are available to pursue. The right section (purple background) also visualizes how the PKMS features expand the information space for the benefit of knowledge workers and their acquaintances and organizations. Nevertheless, institutionalizing the PKMS approach has profound implications and has been termed by Levy as a "decentralizing knowledge management revolution" [26]. The emphasis on a sustainability vision is envisaged to assist in paving the way for a successful launch.
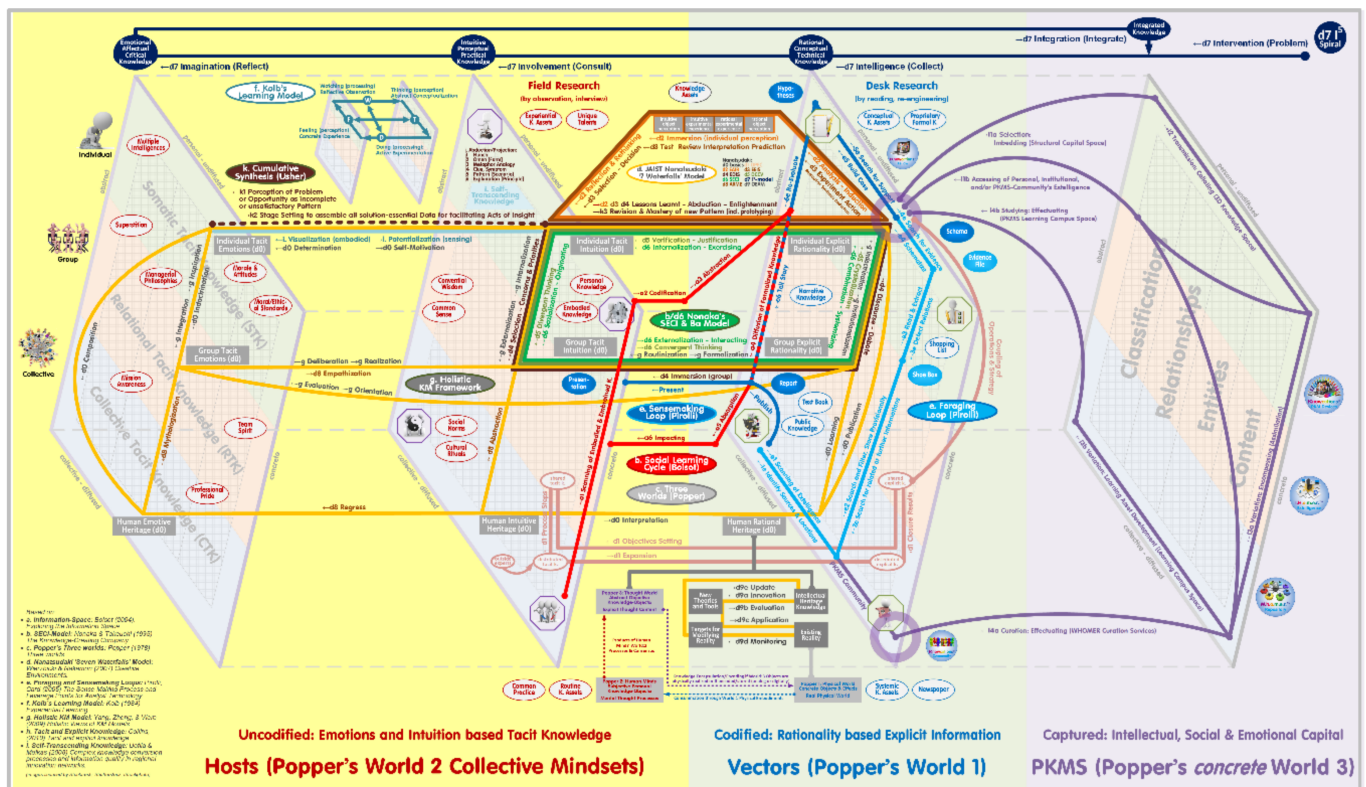
Figure 3. PKMS's integrated frameworks presented as "public-transport-like" 3D-map [23,24].

3. Vision Engineering for Overcoming an Unsustainable State of KM

Using the Memex (considered as the closest ancestor of the novel KMS approach) as a point of departure, Bush's conception is also used to exemplify how it fell short as a vision and how these shortcomings can be overcome by applying a more structured "visioneering" approach [15].

An effective vision needs to provide a "clear image of a fulfilling and desirable future which can be described to others and which is possible to be realized in any–maybe extremely challenging–way, shape or form" [15]. Further to "imaginative and sweeping ideas for how new technologies might dramatically reshape society, [it] requires some application of technical skills, knowledge, and calculations to press forward toward the technological future" [27]. It, consequently, must be rigorously described and clarified as a "future state (i.e., goals and targets, relationships, exogenous drivers and indicators)" involving complexities, interdependencies, and emergent dynamics to enhance "systems thinking, while also contributing to [its] coherence, plausibility, tangibility and specificity" [10]. A DSR publication, for example, employed systems thinking methodologies (system dynamics; agent-based, discrete-event, and process-resource modelling) for PKMS documentation using simulation software [28].

As an early KM critic, Wilson once concluded that the whole KM concept is based on "a Utopian idea of organizational culture in which the benefits of information exchange are shared by all, where individuals are given autonomy in the development of their expertise, and where "communities" within the organization can determine how that expertise will be used" [29]. The novel KMS, as will be argued, aims to turn this and other ideas into a viable KM reality.

3.1. Utopian versus Sustainability Visions

Systems are interconnected sets of elements which are coherently organized to serve purposes or functions. A system's purpose "gives birth to a vision and is often the most crucial determinant of a system's behavior". Sharing and embracing such a vision also

allows us to transcend individual success for the benefit of a sustainable future, whereas, without visioneering (the engineering of a clear vision), "the purposes of subunits may add up to an overall behavior that devastates the whole system" [30].

Utopian ideas or utopian visions, in contrast, are "not primarily technological roadmaps awaiting realization, but rather an expression of a form of public communication [that] derives from comprehensive patterns of complexity reduction that parallel the general selection criteria of the mass media.". While accelerating change is fueling the demand for guidance, resurging decades-old utopian beliefs (still lacking a plausible technological foundation) and contemporary immature ideas (decoupled from past experiences and feasibility concerns) just offer orientation without "socio-structural contextualization and an understanding of long-term social transformation processes" [31].

McCray, having coined the term "Visioneering" [32], defines it as "developing a broad and comprehensive vision for how the future might be radically changed by technology, doing research and engineering to advance this vision, and promoting one's ideas to the public and policy makers in the hopes of generating attention and perhaps even realization" [27], preferably by strengthening sustainable considerations. Section 5 will argue that Bush's Memex fell short in several vision quality categories and, hence, qualifies more as a utopian system vision.

3.2. Sustainable Development and Sustainability Visions in the KM Context

Sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" [33]. Digital technologies are assisting sustainability science in this endeavor by "gathering data to analyze pathways towards a (more) sustainable world". However, although "sustainability is expected to adapt to the new possibilities and perils of the digital age, or vice versa", it is also profoundly affected by the changes that digitalization initiates [34].

In the novel KMSs' context, the ecosystems to be sustained (depicted as ten pentagons in Figure 4 to be further detailed later) have been carved up into three parallel interdependent worlds: The physical world:1 of concrete objects and effects, the mental or psychological world:2 of human minds and subjective knowledge objects), and the intangible non-interrogatable world:3 of abstract explicit objective knowledge objects (inner circle of Figure 4 corresponding also to green middle, yellow left, and purple right sections of Figure 3). The latter serves Popper's view that a subjective thought can only be shared and objectively criticized (judged on its own merit independent of its creators) once its content has been explicated [35].

As a mainly philosophical construct, world:3 bridges the physical and mental worlds only metaphorically; for access and impact, its abstract knowledge objects still need to be resourcefully combined and encoded (or encapsulated) in concrete physical objects [36].

Relying on fewer and more costly sources and channels, our recent KM past suffered from information scarcity. As consequence, the redundant duplication of knowledge was experienced as a blessing rather than a curse, and the world:3 and its wider entropic and generative implications (to be alluded to) were not prioritized. Accordingly, traditional KM models (as exemplified by Nonaka's socialization, externalization, combination, and internalization (SECI)) and Ba model [37,38] in the center of Figure 4 (and green parallelogram in the center of Figure 3 integrated within the eleven other complementing knowledge creation models) are mainly addressing world:1′s and world:2′s issues, an oversight which now steadily emerges as no longer sustainable.

Recent publications have detailed how the familiar information-scarcity has transformed into a never-before experienced ever-increasing attention-consuming information abundance by applying the strengths, vulnerability, and intervention assessment related to digital threats (SVIDT) methodology [39,40], by adapting the psycho-social notion of generativity (in line with recent discourses in technology and innovation) [36,41], and by pinpointing the (neg)entropic consequences [42,43].
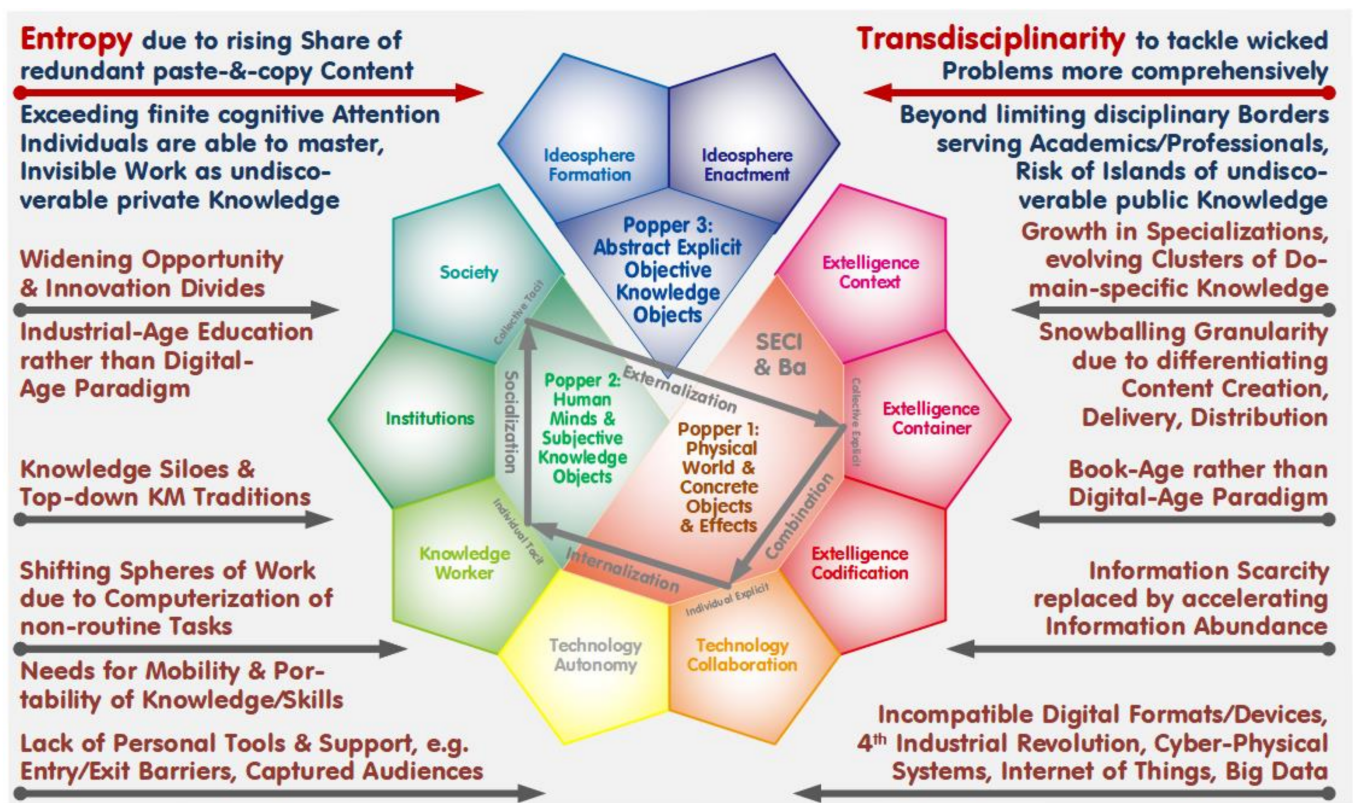
Figure 4. Selected unsustainabilities related to Popper's worlds, digital ecosystems, and KM phases.

Some of the resulting unsustainable challenges and fixations encountered are highlighted in Figure 4 (to be further elaborated on). They have been attributed to the ten digital ecosystems (surrounding the three worlds and the SECI/Ba flows in Figure 4). These KM ecosystems are based on Gibson's and Briscoe's notions [13,44–46] and are uniquely defined by their key properties, structures, processes, and roles. Although highly interdependent, they allow for exploring specific fixations and barriers as well as affordances and impacts.

Their inherent complexities qualify any remedial sustainable KM approach as a "wicked" problem space, characterized as ill-defined, incomplete, contradictory, and by changing requirements and complex interdependencies, where the information needed to understand the challenges depends upon one's idea or concept for solving them [47].

To address the current sorry KM state and its proposed potential decentralized KMS solution in the context of a "Desirable Sustainability Vision", hence, adds to the quality and communication of a purposeful design and theory effectiveness. It also allows for tapping into the visioneering's "vast potential for investigations and increasing public, political and scientific relevance", including the "attribution of desirability to the vision" [32]. It, moreover, seems to facilitate good opportunities to share the potential prospects with a wider critical mass of stakeholders as a prerequisite for creating the respective reality of decentralized KM and generative Personal KMSs.

4. Knowledge-Based Visioneering Theory in Support of PKMS Adoption

A vision statement requires a detailed, customized, unique, reasonable, and documented purpose [15] to be based—in the PKMS context—on the visioneering needs analysis of this article. Detection of its key necessities follows Kaiser's "Knowledge-based Visioneering Theory" which encompasses Scharmer's "Theory of Learning from the Future as it Emerges" [16] with its five-level-framework of change (Figure 1): (1) reacting (selecting and applying known solutions), (2) restructuring (incrementally adapting solutions-in-use), (3) redesigning (innovating based on new perspectives), (4) reframing (radically innovating based on new conceptual frameworks and paradigms), and (5) regenerating (ex-

istential change based on presencing). The levels' chronological milestones and conceptual contributions already reflect the PKMS's development stages so far.

4.1. Level 1-Reacting: Learning from an Envisioned Future

Kolb defines "Learning" as the process of transforming experience into knowledge embracing creative tensions among subjective personal and objective environmental concerns and among four dynamic recursive learning cycle modes: (1) immediate or concrete experiences (CE) are the basis (2) for reflective observations (RO). The latter are assimilated via thinking and (3) distilled into abstract conceptualizations (AC) (4) from which new implications for action can be drawn and which can be tested via active experimentation (AE) resulting in informing guides for creating (back to (1)) novel experiences [48].

Learning from an envisioned future (EF) can be defined as reflecting about envisaged hypothetical future scenarios transcending the boundaries of today's fixations, barriers, and unsustainabilities. "The narrative result enables externalization of tacit dreams, wishes and desires as if they had become true and thereby generating a picture of the desired personal future from which explicit knowledge can be derived in order to act accordingly in the present" [15]:

- The initial idea for a personalized KM system emerged in the 90 s from the need to support personal consulting, scholarly, and managerial activities. The early system catered solely for the author's own KM needs but has been, over time, continuously adapted and expanded (CE). The author's professional and academic interactions spanning working environments in developed and developing regions have further underpinned the perceived need for PKMS-like support interventions (RO), a view shared by other writers as referred to in this article.
- However, only the recent technological progress in development, hosting, cloud, and noSQL database platforms initiated the conceptualization (in contrast to the Memex) for advancing the "private" PKMS into a "public" application (AC) serving an envisaged growing PKMS community across their technological devices. In parallel, a series of multi-disciplinary papers and articles have been presented and published in order to report to and receive feedback from peers, readers, attendees, and students (AE) which inspired supplementary foresights and inventiveness (EF) to, in turn, inform subsequent design stages and publications (CE).
- Having experienced the envisioned future, the knowledge output at this first level is a "Vision-1" externalizing the ideas and prospects to overcome constraints and fixations and to meet potential beneficiaries' needs via affordances. Kaiser refers to the latter as "Satisfiers" (culturally determined concrete solutions to needs or desires) [15]. Any initial vision-1, at this stage, may be incomplete, fragmentary, and-in parts-even illusionary and unsustainable, but it provides a basis for further scrutinizing the needs and their interdependencies to set feasible priorities and/or identify alternative solutions. Vision-1-type PKMS examples are the identification of barriers preventing PKMS-type innovations so far, of wastes in knowledge life cycles, and of vital provisions such systems ought to afford to a user community [46,49,50].

4.2. Level 2-Restructuring: Crystallizing the Essence for the Substantial Needs

Defining sustainability for a fulfilling life strongly aligns with the capacity to meet substantial human needs which (based on vision-1 satisfiers) have to be substantiated to allow for assessing possible actions and developing alternative solution strategies [15]:

- A case in point is an information and communication technologies for development (ICT4D) approach by Johri and Pal. They observed that developmental efforts in low-resource environments disproportionately cater for basic user needs "without adequate attention to user-motivated concerns which would enrich their lives". They propose prioritizing four design characteristics aiming to make a "real difference in the lives of its intended beneficiaries-those that are significantly disadvantaged in terms of resources as well as opportunities": (1) access to artefacts (accessibility easiness),

(2) ability for self-expression (expressive creativity), (3) ability to interact and form relationships with other people (relational interactivity), and (4) opportunity to enrich the environment (ecological reciprocity) [51].

- From a PKMS perspective, these criteria are too narrowly framed. A "PKM for Development" framework (PKM4D), hence, expanded the four criteria above to twelve progressing sub-needs which also correlate closely to Maslow's extended "Hierarchy of Needs" [52]. The satisfaction of these sub-needs impacts on individuals as "exciters & delighters" whereas their neglect causes detrimental effects in form of "inhibitors & demotivators". As these sub-needs correspond to the PKMS digital ecosystems alluded to (see also later in Figure 6, column 6) and their distinctive characteristics and affordances, growing PKMS communities may successfully narrow opportunity divides at societal level which can be targeted by six intervention clusters (scaping, sight setting, socializing, striving, systemizing, and scaling) [53].

4.3. Level 3-Redesigning: Transforming, Validating, and Applying Needs to Vision

To transform the prior outputs into a "Sustainable Vision", this third level considers the requirements and consequences for others and the common good of realizing this vision. The task is successful only if "the substantial needs of an individual or a social system [are addressed] without compromising the ability of others and future generations to meet their own needs" [15]:

- The affordances envisaged to be bestowed on the PKMS user community have been related to network communities' needs (in support of communication and collaboration [54] and social knowledge sharing [55]). The results confirm the fragility and unsustainability of today's state, but also that the narratives covered in these two publications only partially cover the transformative needs expressed in the PKM4D framework. The affordances and fixations, thus, needed to be expanded and reprioritized as well as to be restructured to fit the PKMS ecosystems and developmental clusters as well as the generativity and (neg)entropic aspects alluded to [36,42,46].
- From the grass-roots perspective, the concepts and frameworks allow individuals to judge how their "status is weakened under the current technological options and constraints, and how it can be considerably strengthened" by PKMS-like technologies. From the bird's-eye view, digital vulnerabilities and threats have been addressed utilizing the SVIDT methodology with its impact and intervention clusters which inform stakeholders to assist tackling opportunity divides [40].

4.4. Level 4-Reframing: Sustainable Social Networks and Digital Services

A past publication has attended to the reframing context by considering as to what extent the PKMS may be regarded as a disruptive innovation and/or general-purpose-technology (GPT). For this purpose, the respectively combined criteria [56,57] have been used to positively appraise the potential impact of the envisaged decentralized generative KMS [58].

In addition, a complementing fourth-level extension of the visioneering theory [15] is suggested since the current concluding third level with the "Do-No-Harm-Notion" is not always sufficient. Although it may be argued that the terms "Consequences & Compromising" (level 3) implicitly incorporate the suggestion, an explicit distinct level for addressing the notion of "Growth" versus "Sustainable Growth" seems critical:

- Growth is-in some instances (e.g., participation in digital communities, platforms, or infrastructures)-not an optional but essential virtue for survival as well as for a disruptive innovation: "A new person added to a network adds value as a member and also adds some value for each other member in the network, so each new member in a large network is worth more than a new member in a small network". These so-called network effects feature, also, as GPT-criteria and also define the value of social networks as an increasing popularity of one network or social platform can have a devastating competitive impact on the sustainability of others [56].

- However, instead of offering generative accommodating features to collaborate and create across spaces for qualitative growth, current digital platform providers abuse their market position and maintain their continued growth by enforcing inflexible exit, entry, and data format and export barriers at the expense of their captured audiences' attention, time, productivity, funds, and status [40]. Discouragingly, developing the currently dominating community-support technologies is "left in the hand of [just a] few big players while the research community is just observing and reporting on their usage in different contexts", a situation which "is stifling the development of real alternatives and the quest for disruptive innovation" [55].
- As growth and technological advances depend on "appreciative humans in pursuit of superior affordances" [36], they need to be made aware of quantitative and qualitative differences. Accordingly, a multi-level heuristic "Appreciation Model" has been devised as an enabling driver of network effects [13,59] by focusing on (1) aesthetic elegance, (2) schematic resonance, (3) contextual relevance, (4) utility, (5) advancement, and (6) enactment. (7) To retain PKMS community users, benefits need "to significantly outstrip the user's perceived inconveniences due to time, effort, and self-discipline invested" [60].

The levels 1–5 define pre-PKMS-user-stages and allow for differentiating the logic and logistics of informing, familiarizing, and servicing and for catching the attention of an envisaged sustainably developing network (by, for example, print/online publication, tutorials, collaborations with educational institutions, learning management systems, and non-government organizations).

To maintain and grow levels 6–7, the task complexities facing a user need to be sufficiently eased by intelligible comprehensible concepts, well-thought-out design, and educational features.

This article, accordingly, utilizes the synergies between the novel KMS's GPT-potentials previously addressed [58] with the three vision quality criteria categories to be detailed [17].

4.5. Level 5-Regenerating (Presencing and Emerging Futures)

This fifth level allies with the notion of "Emergent Innovation" which attends to the high failure risk of radical innovations and paradigm shifts due to their lack of acceptance and/or sufficient deployment. One crucial remedy is to reduce actors' unfamiliarity with novelties by affording connection points stakeholders are accustomed to in order for the radical change or innovation to "fit organically into and get into resonance with the existing structures of our thinking, organization, markets". Such an approach promises profound, meaningful, and sustainable contributions by easing complex tensions between radically new and established perspectives and structures [61].

Section 4.2 has referred to some of the "existing structures" where a solution following the "emergent" logic has to organically fit into. Figure 4 has also presented a selection of current shortcomings deemed unsustainable; some more or less are consequences of others. The recent attention paid to generativity [36] and (neg)entropic [42] notions allowed identifying the most critical points, predominantly positioned within the Popperian world:3 or ideosphere ecosystems currently underserved by traditional KM approaches. The PKMS design concept (as to be argued in Section 6) promises an approach to tackle these key areas:

- Rising stakes of the ever-increasing attention-consuming information abundance include undesirable entropy (e.g., paste-and-copy quotes, duplications, fragmentations, inconsistencies, untraceabilities, corruptions, decay, obsolescence, and fake facts) which is threatening the finite attention individuals' cognitive capabilities are able to master. With search engines unable to keep this "negative generativity" in check, scarce attention needs to be supported by eliminating entropy "so that far less information needs to be read, written, or stored" [62].
- IT and KM practices, fixated on outdated book-age paradigms, still rely on the "over-simplistic modelling of digital documents as monolithic blocks of linear content, with a lack of structural semantics [by] unnecessarily replicating content via copy and paste

operations, instead of digitally embedding and reusing parts of digital documents via structural references" [63]. Prioritized developments (industrial internet, big data) are likely to increase entropy further.

- Bush's criticized "generations-old" "totally inadequate" diffusion and review methods [1] similarly persist as evidenced by calls for more rapid iterative improvement and reputation-based research systems/metrics [64]. Consequently, "magnitudes of invisible work" (defined as "gap between formal representations, including publications, and unreported 'back stage' work") [65] result in undiscoverable private knowledge and entropic repetitive efforts.

- Unfortunately, also the negentropic stakes of our knowledge bases are far from effective. Although "wicked" problem spaces (like the PKMS) require transdisciplinary holistic approaches, Bush's criticism of "being bogged down today as specialization extends" [1] has increased with the present disciplinary "silos" and their carved-up "curricular and bureaucratic domains"; Bernstein, hence, urges to "creatively re-imagine the disciplines and the possibilities for combining them" [66,67]. Continuing as usual implies that "Structural Holes" [68] (referring to non-existing but viable beneficial ties) are poised to further multiply and expand in line with the risk of more disconnected islands of undiscoverable public knowledge [69].

4.6. Perceiving the "Memex" over Time as Seen via the Five-Level-Framework

What has made Bush's Memex a great idea and such a classic article (over 12,700 Google Scholar hits as of March 2021) is not only Bush's envisioning of possible technologies and systems but also the promoting of their enticing impacts [6]. However, to furnish a viable "Desirable Sustainability Vision" for the PKMS, it is worth focusing—in the context of the prior section—also on its shortcomings.

As a never-realized vision, the Memex's state of visioneering is mainly confined to the steps of reacting and restructuring (Sections 4.1 and 4.2, Table 1); its technological feasibility was based on Bush's post-second world-war assumption that progress had "arrived at an age of cheap complex devices of great reliability; and something is bound to come of it" [1]. Bush conceded later that his "object was not to propose a practical device, but to try to take a long look ahead" and that, at this ideation stage, the Memex "was a crude device, even although it involved the use of techniques not then developed" [70]. According to the quality criteria (Section 6) [17], these gaps disqualify it as a sustainability vision.

Table 1. Pros and Cons attributed to the Memex over Time.

Visioneering	As Inspiring Vision Never Realized, Pros and Cons Have Been Attributed to:
Reacting to known solutions	To Bush's imagining of an innovative system based on "new forms of interwoven documents" and new ways of how "scientists and scholars could handle and share their ideas, writing, reading and filing in a magical system at their desks [. . .] to be consulted with exceeding speed and flexibility" [3], "envisioned to tackle the 'information overload' problem, already a formidable one in 1945" [5]
Restructuring of solutions-in-use	To Bush's "vision of how information could be manageable [by utilizing] personal associations derived from experience, and not abstract structures" and indexing [7]. However, "the early pioneers of hypertext were [also] all directly influenced by Bush's vision" [4] and "Bush never foresaw that the technologies he hoped would tame the [information] problem might actually contribute to its intensification" [6].
Redesigning for new perspectives	To his Memex which "was an early example of exactly what [our] survey will characterize as a personal knowledge base [which integrated] collaborative aspects as well, and even a world-wide system that scientists could freely consult" [5].
Reframing for radical innovation (reason no viable Memex exists yet)	To "the broad spectrum of demands that could be placed on such a system [although] such applications could radically improve the way people deal with computers, information, and their entire world" [5]. "If a Memex was needed in Bush's day, then today's information explosion makes it an order of magnitude more important" [8].
Regenerating and the current state of coming-into-being	To "future tools [Bush hoped to see] that would reduce information overload and promote information synthesis, tools that would allow humanity truly to encompass the great record and to grow in wisdom" [6]. However, "while today we have many powerful applications for locating vast amounts of digital information, we lack effective tools for selecting, structuring, personalizing, and making sense of the digital resources available to us" [71]. The PKM tools and systems available "are not integrated with each other [and] provide only a partial support to knowledge workers" [72].

5. From the "Memex" to a PKMS Supporting a Digital Platform Ecosystem

While the system's view of Bush's Memex has been a powerful inspiration and its associate indexing forms part of the PKMS [1], later concepts and notions being put forward over time by renowned authors have similarly impacted the PKMS design, as, for example, generativity [41]; cumulative synthesis [73,74]; attention management, information abundance and redundancy [62]; memetic evolution [75]; three worlds [35]; affordances [44]; SECI/Ba model, knowledge assets, and the related personal knowledge-related proficiencies/assets and autonomy [37,38]; extelligence [76]; schools of KM [77]; knowledge assets and information space [25]; bottom-up KM approach [78]; digital ecosystems [45]; human capital and nano-performances [79]; decentralizing KM revolution and creative conversations [26]; and calls for more rapid iterative improvement [64], to name some of the most influential conceptualizations.

These diverse concerns were compellingly articulated by their respective authors, but in isolation from each other and, therefore, were not systematically combined and investigated to address the wicked KM problem space for yielding adequate methodological and technological responses. A holistic transdisciplinary approach is, however, vital for structuring comprehensive complex resolutions and their informing approaches (including a sustainability vision) to facilitate understanding and acceptance [40].

One of the research contributions of the PKMS design is, thus, to cumulatively synthesize these diverse notions and to identify and benefit from their sustainable wickedness-defying negentropies, generativities, and synergies which are currently being validated by prototyping.

5.1. Visualizing the Meta-Landscape of the PKMS Concept for Visioneering

The aim of the PKMS, like the Memex, is rooted in a decentralized KM concept to support individuals' capabilities, autonomy, and collaborative endeavors. Its concept synergetically integrates with the notion of digital platform ecosystems (DPE). DPEs are generically defined as meta-artefacts which afford clients with highly diverse skills (gifts) and ambitions (ends) to gainfully utilize its resources and generative potential (means) in their personal and local settings (contexts) [80]. An article has used the gifts-contexts-means-ends perspective to point out the additional complexities such a DPE faces compared to organizational KMS [43].

Figure 5 presents the DPE from a bird's-eye view. It depicts individual social actors (left) with their decentralized Personal KMS devices as members of the PKMS user community. The anti-clockwise workflow shows that the voluntary shared individual content is centrally synthesized and curated (top-right) before it is fed back to the community. It may also be repurposed as learning assets to foster personal learning environments (PLE) which comprise self-developmental activity spaces which encourage the reusing, remixing, and sharing of learning resources [81]. Adding to the broader DPE context are further interactions with organizational knowledge and learning management systems (OKMS, LMS) (top-middle-and-right). The areas termed knowledge worker, technology, extelligence, ideosphere, and society indicate the PKMS ecosystems to be referred to. The differentiated projects below are also referenced later.
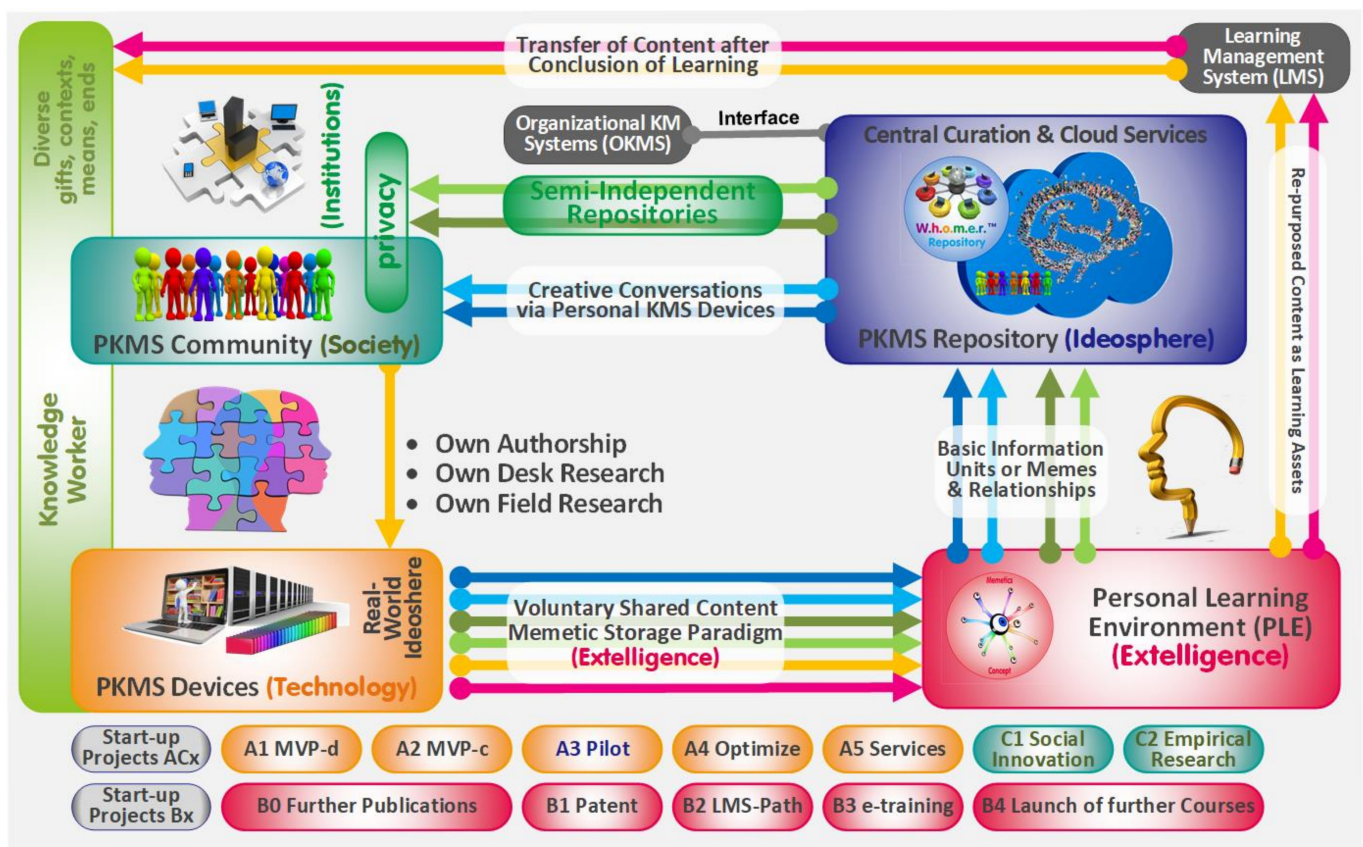
Figure 5. PKMS as a digital platform ecosystem (DPE) [36].

5.2. The PKMS SICEE Workflows versus Nonaka's SECI Model and DEE Flows

Figure 6 details the PKMS's conceptual contribution within this DPE (Figure 5) and visualizes its key structures workflows (seizing, imbedding, collating, encompassing, and effectuating (SICEE)) as six columns (with horizontal alignment indicating relations):

- Column 1: Nonaka's clockwise document—and record—centric workflows of the SECI and Ba model.
- Column 2: Popper's three worlds with their clockwise workflow cycle.
- Column 3: PKMS's ecosystems and eco-subsystems.
- Column 4: PKMS's anti-clockwise meme-based (see below) workflows of the SICEE cycle.
- Column 5: C-K-design theory generativity types and DEE flows aligned to SICEE workflows.
- Column 6: PKMS's twelve PKM4D criteria (left) and their corresponding hierarchy-of-needs levels (right). Their vertical structure does not align horizontally to the ecosystems on the left due to the divergent progression of the PKM4D framework (Section 4.2); the alignment is, instead, indicated by the color-scheme (as used in column 3).

Memes were originally described by Dawkins as units of cultural transmission or imitation (e.g., ideas, tunes, catch-phrases, skills, and technologies). They are (cognitive) information-structures that evolve over time through a Darwinian process of variation, selection and transmission with their longevity being determined by their environment [75]. In the PKMS context, Memes introduce the suitable metaphors of knowledge as living organisms where authoring increases the potential of memes to mutate into new variants or form symbiotic relationships with other memes (memeplexes) to mutually support each other's fitness and to replicate together in an "Ideosphere" [82], an "invisible but intelligible, metaphysical sphere of ideas and ideation" where we engage in the creation

of our world [83]. This memetic perspective benefits a standardized negentropic storage regime as well as a better suited analogy for user education.
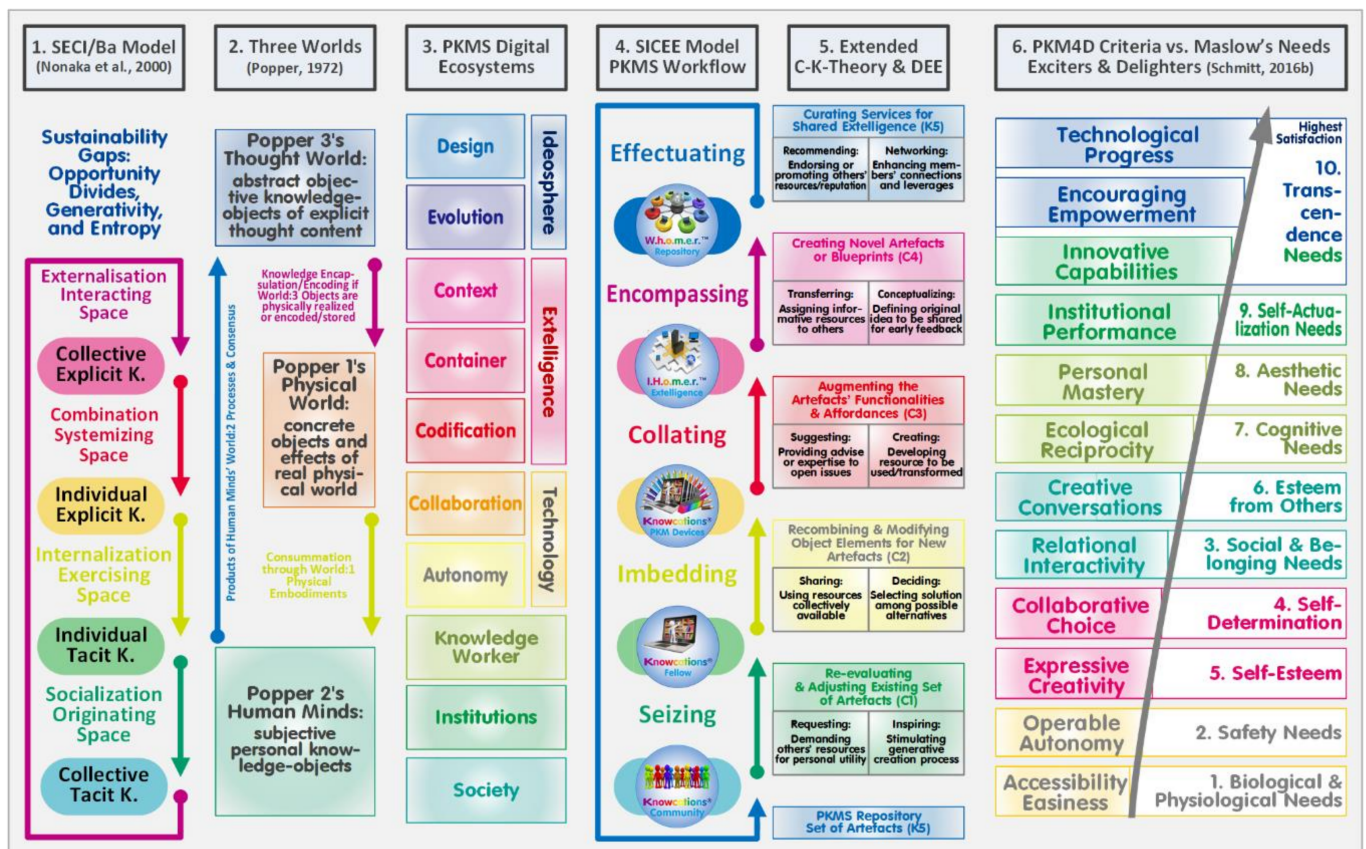

Figure 6. PKMS ecosystems aligned to three worlds. Socialization, externalization, combination, and internalization (SECI) and seizing, imbedding, collating, encompassing, and effectuating (SICEE) models and PKM for development (PKM4D) framework.

The SICEE workflows (anti-clockwise instead of the clockwise SECI model as depicted in Figure 6) embody the following PKMS activities: A user/fellow either collects/comprehends or authors/composes knowledge (seizing by knowledge worker) and subsequently captures it as basic information structures (ideas or memes with their relations) in his/her personal PKMS device (imbedding into technology). The memes captured can be utilized in any combination of four modes (reposit, revise, reclassify, and/or redeploy) to create memeplexes, knowledge assets, or digital documents (collating as extelligence) by structurally referencing instead of redundantly copying them. Extelligence positions the explicit record as the externally stored counterpart to the intelligence of the human brain/mind tasked with understanding; together they are driving each other in a complicit process of accelerating interactive co-evolution [76].

PKMS content can be voluntarily shared but needs to be curated first (alike memes are merged with their relations consolidated, trail-mapped, and associatively indexed) resulting in a unified transdisciplinary "World Heritage of Memes Repository (WHOMER)" (encompassing as ideosphere). Its navigational as-created-genealogies (to be further alluded to) facilitate the use of content and computation of reputation and citation metrics, which enhances its utility for the PKMS community to enable content access, augmentation, and re-purposing (for example, authorship or learning assets) (effectuating for society). PKMS community users/fellows may then access their own or shared content from the WHOMER repository (seizing by knowledge worker), closing the iterative cycle.

This SICEE sequence has recently been corroborated [84] by empirical knowledge-heritage-research [85] which resulted in extending the C-K-design theory (CKDT) [86]. The five correlating generative types of the extended CKDT are depicted in Figure 6, column 5 (C1-C4, K5). CKDT offers an appealing approach supporting continuous design improvements. It specifically focuses on the iterative nature of developmental processes and promotes the generative interaction between the two co-evolving spaces of knowledge (K as logical true/false propositions) and concepts (C as attractive propositions that modifies an existing knowledge space). CKDT has featured in educational (e.g., engineering, business, design, or entrepreneurship) as well as industrial (start-ups, small and medium-sized enterprises (SME), or big firms) contexts [87]. As published earlier [88], PKMSs may also assist SMEs to more effectively navigate their dynamic growth stages challenged by performing and innovating under growing pressures and communication needs.

As the most relevant flows within the respective digital entrepreneurship ecosystems have been recently detailed [9], they have been added to the five generative CKDT types in Figure 6, column 5, to further re-interpret the SICEE cycle in these ten DEE terms (original terms provided in italics). While the five terms on the left reflect on more passive activities, their right counterparts are pointing to more active user engagements:

- Seizing (K5–C1): The WHOMER repository and curation services provide comprehensive knowledge accessibility to its PKMS user community (*request: Demanding others' resources for personal utility*) to gainfully utilize its resources and generative potential in their personal and local settings (*inspire: Stimulating generative creation process*).
- Imbedding (C1–C2): As associatively structured content in standardized memetic formats (*share: Using resources collectively available*), users may easily trace, select, and embed transdisciplinary extelligence for use in their own artefacts (*decide: Selecting solution among possible alternatives*).
- Collating (C2–C3): They may engage by annotating existing memes (*suggest: Providing advice or expertise to open issues*) or by authoring their own memeplexes and knowledge assets (*create: Developing resource to be used/transformed*).
- Encompassing (C3–C4): The re-purposed or re-classified memes and their relations may be voluntarily shared (*transfer: Assigning informative resources to others*) as well as any self-authored novel contributions (*conceptualize: Defining original idea to be shared for early feedback*) by uploading them from the personal devices to the centralized cloud-based WHOMER repository.
- Effectuating (C4–K5): As a user like any other member of the PKMS community, the centralized PKMS may engage in any of the eight DEE flows reinterpreted above. As managing agent, its curation services ensure the associative integrity and negentropy of its knowledge base and the accuracy of content and member metrics (*recommend: Endorsing or promoting others' resources/reputation*) as well as the utility of other added-value services and affordances (*network: Enhancing members' connections and leverages*).

All ten DEE flows are, thus, accounted for although PKMSs only operate on extelligence which covers explicated tacit (human minds) and explicable encapsulated (physical objects) knowledge. Each of the nine DEE cases presented by Elia et al. covers this spectrum only partially but their DEE scope of digital artifacts, infrastructures, and platforms also incorporates physical components and applications as, for example, Fab Labs, 3D printers, or browser extensions [9].

5.3. PKMS as a Disruptive Innovation and General-Purpose Technology

Digital artefacts, including KM systems, are not merely "means to an end of achieving sustainable development" but ought to be desirable, accessible, and sustainable [89] as well as affordable, explorable, and exploitable by themselves. As drivers of human progress and productivity, KM systems and practices have historically co-evolved with general-purpose technologies (e.g., language, writing, printing, computing, or the internet) [13].

The GPT term applies to transformational changes affecting "both household life and the ways in which firms conduct business" [57], as exemplified by digital technologies

where the recent shift from information scarcity to abundance has drastically altered the fabric of society due to their profound impacts on our personal development and work spheres.

Accordingly, GPT's describing criteria (Table 2 top: Focus on generic features, input characteristics, dominant designs, prevalence) form a subset of sustaining/disruptive-impact innovations (Table 2 bottom) with their systemic roots (and emphasis) in products (utility gaps and chances), processes (effectiveness), relations (social relevance), or cultural shifts (adapting and innovating) [56]. Both of these sets were combined, as mentioned in Section 4.4, and aligned to the ten PKMS ecosystems to appraise the PKMS's respective potential fit [58].

Table 2. Criteria addressing disruptive innovations and general-purpose technologies.

Criteria GPT	Attributes of General-Purpose Technology [57]:
General Purpose	To perform enabling generic functions for complementary innovations triggering transformational developments and general productivity gains.
Prevalence	To persist over time despite challenging alternatives based on coordinating agents' choices in the context of systems' systemic technical interrelatedness, quasi-irreversibility of investment via switching barriers, and positive externalities from supply-side learning and/or demand-side network effects.
Input Characteristics	To widely impact on general applicability and productivity growth, dynamic technical change and improvements, and product and process innovation.
Dominant Design	Based on usefulness, wide acceptance and usage, or establishment as standard, leading to dominance over alternatives, path-dependency, market allegiance.
Criteria Disruption	Systemic Roots of Sustaining or Disruptive Innovation [56]:
Product Innovation	Emphasis on changes in object attributes and distinctions between ideal and actual operating performance as a dominant influence in their evolution.
Process Innovation	Emphasis on improving manufacturing practices as well as product usage to aim for dominant designs to stimulate product loyalty in the customer base.
Relational Innovation	Emphasis on developing desire for products/services based on subjective (popular demand based) and objective (generic needs based) social relevance.
Cultural Shifts	Emphasis on social/historical contexts as basis for individuals and institutions to interpret information for (re-)creating meanings, familiarity, comfort.

By instantiating Popper's three worlds, Figure 6 cumulatively synthesizes the conventional organizational and the novel decentralized KM models and constructively links them to the generative levels of design theories and entrepreneurial ecosystems. As a common structure, the ten PKMS eco-subsystems (column 4) provide a meta-framework which not only accommodates the PKM4D, disruptive, and GPT attributes but also the ten vision quality criteria to be discussed next.

6. Applying Vision Quality Criteria for Crafting a PKMS Vision

As a so-to-speak descendant of the Memex, the visioneering state of the PKMS concept has evidently progressed. The technologies the PKMS is based on (development, hosting, cloud, and noSQL database platforms) have been recently introduced. However, to furnish the PKMS with a "Desirable Sustainability Vision", available meta-technologies, ongoing development efforts, and clarity of conceptual syntheses need to be complemented by adequate innovative impactful affordances.

6.1. Cross-Fertilization Potential of Innovation and Vision Quality Criteria

The attributes of sustainability concerns [40] and generativity models [36] as well as the combined GPT/Disruption criteria (Table 2) and the vision qualities to be presented are highly interdependent within and across their categories; they somewhat apply to all ecosystems depicted (Figure 6, column 3) across social (society, institutions, and knowledge worker), technical (technologies serving autonomy and collaboration), informational

(extelligence dependent on codification, container, and context), and systemic concerns (ideosphere affected by evolution and design).

As these diverse criteria and attributes correlate to each other to a greater or lesser extent, they can still be effectively combined and assigned to the most appropriate ecosystem to assist in determining the suitability of PKMS affordances and features. The ten criteria suggested for assessing sound visioning approaches with their wide scope of normative (visionary and sustainable), construct (systemic, coherent, plausible, and tangible), and transformational (relevant, nuanced, motivational, and shared) qualities [17] have been used accordingly to further qualify the twelve criteria sets utilized previously in the GPT context. These extended sets assist differentiating the vision-related aspects of the PKMS.

Figure 7 shows a matrix of twelve criteria sets depicted as multi-row multi-colored blocks. Each depicts one of the distinct triple-vision-quality-clusters and is identified by its vision quality category and attribute (first row aligned within rows), its disruptive-innovation-relevance (second row aligned within columns and top row), by its general-purpose-technology-focus with its full-text descriptor (third row in italics referring to 2nd top row), and its close affiliation to one of the ten PKMS ecosystems (fourth row with color aligned to column 3 of Figure 6. The left column in Figure 7 (normative, construct, and transformational attributes) frames the three vision quality categories to be further detailed.

Figure 7. Cross-criteria-clusters combining innovation, general-purpose-technology (GPT)-impact, vision quality, and ecosystems.

6.2. Individual Vision Quality Criteria Applied in the PKMS Context

The conceptual and systemic PKMS features, as pointed out, were positively assessed against the combined GPT/disruption criteria and were previously presented in sequence with the "SICEE" workflows [58]. The discussion of the cross-criteria-clusters follows the newly embedded vision criteria by focusing on "Individualization and Personalization" (Section 6.2.1: Normative), "Nano-Contributions and Memetics" (Section 6.2.2: Construct), and "Revolution and Evolution" (Section 6.2.3: Transformational). These three subsections open with a description of currently developing settings affecting the vision quality categories with their four cross-criteria-clusters each.

Distinctly segmenting the twelve individual criteria-clusters or blocks (Figure 7) by connecting the appropriate KM-related dots is a comprehensive undertaking where the intended differentiation is at risk to become lost in detail. The essence of this effort has, hence, been summarized as overviews (Tables 3–5) presented in the three following subsections while the full text has been placed in the Appendices A–C (where each cluster is first identified by its vision-quality, disruptive-innovation, GPT, and ecosystem affinity and then further characterized by the related pressing PKMS aspects).

Table 3. Summary of individual normative vision quality criteria as detailed in Appendices A.1–A.4.

GPT Criteria Descriptor with Reference to Subsections in Appendix A	
- Vision Quality Criteria - Innovation Criteria - PKMS Ecosystem + Knowledge and People Attributes * Aim of Affordances	Key Affordances and Argumentation Points - Synergies with renowned dynamic knowledge creation models. - Potential of co-evolution between personal and organizational KMS.
A.1 General Purpose 1: Performing Generic Functions for Downstream Generalized Productivity	
- Normative 1: Visionary - Cultural 1 (PKM4D Framework) - Society (including PKMS Community) + Accessibility and Thrivability * Narrowing opportunity divides	- Individuals' intellectual, social, emotional, structural capitals. - Role of "nano"-actions in organizational and societal performance. - Individuals' contributions to knowledge economies and societies. - Realization of individual' maximal potential and prosperity.
A.2 General Purpose 3: Transforming Economic System driven by Down-stream Productivity Gains	
- Normative 2: Sustainable - Process 1 (Acceptance) - Knowledge Worker + Decentralization and Absorptive Capacity * Easing knowledge access/use/creation	- Decentralization of KM to give more autonomy to individuals. - Enabling meeting relevant, context-rich information needs. - Enabling portability and mobility of personal skills and know-how. - Strengthen absorptive capacity, self-development, and creativity.
A.3 Prevalence 3b: Positive Demand Side Network Effects based on increasing Adoption Rates	
- Normative 3: Visionary - Relational 1 (Empowerment) - Knowledge Worker + Decentralization and Absorptive Capacity * Easing knowledge access/use/creation	- Multi-level appreciation model. - Effective low-cost KM applications. - Individual benefits from self-identification/worth and association,
A.4 Dominant Design 1: Dominant Design based on Usefulness to achieve wide Acceptance and Usage	
- Normative 4: Sustainable - Product 1 (Paradigm Shift) - Ideosphere (Enactment/Evolution) + Synergies and Generative Potentials * Fostering digital platform ecosystem	- Overcoming current inferior social media and KMS designs. - Current state no effectual barrier for better solutions and services. - Shift to grassroots, personal, generative, bottom-up KM focus. - Synergies between KM schools and creative PKM conversations. - Implementation, enactment, and evolution of memetic features.

Table 4. Summary of individual construct vision quality criteria as detailed in Appendix B.

GPT Criteria Descriptor with Reference to Subsections in Appendix B	
• Vision Quality Criteria • Innovation Criteria • PKMS Ecosystem + Knowledge and People Attributes * Aim of Affordances	Key Affordances and Argumentation Points • Advances in development, hosting, database, and cloud platforms. • Traceability and as-built genealogies as in manufacturing systems.
B.1 Dominant Design 2: Leading to Standard winning over Stakeholders' Allegiance in Market Place	
• Construct 1: Coherent • Cultural 2 (WHOMER database) • Extelligence (Context) + Trans-disciplinarity and Non-linearity * Promoting personal KMS needs	• Meme metaphor as living organisms for cultural transmissions. • Basic information-structure and building block of knowledge. • Support bottom-up knowledge development and sharing activities. • Educational interventions applying non-linear e-learning options. • World Heritage of Memes Repository (WHOMER) as single unified library for accessing past and current ideas, records, and publications.
B.2 Input Characteristic 2: Wide Scope of Credible Improvements and Prospects for Enabling Environments	
• Construct 2: Tangible • Process 2 (Memetics) • Extelligence (Codification) + Granularity and Attentiveness * Reducing knowledge entropy	• Lack of tools as barrier to individual and collective development. • Bottom-up processes and finer associatively-indexed granularity. • Interlinked records in growing meme-based unified repository. • Support independent of space, time, discipline, or role. • Better attention management, knowledge retention and retrieval.
B.3 Prevalence 1: Systemic Approach facilitating Technical Inter-relatedness of Components	
• Construct 4: Systemic • Product 2 (Synergies) • Technology (Collaboration) + Diffusibility and Connectedness * Co-evolving with Institutional KMS	• Meme content, aboutness, connections, intent, and monitoring. • Standardized memetic format and associative indexing structures. • Information-rich, multi-dimensional, traceable representations. • Easing digital scholarship/curation and knowledge assets creation. • Enhanced sharing/diffusion for rapid iterative improvement.
B.4 Prevalence 2: Quasi-Irreversibility of Switching Costs related to Alternative Options	
• Construct 3: Plausible • Relational 2 (Virtue of Responsibility) • Technology (Personal Autonomy) + Transparency and Self-Reliance * Instantiating Popper's 3rd World	• Creating body of personal knowledge and skills in multiple domains. • Hosting of peoples' diverse intellectual, social, emotional capitals. • Adaptive/generative learning and knowledge retention/classification. • Cumulative synthesis complementing Nonaka's SECI and Ba model. • Facilitating associative integrity, traceability, and transdisciplinarity.

6.2.1. Normative Vision Quality Focus: Individualization and Personalization

Many organizational efforts and investments are failing the KM promise of "enabling people to obtain relevant, context-rich information, and connection with appropriate experts easily, when they need it, so that they can be more effective doing their unique jobs" and, hence, are also failing to gain vital workforce acceptance. To fuel a more productive sharing and utilization of ideas and information, Pollard suggests to "go back to the original premise and promise of KM and start again-but this time from the bottom up" by developing structural capital and practices for improving knowledge workers' efficacy and sense-making with a focus on peer-to-peer content-sharing, expertise-finding, and connectivity instead of top-down community-of-practice management and top-down centralized content acquisition and collection [78].

The granularity of the labor markets, however, has recently been increasing due to changing demands for flexible labor capacities (rather than discrete units). As a result, the control over the timing, location, mode, and recipient of one's offered capacity and capabilities is more and more individualized and moved to the suppliers [90]. This trend induces

rising competitive pressures, evolving domain-specific knowledge and specializations, and growing needs for flexible skill sets and self-development [91].

Table 5. Summary of transformational vision quality criteria as detailed in Appendices C.1–C.4.

GPT Criteria Descriptor with Reference to Subsections in Appendix C	
	Key Affordances and Main Discussion Points
• Vision Quality Criteria • Innovation Criteria • PKMS Ecosystem + Knowledge and People Attributes * Aim of Affordances	• Challenging conventional KM models, systems, foci, paradigms. • Focus on technologies, knowledge workers, objects, and networks. • Supporting personal discipline for collection, filtering and creative connection (among and between people and data flows). • Supporting dynamic growth stages of entrepreneurs and SMEs. • Individual, organizational, and societal development Interventions.
C.1 Input Characteristic 1: Impact on Technical Change and Productivity Growth across Uses and Industries	
• Transformational 2: Nuanced • Process 3 (Ba and Transcendence) • Extelligence (Container) + Traceability and Creation Heritages * Digital-age instead book-age paradigm	• Knowledge creation as a continuous, self-transcending process. • Concept of "Ba" as a shared context or place (physical or virtual). • Bi-directional meme relationships as in industrial supply chains. • Potential to improve academic reputation-based citation systems. • Support of "Creation Heritages" with transfer of "creative spirit".
C.2 Prevalence 3a: Externalities from Supply Side Learning Effects (learning by doing or using)	
• Transformational 3: Motivational • Relational 3 (Personal Learning) • Extelligence (Container) + Traceability and Creation Heritages * PKMS educational agenda	• KM unable to provide coherent guidance for knowledge society. • PKMS uses hundreds of KM methodologies, practices, and sources. • Consistent content fit to serve personal KM learning environments. • Response to call for sustainable growth of personal KM capacities aiding life-long-learning, creativity, authorship, and collaboration.
C.3 Input Characteristic 3: Spawning Innovations in a broad Range of Uses and/or Application Sectors	
• Transformational 1: Shared • Cultural 3 (Evolution) • Ideosphere (Formation/Design) + Negentropy and Resourcefulness * Autonomous PKM capacities	• Better focus of time and attention for exploitation and exploration. • Reducing entropy aligned to extended and reversed SECI cycle. • Forward feeds to inform about obsolescence of prior information used. • Aiding work-life-fusion-trends and multi-generational workforces. • Likely to trigger business needs for further PKMS services.
C.4 General Purpose 2: Promoting Impact by Complementary Innovations in Downstream Sectors	
• Transformational 4: Relevant • Product 3 (Autonomy) • Institutions + Mobilization and Ambidexterity * Generativity and Innovativeness	• PKMS for strengthening individual sovereignty and self-interest. • Autonomy to build personal expertise systematically/sustainably. • Role as contributor/beneficiary to/of collective performances. • Exploiting current capabilities as well as exploring new ventures. • Disintermediation effects in knowledge-intensive value chains.

To adequately respond to these demands, trends, and resulting rising opportunity divides (in the context of, for example, access, digitalization, content, learning, skills, knowledge, innovation, or poverty and wealth issues [92]), the PKMS concept follows a "personalization" strategy (defined as the intended "action of designing or producing something to meet someone's individual requirements" (www.lexico.com (accessed on 30 March 2021))). Accordingly, it has widened its definition of knowledge workers (usually based on the type of work or socio-economic sector) and based it on the virtue of responsibility: Knowledge workers are presumed to self-motivate, to take responsibility for their work lives, to continually strive to understand their contexts, to modify their work practices and behaviors to better fit their personal and organizational objectives, and to drive improvement [93].

Pollard's normative concerns have also been absorbed in the PKMS design objectives and contribute to the PKMS vision's normative backbone which is geared to its basic desirability and ensures it is—as a guide—grounded in comprehensive sustainability concepts, including needs, ethics, identity, or intergenerational equity and able to balance socio-economic needs with environmental capacities without violating essential values of justice, integrity, or even viability [17]. These vision's normative aspects (Table 3) are further differentiated as visionary and sustainable and closely relate to knowledge accessibility, decentralization, and synergies as well as personal absorptive capacities, generative potentials, and thrivability. As a step beyond sustainability, the latter defines a state "in which resilience is achieved within systems and communities" by enabling citizens to "realize their maximal potential and prosperity" based on new educational orientations encouraging collaboration and cocreation to facilitate the cultivation of collective wisdom and co-developing communities [94].

6.2.2. Construct Vision Quality Focus: Nano-Contributions and Memetics

While social media users create connectivity and social capital as a digital equivalent of word-of-mouth communication in neighborhoods and communities, their platforms' institutional structures are managing and disintermediating supply, production, and distribution processes across complex value chains as a means for the combinatorial innovation and competitiveness of organizational capital [90].

The traditional KM processes employed, however, continue to package the knowledge "as monolithic blocks of linear content, with a lack of structural semantics, [which] does not pay attention to some of the superior features that digital media offers in comparison to traditional paper [or digital] documents". It unnecessarily replicates "content via copy and paste operations, instead of digitally embedding and reusing parts of digital documents via structural references" [63].

Recently, publication products have also become increasingly granular due to the differentiation of content creation, delivery, and distribution services by the current network economies. As the messages are unbundled from their medium in order to be re-bundled in unrestrained configurations, information granularity and entropy is snowballing propelled by the flourishing sources of social media and platform algorithms [90].

The PKMS, hence, substitutes this document-centric book-age paradigm in favor of a memetic approach which applies the metaphor of information and ideas as "living" organisms (memes) in an "Ideosphere". In the PKMS context, their purpose is to facilitate their wider/faster sharing, collating, diffusion, and iterative improvement as well as to enable advanced negentropic systems for citation and reputation/impact metrics.

To facilitate the authoring of meme-based knowledge and learning assets, the PKMS adopts the notion of cumulative synthesis. Its iterative sequence of generic steps accounts for the real-time innovation activities of both, researchers and entrepreneurs: (1) perceiving a problem or opportunity as an incomplete or unsatisfactory pattern, (2) setting an appropriate stage to assemble all the data and memes essential to a solution, (3) in order to facilitate acts of insight, (4) critical revision and full mastery of the new pattern (including drafts or prototyping), and (5) as one of the prerequisites for a successful innovation [74].

This approach closely resonates with the author's career and the PKMS design and development process. It also itemizes the key heuristic underlying the PKMS's workflow "as an accumulation of many individual items [or memes] over a relatively long period of time. The magnitude of the individual item is small, but through [progressing constructivist practices of] cumulative synthesis, the product [(memeplex or knowledge asset)] becomes important" [73]. While not every individual knowledge item, idea, or meme captured might be of immediate utility or even deemed irrelevant or misguided, it may well turn out to be valuable later, and vice versa [95].

This constructivist approach aligns to the PKMS's vision's construct backbone to ensure accurately constructed accounting for complexity, coherence, evidence, and specificity. The vision-supporting models employed portray the individual parts of its desirable future

as interconnected through underlying systemic relationships to provide a rich, consistent, and transparent representation of the means, ends, and the complexities involved. Plausibility and acceptance are strengthened by grounding the PKMS vision in current "realities" based on evidence (e.g., concept proofs, verified technologies, pilot projects, prototypes, or peer reviews). Specific targets provide further substance by contextualizing and embedding them through narratives, stories, metaphors, analogies, and visuals for informing to be experiential and meaningful [17]. The PKMS vision's construct aspects (Table 4) are further differentiated as plausible, systemic, coherent, and tangible and closely relate to knowledge granularity, diffusibility, trans-disciplinarity, transparency, and non-linearity as well as users' attentiveness, connectedness, and self-reliance.

6.2.3. Transformational Vision Quality Focus: Revolution and Evolution

Levy's scenario of a decentralizing knowledge management revolution giving more power and autonomy to individuals and self-organized groups [26] provided inspiration in addition to Bush's Memex [1]. It foresees a future of decentralized autonomous PKM capacities, networked in continuous feedback loops, nourished by the creative conversations of individuals' PKMS devices, and enables the emergence of distributed processes of collective intelligence which in turn feedback to the PKMS users [26] to advance their capability endowments via applied learning.

Levy also calls for a personal discipline for collecting, filtering and creatively connecting data flows and people [26] to address the emerging ever more complex granular phenomena which have not been adequately responded to by current KMS. If these anomalies exhibit a "stubborn refusal to be assimilated by existing paradigms", a new paradigm or theory (initiating a scientific revolution) "must displace" existing ones accompanied by the respective "destructive changes in beliefs". However, such new theories do not necessarily need to conflict with its predecessors [96].

In the KM revolution context, the PKMS is, hence, opting for the "emergent innovation" strategy alluded to (Section 4.5) [61]. This feat is to be achieved by actively cultivating and promoting a synergetic co-evolution between the bottom-up SICEE and traditional top-down KM models. As the four remaining GPT-criteria (Figure 7, bottom row) link to the transformational visioneering aspects, the mitigation of current and emerging disruptive changes is of primary concern.

- Focus on technologies: Current digital communication technologies rely on networks of instantly, continuously, and ubiquitously connected agents empowered to collaboratively create and directly share information without the need for market intermediaries [90]. The rising granularity of labor markets (Section 6.2.1) and knowledge objects (Section 6.2.2) is, thus, met by increasingly granular informing and information channels. Further complexities arise from progressing constraints affecting finite human attention capabilities and a range of knowledge-related considerations (e.g., confidentiality, copyrights, commercialization, and dominant market behavior resulting in service barriers, captured audiences, and walled garden approaches) and deficiencies (e.g., incompatibilities, lack of tools, functionalities, and mentoring support).
- Focus on knowledge workers: Although widely disregarded, the Nonaka's SECI and Ba concepts did recommend nurturing knowledge workers' individual autonomy, knowledge-related personal proficiencies/assets, and creative interactions [37] as an essential prerequisite to promote and convert their "nano"-contributions into personal capabilities and institutional and/or societal performances.
- Focus on knowledge objects: Since ideas hosted by their memes flourish in the real-world "Ideosphere" (as maintained by Memetics) as represented by the SECI and SICEE workflows (Figure 6), the PKM repository is dwelling in the equivalent "virtual" space by imitating the ideosphere's memetic riches (content and relations) instead of storing redundant copied texts.

- Focus on knowledge networks: The combination of PKMS devices and the WHOMER repository afford a universal utility benefitting personal and organizational learning and performance by bridging information demand and supply and by fostering absorptive capacities and ambidextrous dynamic capabilities. Ambidexterity implies being capable of exploration as well as exploitation, but also requires efforts "to identify, nurture, and effectively deploy ambidextrous individual researchers [or knowledge workers] and also consider them for participating in innovation teams", as evidenced by a recent meta-study identifying the strongest association between creativity and innovation at the individual (not team) level [97].

The "(r)evolutionary" potential of Bush's and Levy's ideas is, thus, reflected in the PKMS affordances and features to be incorporated in the vision's transformational backbone to encourage real-world change. To ensure conceptualizing a desirable future really serves its intended beneficiaries, it also needs to clearly articulate what is offered, what is required or expected from stakeholders, and at what and whose expense or advantage. The educational focus of the PKMS [98–100] closely aligns to these ambitions and also demonstrates—together with the value-adding services of its negentropic and generative agenda [42]—how its DPE architecture may assist "democratization in the [digital] academic entrepreneurship research" [101].

"Real people, their actions and activities, their roles and responsibilities, their motives and rules-all of these aspects make a desirable future state relevant" and might provide a source for inspiration, buy-in, mutual understanding as well as active and shared commitment of changing traditional assumptions and practices. For successfully transforming complex visions into reality, priorities might have to be set to focus attention and resources [17]. The PKMS vision's transformational aspects (Table 5) are further differentiated as motivational, relevant, nuanced, and shared and closely relate to knowledge traceability, negentropy, and mobilization as well as benefits related to ambidexterity, resourcefulness, and creation heritages.

The notion of "Creation or Generative Heritages" (Appendix C.1) closely relates to the ambitions of the cultural heritage sector to preserve our "resources inherited from the past in all forms and aspects–tangible, intangible and digital (born digital and digitized)" including "skills, practices, knowledge and expression of human creativity". Emphasis is placed on a participatory culture—"enabled by the ever more sophisticated and available ICT products"—which stimulates individuals to contribute "by voluntarily and directly providing new digital objects to enrich the digital collections and virtual exhibitions" [102].

7. Conclusions and the Road Ahead

7.1. From the KM Perspective

IT-supported traditional KMSs have progressed from an initially technology-dominated generation to a practice-and-community-centered focus [103,104]. They can be further differentiated into seven Schools of KM [77,105] which—in technical terms—often lack integration. KMSs' key purpose is still to bridge information demand and supply in predominant support of organizational exploitation and exploration processes aiming at improved performance. This objective is, however, too often hampered by failing KM system implementations and/or the lack of their acceptance by the knowledge workers concerned.

In reviewing the representative literature of the evolution of knowledge management over time, Handzic suggests differentiating its historic stages as fragmentation, integration, and fusion and predicts extension, specialization, and reconceptualization as potential KM futures [106]. Her foresights also include the decentralizing focus to be followed up in this article. However, as argued in this and prior publications, current KM systems can be still considered as (1) divorcing the interests of organizations and knowledge workers (instead of fusing them) [40], (2) prioritizing protection of intellectual capital over generative innovativeness (instead of integrating them) [36], and (3) growing the entropy of knowledge (instead of defragmenting it) [42].

Recently, 111 key reasons were extracted from transcripts to focus on why the 34 knowledge experts interviewed believed that organizations are still struggling to implement knowledge and innovation management. Affecting seven main categories (culture, measurement/benefits, strategy, organizational structure, governance and leadership, IT-related issues, and lack of KM understanding and standards), the key words subsequently underwent a text analysis. Figure 8 shows their frequency (horizontal bars) and their successive clustering based on the linkages expressed (vertical bars) [107]. The color coding of the horizontal bars (added by the author) indicates the proximity to the ecosystems (col.3, Figure 6) to further justify their relevance and highlight the significance of cultural aspects. Using an interpretivist qualitative research paradigm, the responses were also utilized to map the future of KM through Earl's "Schools of KM" taxonomy lens (Figure 8, left). The researchers concluded that "a technocratic approach to KM is likely to lead its future. Not in a way where technology will automate KM, but in a way where human and social interactions will be supported/empowered by KM technologies. Human will always remain at the center of KM activities" [108].
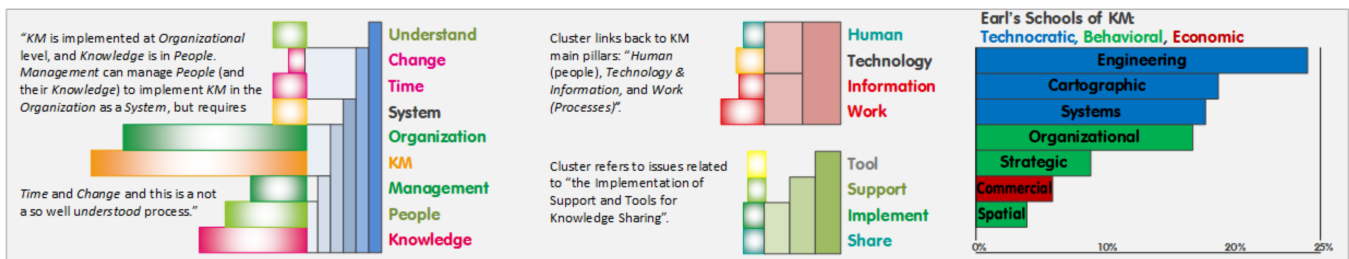

Figure 8. Continuing struggles of knowledge and innovation management: Cluster analysis [107].

The prediction of the next KM system generation has been an ongoing discourse as exemplified above. Due to the wickedness of the problem space alluded to, the discussions predominantly focus on organizational scales and circle more around shortcomings and desires than implementable concepts and solutions. The design-science-research-and-prototyping-project presented offers, accordingly, a novel decentralized, generative, negentropic KM approach which departs from traditional centralized institutional solutions by enabling collaborative workflows based on strengthening individuals' personal means and serving their developmental needs.

7.2. From the Visioneering Perspective

Bush's and Levy's visions compared to the present knowledge management agenda reveal further substantial disparities and gaps. Over the recent years, the DSR project presented has critically reviewed the current KM state and contributes insights into sustainable generative potentials presently not catered for. Having explored the opportunities for a whole range of stakeholders, this article has converted the envisaged systemic enablers into elements for a desirable PKMS sustainability vision (to be finalized after completing system testing) shareable with a critical mass of stakeholders as a prerequisite for creating the respective PKMS reality.

Along the way, the article has portrayed a novel decentralized but collaborative knowledge management system concept and prototype development-in-progress by covering the theoretical foundations, the enabling technologies and workflows, and the envisioned infrastructure, affordances, and impacts. Extending the reach of the twelve GPT/disruption-criteria-sets to visioneering and vision quality considerations has provided a robust pre-testing heuristic which may inspire developers and entrepreneurs to scrutinize their innovative artefacts in a similar fashion.

Within the DSR paradigm, the uniquely combined and applied methodologies constitute a novel contribution to design science research. In the process, Kaiser's "knowledge-based theory of developing sustainable visions" and visioneering approach as well as

Wiek's and Iwaniec's "quality criteria for visions and visioning in sustainability science" have also undergone further testing in an innovative and complex KM context.

The two vision-related approaches have provided an opportunity to structure the envisaged PKMS-DPE in an unusual but distinct format which allows for further quality-assuring the DSR's theory effectiveness and for contributing a KM application case to the vision-research domain. Striving for decreasing entropy and raising generativity to limit the impact of attention poverty and opportunity divides, one could argue that it also qualifies as an eco-innovation (EI) expected to "reduce the environmental impact of consumption and production activities". As EI-literature is generally focused on analyzing "business strategies and external drivers (public policy and stakeholder impacts)" and seldom on "internal factors to the firm such as resources, capabilities and competences" [109], the PKMS-DPE also adds to this perspective of innovation performance. However—to refer to an earlier statement—the novel PKMS-DPE is not merely aiming for sustainable development but also to be desirable, accessible, sustainable, affordable, explorable, and exploitable by itself (Section 5.3) [89].

The PKMS's meta-concept-and-design-elements (summarized in Figures 5 and 6) have evolved from an initial "early vision-1" (Section 4.1) published in 2016 [110] which already integrated SECI-related, meme-based and developmental considerations but did not accommodate the overarching Popperian and eco-systemic perspectives added later.

In regard of the KM/KMS agenda, the benefits include the cumulative synthesis of models and methodologies for designing and prototyping an innovative decentralized KMS. Due to its significant deviation from traditional KM approaches, the PKMS is destined:

- To better serve the growing creative class of knowledge workers and the innovation agenda of knowledge economies compared to current solutions.
- To get a more effective grip on the ever-increasing information abundance, invisible work, structural holes, changing work spheres, widening digital and innovation divides, self-development, and e-training and e-collaboration needs.
- To transform the abstract Popperian third world over time into an expanding tangible accessible interrogatable comprehensive transdisciplinary knowledge base (WHOMER).
- To re-design basic processes of capturing, distributing, and effectively using knowledge (referring to a widely quoted early KM definition [111]) to make a KM difference.
- To strengthen interventions in the individual, organizational, and societal capacity development contexts of education, professions, and knowledge economies.

7.3. From an Implementation Perspective

In advancing the theory of organizational vision into a coherent theory of sustainability vision, Kantabutra asserts that their effectiveness depends on their content (or imagery) and fit with seven attributes: Brevity, clarity, future orientation, stability, challenge, abstractness, desirability, or ability to inspire [112].

As stated, the aim of this article was not to present a polished self-contained vision statement, but rather to prepare for the authoring of a sustainability vision for an innovative KMS-related endeavor and enterprise. Such a document may have a top layer of a vision statement which contains just the recommended "approximately 11–22 words" pointing directly at an overarching goal to be achieved [112]. However, other more detailed deliberations will still have to follow to link the goal to strategic and operative intentions, priorities, and plans. For example, a business plan recently produced has distilled the wide range of issues discussed in this article in one 30-word-mission-statement:

Serving Knowledge Workers with diverse Ambitions and Potentials to gainfully partake in a Novel Grassroots Knowledge Management Concept, Technology, and Community for advancing their Local Personal and Global Collaborative Contexts.

The business plan served in an application for an innovative start-up venture and investment which just has been approved by the governmental board in principle allowing to proceed to the administrative stages to set up a company. It defined and sequenced

eleven distinct projects (labelled A1–5, B1–4, and C1–2 shown in the bottom rows of Figure 5) as the start-up's main activities and milestones.

As this visioneering approach has iteratively co-evolved with the parallel undertaking of establishing an implementation, business, and roll-out plan for the PKMS-DPE, its utility has, thus, been further substantiated by these eleven projects. After completing the test phase of the prototype (minimum viable software application/product) within the first year, its transformation into a viable PKMS device application and a cloud-based WHOMER server is estimated to take a further 12 months.

Additional analytical research (project B0 in Figure 5) is planned to assess how the PKMS concept compares to, can make use of and add to the advancing semantic web and AI technologies which overlap with some of the PKMS objectives; this includes verifying the PKMS potential to generate rdf-statements and ontologies straight from its content and relations repository. Further testing, empirical studies, and publications are also planned to consider how the novel memetic PKMS storage paradigm compares to traditional document-centric approaches (e.g., Google Scholar, ResearchGate).

Appendix A

Normative Vision Quality Criteria: Individualization and Personalization (Ax, Bx, and Cx refer to the summarized sections in Tables 3–5).

Appendix A.1. Cultural Shift 1 (Normative-Visionary)

This general purpose (1) criteria expects the performing of generic functions for down-stream generalized productivity. Its normative-visionary objective (2) is addressed within the perspectives of the society ecosystem (including the PKMS community) by aiming to prevent harmful opportunity divides and by focusing on accessibility and thrivability.

Any viability and advancement of institutions and societies is based on innumerable small "nano-actions" by individuals (knowledge worker) which govern, if effectively combined, the organizational (knowledge economy) and societal performances (knowledge society). The quality of any of their contributing "nano-actions" depends on peoples' competences, skills, and individual intellectual, social, emotional, and structural capitals [79]. To adequately account for the underlying personal/societal generic needs, the PKM4D Framework provides a heuristic differentiated into twelve ecosystem-grounded progressive sub-needs and desirable levels of personal achievement (Figure 6, column 6) [53]. In the wider societal context, the PKM4D's guidance and interventions aim for "Thrivability".

Appendix A.2. Process Innovation 1 (Normative-Sustainable)

This general purpose (3) criteria expects the transformation of economic systems to be driven by down-stream productivity gains. Its normative-sustainable objective (3) is currently severely hampered by neglecting the needs and aspirations associated with the knowledge worker ecosystem (which is also including the prospective PKMS community fellows) for de-centralized personal absorptive capacities (ability to recognize, assimilate, and apply new valuable information).

Organizational KM is currently failing its underlying promise of "enabling people to obtain relevant, context-rich information, and connection with appropriate experts easily, when they need it, so that they can be more effective doing their unique jobs" [78]. KM

investments are, consequently, struggling to get the necessary acceptance from the work force [78,113,114].

KM's unsatisfactory and unsustainable status quo further neglects today's expectations regarding portability and mobility of personal skills and know-how, and that knowledge workers ought to be able to decide autonomously "on where, how, and for whom they will put their knowledge to work" [115], particularly relevant for entrepreneurs and SMEs. To remedy the shortcomings, Levy calls for a decentralization of KM to give "more power and autonomy to individuals and self-organized groups" [26].

By integrating the necessary technological and educational facets, the PKMS concept is able to assist knowledge workers in augmenting their skills and competences including their individual intellectual, social, emotional, and structural capitals [79] which together determine their personal absorptive capacity and support their creativity.

Appendix A.3. Relational Innovation 1 (Normative-Visionary)

This prevalence (3b) criteria expects positive demand side network effects based on increasing adoption rates. Its normative-visionary objective (4) is addressed by providing guidance targeted at the knowledge worker ecosystem (related to the general purpose (3) criteria, de-centralization, and absorptive capacity referred to earlier).

PKMSs—from a demand-side-empowering perspective-present proficient users and their professional habitats with an arsenal of enabling affordances [46] based on synergies within a PKMS-DPE environment. They promise to sustainably narrow or eliminate opportunity divides via effective low-cost KM applications, ease of knowledge access/use/creation, and adherence to vital PKM provisions currently not catered for which positively affect ownership, consistency, stability, collaborativeness, and absorptive capacity in personal contexts [43,49,116].

To provide for subjective popular demand, an appreciation model (Section 4.4) has been adapted to fit the PKMS context stretching over several levels ([13] based on [59]). Further affordances are conferred by the user community as, for example, participation in creative conversations with a community of like-minded knowledge workers giving rise to "a wholly personal benefit of association, self-identification, and self-worth" [56]. Increasing adoption rates add further value and momentum to this collaborative realm via network effects [56]. Applied to a thriving community of PKMS users, the current providers of attention-consuming, high-barrier, inferior services with their focus on captured audiences are likely to be negatively affected.

Appendix A.4. Product Innovation 1 (Normative-Sustainable)

This dominant design (1) criteria expects dominant designs to be based on usefulness for achieving wide acceptance and usage. Its normative-sustainable objective (1) is currently not adequately pursued. As a result, opportunities to yield synergetic and generative potentials are over-looked and/or squandered and, are, hence, prioritized within the newly emphasized ideosphere ecosystem and its affordances (by promoting implementation, enactment, and evolution of its memetic features to be further detailed).

Current "leading-edge" social media and KMS designs, unfortunately, reinforce silos of proprietary digital formats and knowledge repositories accompanied by "walled garden" apps and platforms running counter to an open connective web. They are controlled by big players with a focus on capturing their audiences by enforcing inflexible exit, entry, and data export barriers at the expense of their clients' attention, time, productivity, funds, and status causing annoyances which are likely to continue if the lack of alternatives persists [26,46,117,118].

With the growing needs for personalized tools to support knowledge workers and to tackle opportunity divides not catered for one can safely conclude that a dominant design has not been able to emerge yet and that the current sorry state does not present an effectual barrier for better solutions and superior collaborative services.

The PKMS concept aims, thus, to tackle these continually escalating "wicked" problem spaces holistically and in pursuit of DSR's "theory effectiveness" alluded to [20]. The resultant system design challenges key aspects of the conventional KM world view by favoring paradigm shifts from an organizational, protective, top-down to a personal, generative, bottom-up focus.

The PKMS (Figure 5) [36] envisages a central DPE service structure able to instantiate a digital version of the PKMS's ideosphere and to productively interact with external OKMS and LMS. Accordingly, synergies and opportunities are expected to arise from the fruitful co-evolution of the grass-roots PKMSs with their centralized organizational KMS and LMS counterparts based on common objectives, shared KM methodologies and practices, and a constructive fit of the decentralizing KM-scenario with the configurations of Earl's "Seven Schools of KM" [77,88]. A recent publication, furthermore, aligned the twenty-six attributes from four generativity-related models to the PKMS's key features, affordances, ecosystems, and workflows to zoom in closer to the anticipated synergetic and generative potentials [36].

Appendix B. Construct Vision Quality Criteria: Nano-Contributions and Memetics

Appendix B.1. Cultural Shift 2 (Constructivist-Coherent)

The dominant design (2) criteria expects that activities are leading to standards able to win over stakeholders' allegiance in the marketplace. This constructivist (coherent) objective (4) is addressed by the extelligence contexts (enabling encompassing workflow) supporting trans-disciplinarity and non-linearity.

The notions of memes as living organisms and as units of cultural transmission [75] provide a powerful metaphor to promote the necessity of personal KM education and technologies as advocated by Bush and Levy as well as the status of the PKMS as a potential GPT. As a basic information-structure and building block of knowledge, a meme is to be captured in a quasi-atomic state which should be understandable by itself without piggybacking irrelevant or potentially redundant information (subject to the eyes of the beholder), so it can be easily re-used subsequently in combination with other memes.

Koch reminds us, that not the physical script matters but the ideas it contains: "It must be valued, either for its own intrinsic appeal or because it can help to deliver other things that people want, or help to deliver them at a higher quality level or using fewer resources" [119]. Accordingly, memes captured in original or pre-edited states may further evolve as referenced, re-purposed, and/or already re-combined memeplex versions according to users' individual preferences and objectives [120].

These operative, bottom-up, knowledge development and sharing activities expand–with a growing user base over time–the meme repository. In the process, the PKMS community members' voluntarily shared, individual, distinctive, multi-disciplinary knowledge memes/objects/assets are merged into an accessible single unified digital library or knowledge base (WHOMER) of current ideas, records, and publications while—due to the inclusion of cited memes from prior publications—the historic record also steadily grows; Google Scholar or Research Gate, for example, are evolving in a similar fashion; their references, however, do not link directly to cited memes but only to their knowledge containers (documents) [49].

As the associatively-indexed memes are transgressing disciplinary boundaries, WHOMER's repository reduces the risk of currently unconnected "undiscoverable" public knowledge which may also "yield new and unexpected knowledge" and "enhance the rate of scholarly (and technical and other sorts of) advance" [69]. Eliminating redundant memes via the PKMS curation services further eases interdisciplinary knowledge organization and classification. Utilizing the captured associative relationships also allows informing dependent (stored or prospective child) memes and their authors/readers that cited memes (ancestors in an as-built genealogy) have been updated, invalidated, or acknowledged as out-of-date or fake [50].

Envisaged educational interventions further include, for example, the non-linear interrogation of learning content and assets via three-dimensional topological structures,

the transfer of meme-based content learnt into the learner's PKMS devices for effective retention and utilization.

Appendix B.2. Process Innovation 2 (Constructivist-Tangible)

The input characteristic (2) criteria expects a wide scope of credible improvements and prospects for enabling environments. This constructivist (tangible) objective (3) is addressed by guiding the codification of extelligence (including supporting the "collating" workflow) to assure maintainable granularity and safeguard user attentiveness.

The PKMS approach is closing in on the Memex, which is supposed to operate—like the human mind—by association instead of indexing. Bush envisioned knowledge to be more easily shared, classified, repurposed, curated, and traced across time, distance, and disciplines. However, even back then, he already considered the accelerating information load and the lack of adequate personal tools as the crucial emerging barrier to individual and collective development [1].

While Bush's vision was decades ahead of the technologies available at the time, the PKMS is significantly benefitting from the progressing capabilities of today's advancing information and communication technologies (e.g., development, hosting, cloud, and noSQL database platforms). Profiting from Bush's basic bottom-up processes and finer associatively-indexed granularity (related memes instead of monolithic documents), the networked PKMS devices are expected to accumulate the shared and interlinked historic and novel records in a steadily growing meme-based unified repository to support knowledge workers independent of space (e.g., developed/developing countries), time (e.g., study or career phase), discipline (e.g., natural or social science), or role (e.g., student, professional, or leader).

While the wealth and impact of the ideas to be created by a collaborating PKMS community defies prediction, the rich PKMS support functionalities promise productivity gains derived from better attention management and knowledge retention, superior retrieval based on captured trails and associations, and prevention of redundant and fragmented knowledge, so typical for document-centric KM practices.

Appendix B.3. Product Innovation 2 (Constructivist-Systemic)

The prevalence (1) criteria expects a systemic approach facilitating technical inter-relatedness of components. This constructivist (systemic) objective (2) depends on the affordances offered by the (collaborative-community-focused) technology ecosystem (including networked PKMS devices) affecting diffusibility and connectedness.

Any basic meme in the PKMS repository may be comprised of content (e.g., parts of this paragraph, citations, or visuals), aboutness (e.g., article review, wordcount, or author's profile), structural connections (e.g., links between authors, papers, publishers, and references), intent (e.g., tasks to do), and monitoring (e.g., schedules, to-do-lists, or progress made), all captured based on the PKMS's standardized memetic format and associative indexing structures. Disseminating a document just means publicizing a particular static snapshot from a virtual subset of the PKMS repository; it includes a first level of ordered memes (text and figures) together with its first-level relationships (footnotes, citations, and references).

The virtual version stored, by comparison, is information-rich, multi-dimensional, and may further expand by being cited, amended, or added to in order to facilitate traceability and repurposing of knowledge across time, distance, and disciplines. With memetic storage substituting traditional documents-centric knowledge bases, memes are becoming system components with their inter-relatedness contributing to their cumulative synthesis.

The users' PKMSs for accessing, capturing, collating, and sharing memes are equally system components. As autonomous affordable decentralized devices and meme repositories, they are substituting costly monolithic document-centric "book-age" technologies and applications. The significance of this memetic approach [40] has been assessed against the notions of digital scholarship, curation, and knowledge assets creation [49].

The grass-roots PKMSs, as alluded to, are meant to synergetically co-evolve with their centralized OKMS counterparts into a novel KM system generation [104] and PKMS-DPE (Figure 5). The memetic granularity, thus, allows not only for effectively combining the individual "nano" actions and contributions referred to but also support Nielsen's call to reduce current barriers preventing potential contributors from engaging in a wider sharing and faster diffusion of their ideas, sources, data, work-in-progress, preprints, and/or code for the benefit of more rapid iterative improvement [64]. The PKMS follows, in effect, Pollard's advice to go back to the original KM premise and promise of KM as referred to earlier [78].

Appendix B.4. Relational Innovation 2 (Constructivist-Plausible)

The prevalence (2) criteria expects the quasi-irreversibility of switching costs related to alternative options. This constructivist (plausible) objective (1) depends on the affordances offered by the (personal-autonomy-focused) technology ecosystem (imbedding workflow) to constructively guide transparency and self-reliance for convincing value propositions.

In order to script personal careers that can bring fulfilment and meaning, individual knowledge workers (fitting the widened responsibility-related definition, Section 6.2.1) are advised to differentiate themselves from the crowd by building depth and by putting in the time and resources to create a body of knowledge and skills for themselves-not only in one single but multiple relevant domains [91].

The PKMS's memetic concept credibly supports individuals in these endeavors by hosting their diverse intellectual, social, and emotional capitals. It facilitates adaptive and generative learning [121], knowledge retention and classification, and the collaborative authoring and innovation of the "nano"-contributions alluded to, closely aligned to the model of cumulative synthesis [74] being complementary to the SECI model of organizational dynamic knowledge creation [37] (Figure 6, column 3).

Due to the PKMS community's creative conversations (shared memes and relationships) and the PKMS knowledge base's emerging attributes (associative integrity, traceability, and transdisciplinarity), Popper's abstract inaccessible non-interrogatable world three (Figure 6, column 2) [35] as counterpart of the ideosphere ecosystem is ultimately transformed into a tangible accessible interrogatable comprehensive WHOMER repository. Driven by the underlying cumulative-synthesis-heuristic (Section 6.2.2) [73,95], PKMSs allow individuals and institutions to better focus their time and attention; current prototype test repositories, for example, host a variety of data sets, including the PKMS publications with their references; personal contact bases and libraries; personal chronological biographies and family trees; cocktail database; directories of journals, universities, cities, regions, and countries; Excellence in Research for Australia (ERA) database sets; industrial classification systems; a business plan; standards, criteria, and a self-assessment exercise for a MBA program accreditation [13].

Moreover, applying Bush's concept of "Associative Indexing" fosters transparency by affording the forward/backward tracking of relations/trails captured and by enabling knowledge-enriched and entropy-reduced scholarship as any "inheritance from the master becomes, not only his additions to the world's record, but for his disciples the entire scaffolding by which they were erected" [1].

As these examples present just a subset of the many more unique PKMS affordances to be provided, the risk of system switching is expected to be low; especially, since current KM offerings fail to provide even the most vital PKM provisions for autonomy and self-reliance and are unable to assure that digital personal knowledge (1) stays always in the possession and at the personal disposal of its owner or eligible co-worker, (2) is based on standardized, consistent, transparent, flexible, secure, and non-redundant formats, and (3) is not negatively affected by changes in one's social, educational, professional, or technological environment [49].

Appendix C. Transformational Vision Quality Criteria: Revolution and Evolution

Appendix C.1. Process Innovation 3 (Transformational-Nuanced)

The input characteristic (1) criteria expects impacts on technical change and productivity growth across uses and industries. This transformational (nuanced) objective (3) is addressed by the extelligence container ecosystem (including individual/institutional (i) HOMER repositories) supporting traceability and creation heritages.

The SECI model closely relates to the PKMS's processes by defining knowledge creation as "a continuous, self-transcending process through which one transcends the boundary of the old self into a new self by acquiring a new context, a new view of the world, and new knowledge". Central to this notion is the concept of "Ba" as a shared context or place (physical or virtual) in which knowledge is shared, created, interpreted, and utilized [37]. This "spiral" of knowledge creation is complemented by the PKMS concept's reverse SICEE workflow as alluded to (Figure 6, columns 3 and 4) as a response to the current significant gaps between actual and conceivable KM systems and practices [104].

The PKMS regards knowledge assets and their containers as being made up of bi-directional relationships between memes in the same manner industrial supply chains rely on technical inter-relatedness by connecting discrete parts, ingredients, and labor to their final products and services. Due to the captured relations, any meme can similarly be tracked and traced by creating as-built genealogies either back in history to locate prior usage or an original author or forward into the future to follow-up on subsequent uses and citations [49].

In contrast to industrial inventories, however, a meme stored in PKMS repositories as a unique atomic information-structure is not consumed when utilized or transferred. As a virtual copy, it can be employed indefinitely for integration in any type of authoring and sharing activity independent of time, distance, disciplines, and purposes. This traceability does not only ease the creation of knowledge assets, it also presents, for example, a potential for supporting or substituting current academic reputation-based citation systems by superior content tracing, citation and impact metrics as part of WHOMER's services portfolio.

As a further extension, a recent article [84] is focusing on the transferring of creation heritages. Since the design of artefacts and services for digital transformation is essential for extending the boundaries of human and organizational capabilities by co-creating and co-delivering affordances for citizens and institutions, the concepts of "Creation or Generative Heritages" [85] aim to not only share knowledge resources but also to transfer the capacities or "creative spirits" to utilize them, including, for example, "eliciting generative gains in the form of identifying gaps (turning unknown unknowns into known unknowns, filling gaps [turning known unknowns into known knowns], sharing object structures, progress principles, creative reasoning, usage metrics, value criteria and desires as well as creating new objects and designs)" [36].

Appendix C.2. Relational Innovation 3 (Transformational-Motivational)

The prevalence (3a) criteria expects positive externalities from supply side learning effects (learning by doing or using). This transformational (motivational) objective (1) is also addressed by the extelligence container (related to the input characteristic (1) criteria, traceability and creation heritages referred to earlier).

Due to differing and inconsistent scholarly contributions, KM has been unable to provide the urgently needed coherent guidance any striving knowledge economy or society requires. However, what initially appeared as difficult to reconcile (e.g., KM's objectives, philosophies, and methods) has been integrated into a PKMS design covering some hundred renowned KM methodologies, practices, sources and over fifty publications. This consistent content is also fit to serve personal learning environments for a comprehensive KM education, including the rationale for how and why some of the original methods had to be adjusted, extended, re-purposed, or merged [99].

The PKMS educational agenda, thus, respond to the call for the sustainable growth of autonomous personal KM capacities based on a personal discipline for collection, filtering and creative connection [26]. The repurposing-in-progress of the meme-based prior PKMS publications into learning assets for e-learning is further contextualized by analogies, metaphors, narratives, cases, visuals, and PKM frameworks, as exemplified, by the PKM4D framework and the "public-transport-like" map alluded to [23,53].

After successfully completing learning assets, their key memes can also be transferred to the learner's PKMS device for effective learning retention, for utilizing their additional PKMS connectivity, or for repurposing them in educational or professional contexts. PKMSs, thus, seek to aid life-long-learning, resourcefulness, creativity, authorship, and teamwork of knowledge workers.

Appendix C.3. Cultural Shift 3 (Transformational-Shared)

The input characteristic (3) criteria expects that activities are leading to spawning innovations in a broad range of uses and/or application sectors. This transformational (shared) objective (4) is addressed by the ideosphere (formation and design) (including effectuating workflow) supporting negentropy and/or resourcefulness.

PKMSs support organizational learning processes and performances by bridging information demand and supply and by reinforcing individuals' personal and collaborative abilities. They accommodate Sarooghi's advice by strengthening the absorptive capacity, ambidexterity, and ensuing dynamic capability of organizations considerably while simultaneously serving the very professional aspirations of those involved. PKMSs are to fit general-purpose technology features by easing knowledge asset innovation (spawning). The scope of anticipated processes and outcomes allows individuals and institutions to better focus their time and attention on exploiting their knowledge and on its further exploration for mutual benefit [50].

The design of the PKMS structures, workflows, and functionalities is aiming to reverse entropy (to strive for negative entropy, also referred to as negentropy) by affording order and organization following an extended and reversed SECI cycle, as detailed in the SICEE workflows (Figure 6). The resulting trails captured in the resulting unified transdisciplinary WHOMER repository may be utilized to forward feed information about an ancestor-meme's obsoleteness, authenticity, and validity to their subsequent uses and users.

Envisaged educational interventions further include, for example, the PKMSs' backing of work-life-fusion-trends and multi-generational workforces [122] by affording continuous life-cycle support from citizen, trainee, student, novice, or mentee to activist, professional, expert, mentor, or leader. Expected to excite relevant stakeholders, a PKMS roll-out is likely to trigger business needs for further content conversion, authoring, publishing, and trans-disciplinary retrieval/application services as well as to contribute towards PKMS community members' resourcefulness and the emergence of PKMS as a dominant design and/or standard.

Appendix C.4. Product Innovation 3 (Transformational-Relevant)

The general purpose (2) criteria expects that activities promote impact by complementary innovations in downstream sectors. This transformational (relevant) objective (3) is addressed by the Institutions (seizing workflow) supporting mobilization and ambidexterity.

Organizational KM aims to explicate individuals' tacit knowledge, so it can be measured, captured, stored, protected, shared, and further utilized in a "spiral" of knowledge creation for organizational benefit and independent of the initial knower concerned. For this purpose, Nonaka et al. not only furnish organizational leadership with their SECI and Ba model, but also recommend emphasizing knowledge visions, assets, and proficiencies as well as personal commitment, trust, and autonomy [37]. These latter aspirations are currently neglected but can be re-energized by strengthening individual sovereignty utilizing PKMS's affordances. Appealing to knowledge workers' self-interest in this way means effectively fostering organizational KMS acceptance.

In response to the mobility and portability concerns referred to [115], professionals are also enabled to carry-while moving from one project or responsibility to the next-their particular version of a PKMS with them, presenting them with the autonomy to develop their personal expertise systematically and sustainably and to voluntarily share it with associates and institutions close to them. Such a feature factors into a PKMS's dominant design by aiding a knowledge worker's dual role as contributor to and beneficiary of personal, organizational, and societal performances.

Organizational leadership ought to be eager to mobilize these kind of potential absorptive capacities (as dispersed individually over the knowledge workers employed) to benefit their firm's realized absorptive capacity, since "their success rests on converting tacit into explicit actionable knowledge, on aggregating individual into organizational performance, and on balancing between the exploiting of current capabilities versus exploring new ventures (to become an ambidextrous organization), all by dealing with unfamiliarity and perceived difficulties" [116].

From the disruptive perspective, the ensuing decentralizing KM revolution affords productive creative conversations among the PKMS community and is expected to affect stakeholders engaged in current traditional knowledge-intensive value chains by disintermediation effects. Unless an enterprise, provider, or regulatory body adds value to an economic, research, or collaborative relationship, it may become obsolete. Assuming an optimistic PKMS scenario, sharp, sudden, and sizeable "industry shake-outs" might occur [123] which may lead to the death of earlier pioneers as well as traditional businesses [56].

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