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PEOPLE HAVING ORDINARY SKILLS IN THE ARTS

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ABSTRACT

The person having ordinary skill in the art ("PHOSITA") is the central legal construct on which much of patent law doctrine is built. By adopting the perspective of the PHOSITA, examiners and judges aim to objectively assess whether an invention satisfies the core elements of patentability — most importantly, whether the invention would be obvious to a PHOSITA under § 103 of the Patent Act. Much debate has focused on who the PHOSITA for a given invention should be, what degree of skill they should have, and, perhaps, how creatively they should be assumed to synthesize the available prior art. What is not questioned is that the hypothetical PHOSITA should be imagined just as its name describes: a single person and one with skill primarily in a single technological domain.

In the real world, however, innovation is not an individual enterprise. As we demonstrate, most inventions are now created by groups of people working together, and this has been increasingly true over time. Moreover, a substantial portion of groups working to develop new inventions are now multidisciplinary, with different group members employing skills from distinct technological domains. In reality, then, the primary agent of innovation is some combination of *people* having *skills*, often in several different *arts*. There is thus a glaring mismatch between how innovation is conceived of in patent law and how it is done in the real world. While this discrepancy is problematic for a number of reasons, the non-obviousness standard is the most significant: what is obvious to a team of people with varied expertise is often not obvious to a single person, even one of extraordinary skill.

We propose as an alternative legal construct the team having ordinary skills in the arts ("THOSITA"). Drawing on cross-disciplinary literature on group-based innovation, we describe what a typical THOSITA looks like for a range of innovations and show how the construct can be used in practice to decide key questions of patentability. We then evaluate the potential efficacy of this alternative standard

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in accomplishing the main objectives of patent law and describe judicial and institutional mechanisms for implementing it. We conclude by discussing the likely results of this shift away from the hypothetical individual inventor and toward the more grounded and realistic THOSITA.

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I. INTRODUCTION

Innovation, we are often told, is an individual pursuit. In the traditional view, the great inventors of history, while standing on the shoulders of earlier giants, work alone in applying their genius to new problems and moving society forward. To be sure, the history of American innovation is replete with these figures: Fulton and the steamboat; Morse and the telegraph; Bell and the telephone. Even in the modern digital economy, the image of the individual entrepreneur-inventor remains a powerful one: Berners-Lee and HTML; Zuckerberg and social networking; Jobs and any number of Apple gadgets from the past thirty years. Collectively, these figures give shape to a defining theme in the standard American story: technological progress as the result of the brilliance and determination of individual inventors.

Patent law is largely built on this conception. The central legal construct on which much of patent law doctrine is predicated is the

person having ordinary skill in the art ("PHOSITA").[1] The PHOSITA, like other "ghosts in the law" such as tort law's reasonable person, is an ideal, imagined agent who forms the basis for a host of legal tests.[2] Only by adopting the hypothetical viewpoint of the PHOSITA can patent examiners and judges assess whether an invention satisfies many of the core elements of patentability, including non-obviousness, enablement, and utility.[3] The meaning of patent claims must also be interpreted from the PHOSITA's perspective. The construct thus provides a means for analyzing patent questions free from the subjective impressions of the examiner, judge, or litigant. It establishes — at least in theory — a consistent grounding on which the patent system can operate.

When confronted with a patent issue, one must often start with who the PHOSITA for the patent or invention in question is.[4] Once the PHOSITA has been identified, one can proceed through doctrinal analysis. Is the invention obvious, given the prior art that came before it? Ask what the PHOSITA would have thought.[5] Does the patent document provide enough instruction on how to replicate the invention? Ask whether the PHOSITA could make and use it without too much trial and error.[6] Does the invention have a real-world use at the

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1. Also referred to as the "person of skill in the art" (or "POSA") by some scholars and courts. For discussions of the PHOSITA and its place in patent law, see generally Rebecca S. Eisenberg, *Obvious to Whom? Evaluating Inventions from the Perspective of PHOSITA*, 19 BERKELEY TECH. L.J. 885 (2004); Greg Reilly, *Rethinking the PHOSITA in Patent Litigation*, 48 LOY. U. CHI. L.J. 501 (2016); Jonathan J. Darrow, *The Neglected Dimension of Patent Law's PHOSITA Standard*, 23 HARV. J.L. & TECH. 227 (2009); John O. Tresansky, *PHOSITA - The Ubiquitous and Enigmatic Person in Patent Law*, 73 J. PAT. & TRADEMARK OFF. SOC'Y 37 (1991); Amy L. Landers, *Ordinary Creativity in Patent Law: The Artist within the Scientist*, 75 MO. L. REV. 1 (2010); Joseph P. Meara, *Just Who Is the Person Having Ordinary Skill in the Art? Patent Law's Mysterious Personage*, 77 WASH. L. REV. 267 (2002).

2. The description of the PHOSITA as a "ghost" first comes from *Panduit Corp. v. Dennison Manufacturing Co.*, 810 F.2d 1561, 1566 (Fed. Cir. 1987) ("With the involved facts determined, the decisionmaker confronts a ghost, i.e., 'a person having ordinary skill in the art,' not unlike the 'reasonable man' and other ghosts in the law. To reach a proper conclusion under § 103, the decisionmaker must step backward in time and into the shoes worn by that 'person' when the invention was unknown and just before it was made.").

3. *See infra* Section II.B.

4. Caselaw has developed several rules of thumb for doing so. *See infra* Section II.B for further discussion.

5. 35 U.S.C. § 103 ("A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains.").

6. 35 U.S.C. § 112 ("The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention.").

time the patent application is filed? Ask whether the PHOSITA would think so.[7] What do the patent claims mean? Ask how the PHOSITA would interpret them.[8]

The identity of this enigmatic figure is therefore critical. In the course of a patent dispute, certain characteristics of the PHOSITA are often in contention: how the PHOSITA's "art" should be identified; what level of skill and training they should have; and how creatively they should be assumed to synthesize pre-existing knowledge.[9] What is almost never questioned, however, is that the hypothetical PHOSITA should be imagined as its name appears to describe: an individual person, and one with skill primarily in a single technological domain. In nearly all cases, courts describe the PHOSITA as an individual, either explicitly or implicitly.[10] When applying doctrinal tests involving the PHOSITA, courts are often equally literal. In Judge Giles Rich's famous formulation on how to apply the § 103 standard for non-obviousness, he urged that we "first picture the inventor as working in his shop with the prior art references — which he is presumed to know — hanging on the walls around him."[11]

Patent law's central legal construct is thus consonant with a historical view of how innovation occurs: through the work of the individual inventor.[12] That view, however, does not describe the reality of innovation today. In the modern world, innovation is not an individual enterprise. The age of the lone inventor is long past; modern innovation is the domain of the corporate research and development ("R&D") lab, the tech startup, and the university research group. As we demonstrate empirically, innovation has for decades now been primarily team-based, with the majority of inventions developed by

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7. *See* Nelson v. Bowler, 626 F.2d 853, 856 (C.C.P.A. 1980) ("'Practical utility' is a shorthand way of attributing 'real-world' value to claimed subject matter. In other words, one skilled in the art can use a claimed discovery in a manner which provides some immediate benefit to the public.").

8. *See* Phillips v. AWH Corp., 415 F.3d 1303, 1313 (Fed. Cir. 2005) ("[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application.").

9. *See infra* Section II.B.

10. *See infra* note 71 and accompanying text.

11. *In re* Winslow, 365 F.2d 1017, 1020 (C.C.P.A. 1966). Importantly, Judge Rich was also a coauthor, along with Pasquale Federico, of the principal draft of the 1952 Patent Act that first incorporated the "person having ordinary skill in the art" into the federal statutory scheme. *See* Giles S. Rich, *Laying the Ghost of the "Invention" Requirement*, 14 FED. CIR. BAR J. 163, 168 (2005); Giles S. Rich, *The Vague Concept of "Invention" as Replaced by § 103 of the 1952 Patent Act*, 14 FED. CIR. BAR J. 147, 159–60 (2005).

12. *See* Christopher A. Cotropia, *The Individual Inventor Motif in the Age of the Patent Troll*, 12 YALE J.L. & TECH. 52, 57–61 (2009) (discussing historical ways in which the conception of the individual inventor shaped the U.S. patent system and patent law doctrine); *id.* at 58 ("[I]nvocations of the individual inventor motif in patent discourse are the product of the collective belief in the narrative itself . . . .").

groups of people working together.[13] This trend has increased over time and shows no sign of abating.[14] Most recently, groups working to develop new inventions have been increasingly multidisciplinary, with different members of these groups contributing skills from separate fields.[15] In reality, then, the modern agent of innovation is some combination of *people* having *skills*, often in several different *arts*.

There is thus a glaring mismatch between how innovation is conceived of in patent law and how it is currently achieved in the real world. While myths abound in the law, the discrepancy between fiction and reality in this case is particularly serious. A legal yardstick based on an outdated conception of how invention occurs may not be reliable for accurate assessments of patent issues. Work in the field of innovation studies confirms that teams are more capable innovators than individuals in nearly all respects.[16] Teams leverage a broader range of expertise, identify potential solutions, and synthesize preexisting ideas in a more creative manner.[17] In short, teams are superior innovators to their individual counterparts. While this mismatch is problematic for a number of reasons, the non-obviousness standard is likely the most significant: what a team of people with varied expertise might find obvious could be anything but obvious to an individual person, even one of extraordinary skill. The likely result is overpatenting, as well as a great deal of conceptual confusion for those trying to condense the characteristics of multifaceted teams into hypothetical single individuals.

The solution is to bring patent law back to reality. We propose as an alternative construct the *team having ordinary skills in the arts* ("THOSITA"), which would correct many of the PHOSITA's theoretical and practical deficiencies.[18] This alternative would reflect how

13. *See infra* Sections III.A–B.

14. *See infra* Section III.B.

15. *See infra* Section III.B.

16. *See infra* Section III.B for a discussion of the relative strengths of team-based innovation.

17. *See infra* Section III.B.

18. We are not the first to propose the concept of the "THOSITA." *See, e.g.*, Dennis Crouch, *Person(s) Skilled in the Art: Should the Now Established Model of Team-Based Inventing Impact the Obviousness Analysis?*, PATENTLY-O (May 17, 2011), https://patentlyo.com/patent/2011/05/persons-skilled-in-the-art-should-the-now-established-model-of-team-based-inventing-impact-the-obviousness-analysis.html [https://perma.cc/4LCM-JZJB]; Dennis Crouch, *THOSITA: Obvious to a Team Having Ordinary Skill in the Art*, PATENTLY-O (Oct. 15, 2012), https://patentlyo.com/patent/2012/10/the-number-of-inventors-per-patent-has-risen-fairly-steadily-for-the-past-40-years-today-most-patents-are-directed-toward-i.html [https://perma.cc/F6N3-WYLH] (suggesting a THOSITA as an alternative to the traditional model); *see also* Ryan Whalen, *Second-Order Obviousness: How Information and Communication Technologies Make Inventions More Obvious and Why the Law Should Care*, 97 J. PAT. & TRADEMARK OFF. SOC'Y 597, 623 (2015) (noting the potential use of a THOSITA standard as one tool to deal with the problem of obviousness in an innovation ecosystem with an overabundance of information resulting from information technologies); Laura G. Pedraza-Fariña, *Patent Law and the Sociology of*

innovation occurs in the real world and would be easier to implement in practice than the current standard. Ultimately, the THOSITA standard might even incentivize a new kind of innovative work and a renewed emphasis on disruptive, high-impact inventions. For these reasons, we argue patent law should abandon the myth of the lone inventor and embrace how most innovators actually bring about technological progress: by working together in teams.

This Article proceeds as follows. In Part II, we provide an overview of the PHOSITA construct, discussing its historical development and modern application. We then detail the recent emergence of some rare judicial recognition of PHOSITAs that appear to go beyond the traditional individual model. Part III discusses innovation as it occurs in the real world, beginning with what historical studies of R&D can tell us about the evolution of the typical agent of innovation. We then provide a data-based account of that shifting landscape, showing a clear transition toward a team-based innovation system and ultimately toward a multidisciplinary team system. We then discuss in more detail why the divergence between actual innovation and patent law is a problem. Part IV discusses the THOSITA as a potential solution, outlining how this alternative construct would operate doctrinally and how it might be implemented in practice. We conclude with some more speculative points on how the adoption of the THOSITA as an alternative benchmark might remake patent law as a whole and shift the innovation system in a more desirable direction.

II. THE PHOSITA CONSTRUCT

Like the hypothetical "reasonable person" in tort law, the PHOSITA is the conceptual anchor for much of patent law doctrine. By assessing an invention through the perspective of the PHOSITA, examiners and judges are better able to objectively determine whether the invention meets the requirements for patentability. But one basic question has troubled examiners, judges, and scholars alike since the emergence of the concept: Who exactly is the PHOSITA? Answering this question requires a look back at the historical development of the construct as well as its treatment in recent years. While questions remain about certain posited characteristics of this hypothetical person,

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Innovation, 2013 WIS. L. REV. 813, 867 (noting that the THOSITA is likely a more accurate reflection of the sociological reality of innovation); Lucas Osborn, *Pluralizing the PHOSITA in Patent Law*, PATCON, Apr. 2023, at 1, 1 (problematizing the individualist conception of the PHOSITA and suggesting that a group-based model represents an improvement). We depart from Osborn's interesting argument, however, that obviousness in high-skill, team-based fields should be generally lower due to the lower number of high-skill individuals working on a given problem. In our view, keeping to our conception of the agent of innovation as the team itself, any field dominated by very high-skill teams should substantially raise the standard of patentability for the reasons we suggest further below.

one feature is clear from the history and caselaw: the PHOSITA is an individual, usually with skill in a single technological field.

A. Historical Origins

Early versions of what would become the modern PHOSITA construct began to emerge in the first half of the nineteenth century, when many of the most fundamental design choices in American patent law were still being settled. Initially, patentability was thought to require only novelty and utility since nothing in the early Patent Acts indicated any further hurdle for the applicant.[19] The patentability determination thus focused entirely on the invention itself — whether it differed from pre-existing inventions, and whether it offered some identifiable use — and disregarded all aspects of how the invention was conceived.[20]

The early case of *Earle v. Sawyer*[21] epitomized this tendency. In that case, the defendant had infringed a machine for manufacturing shingles patented by the plaintiff.[22] Since the inventor's machine was clearly new and useful — satisfying the only requirements under the Patent Act of 1793 — the defendant's only argument was that the machine was not sufficiently inventive.[23] In his opinion, Justice Joseph Story restated the defendant's argument that "[i]t is not sufficient, that a thing is new and useful, to entitle the author of it to a patent."[24] In this view, the inventor was required to develop the invention "by mental labor and intellectual creation. If the result of accident, it must be what would not occur to all *persons skilled in the art*[,] who wished to produce the same result."[25] In other words, the defendant argued that the machine, though new and useful, was still not actually an invention. Story rejected this argument, holding that the Patent Act demanded no such inventive faculty.[26] In Story's view, patent law "looks to the fact, and not to the process by which it is accomplished."[27]

The middle of the nineteenth century witnessed a major shift in thinking toward a more robust standard for inventorship. It was during this shift that the person skilled in the art, once flatly rejected as a irrelevant construct in cases like *Earle*, was imported into the core pa-

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19. *See* OREN BRACHA, OWNING IDEAS: THE INTELLECTUAL ORIGINS OF AMERICAN INTELLECTUAL PROPERTY, 1790–1909, at 222–24 (2016).
20. *Id.*
21. 8 F. Cas. 254 (C.C.D. Mass. 1825) (No. 4,247).
22. *Id.* at 254.
23. *Id.* at 254–55.
24. *Id.* at 255.
25. *Id.* (emphasis added).
26. *Id.* at 255–56.
27. *Id.* at 256.

tentability analysis. The 1851 Supreme Court decision in *Hotchkiss v. Greenwood*[28] is widely recognized as the turning point.[29] In that case, Hotchkiss and his colleagues claimed to have invented a new type of doorknob made of clay or porcelain rather than metal or wood, which had long been the standard type, and secured a patent on this improvement.[30] Accused of infringing Hotchkiss's patent, Greenwood defended that the patent was invalid.[31]

The Court agreed, noting that the difference between Hotchkiss's invention and the prior art was "formal, and destitute of ingenuity or invention."[32] Writing for the majority, Justice Samuel Nelson determined that in the course of developing the new doorknob, "unless more ingenuity and skill . . . were required . . . than were possessed by an ordinary mechanic acquainted with the business, there was an absence of that degree of skill and ingenuity which constitute essential elements of every invention."[33] Since Hotchkiss's doorknob was the "work of a skillful mechanic" and not "that of the inventor," it was not the kind of thing a patent could protect.[34] Following *Hotchkiss*, the focus of the patentability analysis shifted from the value of the invention to the qualities demonstrated by the inventor.[35] Patentability now required not just novelty and utility but also some quality of inventiveness, an element judged against the standard of an average workman in the field. This "ordinary mechanic" was the primogenitor of the modern PHOSITA.

In construing this new hypothetical person as well as their "inventor" counterpart, just who might Nelson and other judges of this period have had in mind? In the middle of the nineteenth century, innovation was still largely driven by the individual. This was the era prior to the maturation of industrial capitalism in the United States and the emergence of corporate and university research when the lone inventor was the primary source of new ideas.[36] It would thus have been natural for judges at this time to conceive of an individual person — the skillful mechanic — as the benchmark against which patentable innovation could be measured. Judges would not have

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28. 52 U.S. 248 (1851).

29. *See* Edward C. Walterscheid, *Novelty & the* Hotchkiss *Standard*, 20 FED. CIR. BAR J. 219, 219–22 (2010).

30. *Hotchkiss*, 52 U.S. at 264–65.

31. *Id.*

32. *Id.* at 266.

33. *Id.* at 267.

34. *Id.*

35. *See id.*

36. *See infra* Section III.A. As Mark Lemley has argued, however, the inventions of solo inventors during this period were often simultaneously developed by others, thus further calling into question the "myth" of the lone genius even during what is often thought of as the heyday of individual-led invention. *See* Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 712–15 (2012).

thought to consider a group of individuals working together as the correct agent of innovation — indeed, such a conception would have been premature.[37]

B. The Modern Approach

Following a century of confusion over the boundaries of the inventiveness standard, the ordinary mechanic was finally codified into law with the passage of the 1952 Patent Act.[38] Under this modern framework, § 103 provides that an invention is not patentable if it "would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains."[39] This cemented the PHOSITA's role as the central reference point for the obviousness doctrine. Additionally, the PHOSITA was also identified as the benchmark for the enablement standard, the most fundamental feature of patent disclosure. Under § 112, a valid patent must provide a description that can "enable any person skilled in the art . . . to make and use" the invention.[40] Only by adopting this frame of reference could examiners and judges assess whether an invention was sufficiently inventive or a patent sufficiently instructive.[41] The PHOSITA had thus been elevated to the central construct in patent validity determinations.

The PHOSITA itself, however, remained elusive. The Supreme Court's landmark 1966 decision in *Graham v. John Deere*[42] noted that determining the "level of ordinary skill in the art" was one of the key steps in the non-obviousness analysis, but provided no instruction on how to imagine that skillset.[43] Shortly after its creation in 1982, the Federal Circuit issued its decision in *Environmental Designs, Ltd. v. Union Oil Co.*,[44] which offered a set of concrete factors for courts to

37. This historical context is discussed further below in Section III.A.

38. Patent Act of 1952, Pub. L. No. 593-950, 66 Stat. 792 (current version at 35 U.S.C. § 103).

39. *Id.* at 798.

40. 35 U.S.C. § 112.

41. Other authors have noted that, though the language is virtually identical, the PHOSITA for obviousness may in fact — or should — be different from the PHOSITA for enablement. We return to this possibility in our discussion of a team based THOSITA in Part IV below. *See, e.g.*, Laura Pedraza-Fariña & Ryan Whalen, *The Ghost in the Patent System: An Empirical Study of Patent Law's Elusive "Skilled Artisan,"* 108 IOWA L. REV. 247, 260–61 (2022); *see also* Dan L. Burk & Mark A. Lemley, *Is Patent Law Technology-Specific?*, 17 BERKELEY TECH. L.J. 1155, 1189–90 (2002). For the argument that the identical PHOSITA should be used as the benchmark for both non-obviousness and enablement, see generally Timothy R. Holbrook & Mark D. Janis, *How the Supreme Court Ghosted the PHOSITA:* Amgen *and Legal Constructs in Patent Law*, 109 IOWA L. REV. ONLINE 83 (2024).

42. 383 U.S. 1 (1966).

43. *Id.* at 17–18.

44. 713 F.2d 693 (Fed. Cir. 1983).

take into consideration in making a finding on the PHOSITA's level of skill: "(1) the educational level of the inventor; (2) type of problems encountered in the art; (3) prior art solutions to those problems; (4) rapidity with which innovations are made; (5) sophistication of the technology; and (6) educational level of active workers in the field."[45] Under this framework, the PHOSITA's level of skill is an amalgamation of formal training and the nature of the field itself. The "important consideration," in the Court's view, was to perform the obviousness analysis from the perspective of the PHOSITA with this level of skill and not the "judge," "layman," or "geniuses in the art at hand."[46]

In the years that followed, however, the Federal Circuit and lower courts largely marginalized the concept. By following a "formalistic" approach that looked only to the "four corners of the patent specification" rather than any background facts behind the invention, courts diminished the role of the PHOSITA in judicial decisions.[47] When the PHOSITA did factor into patentability and validity analyses, the bar was set low, with the imagined persona having minimal creativity and capacity to synthesize the prior art.[48]

In 2007, the Supreme Court sought to reinvigorate the standard in *KSR International Co. v. Teleflex Inc.*,[49] its first decision focused on the obviousness standard since *Graham*. Aiming to raise the imagined level of skill and innovative capacity of the PHOSITA from the low standard set by the Federal Circuit, the *KSR* Court made clear that the PHOSITA is a "person of ordinary creativity, not an automaton."[50] More concretely, the PHOSITA should be assumed to respond to "design need[s]" and "market pressure[s] to solve a problem" by pursuing "the known options within his or her technical grasp."[51] Following *KSR*, the PHOSITA, while still not a "genius," is an active problem-solver with substantial domain knowledge.[52]

In constructing the appropriate PHOSITA for a given invention, judicial analysis now tends to focus on three fundamental attributes.

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45. *Id.* at 696.

46. *Id.* at 697.

47. *See* Timothy R. Holbrook, *Patents, Presumptions, and Public Notice*, 86 IND. L.J. 779, 792–96 (2011) (arguing that the Federal Circuit had "marginalized the PHOSITA to the point of near irrelevance").

48. *Id.*

49. 550 U.S. 398 (2007).

50. *Id.* at 421.

51. *Id.*

52. There is an ongoing debate about whether *KSR* has actually impacted how lower courts conceive of and implement the PHOSITA concept in their analyses. *See infra* Part IV for a return to this issue. Most recently, Laura Pedraza-Fariña and Ryan Whalen have conducted an empirical analysis showing that, despite *KSR*'s instructions, the PHOSITA continues to play a minor role in judicial decision-making. *See generally* Pedraza-Fariña & Whalen, *supra* note 41.

The first is what the appropriate art for a given PHOSITA should be. A common proxy that appears in the caselaw is the supposed job title of the PHOSITA or, more generally, the field about which the PHOSITA should be assumed to be knowledgeable.[53] For example, the invention at issue in *KSR* was an adjustable gas pedal with an electronic throttle control for an automobile.[54] The district court thus determined that the PHOSITA was a person that "has familiarity with pedal control systems for vehicles."[55] The second feature is the skill level of the PHOSITA within their field, with education or training as the usual benchmark.[56] The PHOSITA in *KSR*, for example, had an "undergraduate degree in mechanical engineering or an equivalent amount of industry experience."[57] And third, courts must estimate — often implicitly — the degree of innovative creativity exercised by the PHOSITA, usually deduced from the pace of innovation in the relevant field.[58] As the Supreme Court instructed in *KSR*, "ordinary creativity" should be assumed in all cases,[59] but more research-intensive fields are impliedly more creative than others.[60]

In the course of a dispute, opposing sides will aim to characterize the PHOSITA along these axes to their advantage. If a defendant wants to argue that an invention was obvious, the defendant will suggest that the PHOSITA is a specialist in the precise field of the invention, and one with maximum skill, training, and creativity. The plaintiff, in contrast, will argue that the PHOSITA is a generalist, essentially as close to a layperson as possible. The Federal Circuit's

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53. *See, e.g.*, *In re* Entresto (Sacubitril/Valsartan) Pat. Litig., MDL No. 20-2930, 2023 WL 4405464, at *14 (D. Del. July 7, 2023) ("[A] POSA is 'a medical doctor . . . who is interested in developing new drugs for heart failure and hypertension . . . .'") (citations omitted); CAA Indus., Ltd. v. Recover Innovations, Inc., No. 22-cv-00581, 2023 WL 2430149, at *3 (D. Nev. Jan. 12, 2023) (defining the relevant PHOSITA standard as "a person that has experience in designing firearms and/or firearm accessories").

54. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. at 398.

55. Teleflex Inc. v. KSR Int'l Co., 298 F. Supp. 2d 581, 590 (E.D. Mich. 2003).

56. *See, e.g.*, Sightsound Techs., LLC v. Apple, Inc., No. 11-CV-01292, 2012 WL 12896175, at *7 n.12 (W.D. Pa. Nov. 19, 2012) ("Therefore, for this case, the PHOSITA is a person having an undergraduate degree in electrical engineering or computer science . . . ."); Immunex Corp. v. Sandoz Inc., 395 F. Supp. 3d 366, 390 (D.N.J. 2019), *aff'd*, 964 F.3d 1049 (Fed. Cir. 2020) ("[PHOSITA] is 'a scientist with an M.D. or a Ph.D. degree in biology, molecular biology, biochemistry, chemistry, or a similar field.'"); Allergan USA, Inc. v. MSN Lab'ys Priv. Ltd., No. 19-1727, 2023 WL 6295496, at *5 (D. Del. Sept. 27, 2023) ("[PHOSITA] is a person who possesses a Ph.D. in chemistry, pharmaceutical sciences, or related disciplines . . . .").

57. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. at 412.

58. *See, e.g.*, Darrow, *supra* note 1, at 228 (arguing that the presumed level of creativity of the PHOSITA has been raised dramatically, even before the Supreme Court's decision in *KSR*, from the original "ordinary mechanic" standard to one closer to the "ordinary inventor."). In Darrow's view, the PHOSITA for all areas of technology is now assumed to be a "researcher" actively pursuing new innovations. *Id.* at 243–44.

59. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. at 421.

60. *See* Darrow, *supra* note 1, at 243–44.

influential decision in *Daiichi Sankyo Co. v. Apotex, Inc.*[61] offers a striking illustration of how these factors play out in the course of a dispute. The patent at issue in that case covered a method for treating ear infections using the compound ofloxacin.[62] At the district court level, accused infringer Apotex argued that the PHOSITA was a "physician with detailed understanding of ear diseases" who was also a "pharmaceutical scientist" with a doctorate degree.[63] Patent holder Daiichi suggested in contrast that the PHOSITA was a "general practitioner or pediatrician of modest experience."[64] The district court sided with Daiichi,[65] but the Federal Circuit reversed, concluding that the correct PHOSITA was a research-oriented specialist.[66] The dispositive factor in the Federal Circuit's analysis was the level of skill and training of the inventors themselves, who were all researchers with advanced degrees.[67]

What is not questioned in these analyses, however, is that the PHOSITA, as its name might appear to suggest, is nearly always assumed to be a single person. In constructing the PHOSITA for a given invention, examiners and judges envision the skill, training, and creativity that went into creating the invention embodied in an individual. Judges often make this explicit: In *Daiichi*, for example, the question was what the correct level of skill and training of a single hypothesized person in the appropriate field would be, even though the invention itself was the result of three people with slightly different areas of expertise working together.[68] The district court had to decide between a pharmaceutical scientist and a general practitioner, ultimately choosing the latter.[69] On appeal, the Federal Circuit resolved that the correct PHOSITA was "a *person* engaged in developing pharmaceutical formulations and treatment methods for the ear or a specialist in ear treatments such as an otologist, otolaryngologist, or otorhinolaryngologist who also has training in pharmaceutical formulations."[70] This is the pattern we observe in the overwhelming majority of cases: regardless of whether the actual inventor was a person or a group of people,

61. 501 F.3d 1254 (Fed. Cir. 2007).

62. *Id.* at 1255.

63. Daiichi Pharm. Co. v. Apotex, Inc., 380 F. Supp. 2d 478, 484 (D.N.J. 2005).

64. *Id.*

65. *Id.* at 485 ("This person would be, as Daiichi argues, a pediatrician or general practitioner — those doctors who are often the 'first line of defense' in treating ear infections and who, by virtue of their medical training, possess basic pharmacological knowledge.").

66. *Daiichi Sankyo Co.*, 501 F.3d at 1257.

67. *Id.*

68. *Id.* ("At the time of the invention, Inventor Sato was a university professor specializing in otorhinolaryngology; Inventor Handa was a clinical development department manager at Daiichi, where he was involved with new drug development and clinical trials; and Inventor Kitahara was a research scientist at Daiichi engaged in the research and development of antibiotics.").

69. *Daiichi Pharm. Co.*, 380 F. Supp. 2d at 485.

70. *Daiichi Sankyo Co.*, 501 F.3d at 1256 (emphasis added).

the PHOSITA is always a person, though their individual attributes might be in contention.[71]

C. Recent Judicial Recognition of Collaborative Innovation

That courts overwhelmingly tend to conceptualize the PHOSITA as a single person is no surprise. Taken literally, the Patent Act would seem to call for the construction of a "person" rather than multiple individuals, and the legal history would point in that direction as well.[72] In the Supreme Court's most recent statement on the issue in *KSR*, courts are instructed to imagine "a person" with certain habits of mind and capacities for synthesizing the prior art.[73] However, we observe a curious trend that has emerged primarily in the past decade. In a minority of cases, almost all of which involve inventions in the pharmaceutical field, courts have appeared to adopt a more expansive conception of the PHOSITA.[74] Specifically, these courts have deter-

71. *E.g.*, Shure, Inc. v. ClearOne, Inc., No. 17 C 3078, 2019 WL 3555098, at *5 (N.D. Ill. Aug. 5, 2019) (applying a PHOSITA as a "skilled artisan [who] must have at least one year of work experience in the field of digital signal processing"); Hologic, Inc. v. Minerva Surgical, Inc. 764 F. App'x 873, 876 (Fed. Cir. 2019) (applying a PHOSITA as "someone 'who had, through education or practical experience, the equivalent of a bachelor's degree in biomedical engineering, electrical engineering, mechanical engineering or a related field and at least an additional two to three years of work experience developing or implementing electrosurgical devices'"); OrthoPediatrics Corp. v. Wishbone Med., Inc., No. 20-CV-929, 2022 WL 4978169, at *3 (N.D. Ind. Oct. 4, 2022) (applying a PHOSITA as "a person with (1) at least a bachelor's degree or equivalent degree and (2) at least two years of experience in (i) designing, developing or testing computer systems used in medical applications for interpreting medical images, or (ii) using computer systems for medical treatments, including but not limited to orthopedic alignment, or a person having equivalent knowledge and experience in the field of orthopedic alignment"); Biogen Int'l GmbH v. Mylan Pharms. Inc., No. 17-CV-116, 2020 WL 3317105, at *7 (N.D. W. Va. June 18, 2020) (applying a PHOSITA as "someone with 'at least a medical degree, at least three years of training in neurology, and at least three years of clinical experience treating multiple sclerosis patients'"); ProBatter Sports, LLC v. Sports Tutor, Inc., 172 F. Supp. 3d 579, 589 (D. Conn. 2016) (applying a PHOSITA as "someone with knowledge of basic engineering principles who deals with motor control vendors in his work designing and manufacturing pitching machines"); Papyrus Tech. Corp. v. New York Stock Exch., LLC, 653 F. Supp. 2d 402, 416 (S.D.N.Y. 2009), *aff'd*, 396 Fed. Appx. 702 (Fed. Cir. 2010) (applying a PHOSITA as "a person with (1) knowledge of negotiable instruments traded on auction markets, (2) a bachelor's degree in electrical engineering or computer science, and (3) approximately one to two years of practical experience with computers and computer networks").

72. *See* 35 U.S.C. § 103.

73. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 420–21 (2007) ("Common sense teaches, however, that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle . . . . A person of ordinary skill is also a person of ordinary creativity, not an automaton.").

74. We may speculate that courts have tended to adopt an expanded conception of the PHOSITA in the pharmaceutical field due its highly collaborative nature compared to other fields. For an overview of the research landscape in pharmaceuticals and the increasing trend toward a collaborative model of innovation, see generally Angelo Kenneth S. Romasanta, Peter van der Sijde & Jacqueline van Muijlwijk-Koezen, *Innovation in Pharmaceutical R&D: Mapping the Research Landscape*, 125 SCIENTOMETRICS 1801 (2020). It

mined that the correct PHOSITA is some variant of a *team* rather than the typical *person* hypothesized in most cases. Courts have brought in this team-based conception by imagining the PHOSITA in three different ways: (1) as an individual member of a team, (2) as an individual with access to other experts, or (3) as a team itself.

1. Member of a Team

The most common way in which some courts have shifted the standard construct is by envisioning a PHOSITA still as an individual person but part of a larger team, often with other members having different skills. While this interpretation still adheres to a narrow reading of the Patent Act's "person," it clearly expands the traditional conception by recognizing that the hypothetical person can collaborate with others and draw on the collective expertise of a group.

For example, in the 2018 district court case *ProStrakan, Inc. v. Actavis Laboratories UT, Inc.*,[75] an infringement dispute involving a patent on an anti-nausea adhesive patch for chemotherapy patients, the court determined that the PHOSITA "would have had a Master's degree or doctorate in pharmaceutical science, chemical engineering, or commensurate experience in a related field."[76] The court added, however, that the PHOSITA "may have worked as a member of a team that included a person of ordinary skill in the art in pharmacology and/or pharmacokinetics, who would have had a Master's degree or doctorate or commensurate experience in a related field."[77] Expanding the team even further, the court noted that the PHOSITA "may have also worked as a member of a team that included a [PHOSITA] in treating and/or preventing emesis in patients undergoing chemotherapy."[78] While the PHOSITA may still technically be an individual, then, the expertise and skills of that person are expanded substantially as a result of this larger group.[79]

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may also be the case, however, that patent disputes arising from the pharmaceutical sector are simply more common.

75. No. 16-CV-00044, 2018 WL 11363829 (E.D. Tex. Sept. 28, 2018).

76. *Id.* at *38.

77. *Id.*

78. *Id.*

79. Other cases that have endorsed the conception of a PHOSITA as a "member of a team" of which we are aware include: GlaxoSmithKline LLC v. Banner Pharmacaps, Inc., No. CV 11-046, 2013 WL 4082232, at *2 (D. Del. Aug. 9, 2013) ("One of ordinary skill in the art would have an advanced degree in organic or medicinal chemistry, with some experience in drug discovery and development, and access to a team of drug development scientists, including biologists, pharmacologists, and solid-state chemists and formulation scientists."); Allergan, Inc. v. Watson Lab'ys, Inc., 869 F. Supp. 2d 456, 470 (D. Del. 2012) ("A person of ordinary skill in the art with respect to the patents-in-suit would have . . . a Ph.D. in pharmaceutics, pharmacy, chemistry, or a related field, several years of experience formulating and evaluating dosage forms, and would have participated as a member of a development team . . . ."); Pfizer Inc. v. Watson Pharms., Inc., 920 F. Supp. 2d 552, 558 (D.

The Federal Circuit appeared to approve of this move in its 2019 decision in *Indivior Inc. v. Dr. Reddy's Laboratories, S.A.*[80] At issue in that case were multiple patents covering a medication for opioid addiction administered as a dissolving film. The district court determined that a PHOSITA in this context "would possess a bachelor's degree in pharmaceutical science, chemistry, or a related field," and "would also be a member of a team, which would include an engineer or scientist with one to three years of relevant experience manufacturing and optimizing various types of film products using coating and drying processes."[81] Noting explicitly that the district court had cast the PHOSITA as a member of a team, the Federal Circuit found no clear error in this finding.[82] Appellant (and accused infringer) Dr. Reddy's Laboratories had argued that the team should have more collective years of experience than what the district court had attributed, but the Federal Circuit dismissed this argument as "nitpicking."[83]

Del. 2013) ("[A] person of ordinary skill in the art . . . would be a medicinal chemist and/or immunologist, with a clinician as a member of the drug discovery team."); *In re* Brimonidine Pat. Litig., 666 F. Supp. 2d 429, 441 (D. Del. 2009) ("A person of ordinary skill in the art . . . is a person having a bachelor's or PharmD degree in pharmacy, pharmaceutical sciences, or related science disciplines; having three to five years of formulation experience; and being supervised by a Ph.D. or someone with substantially longer formulation experience. The person would likely be a member of a formulation development team that may include analytical chemists and related development scientists."); Adapt Pharma Operations Ltd. v. Teva Pharms. USA, Inc., No. 16-cv-7721, 2020 WL 3428078, at *21 (D.N.J. June 22, 2020) ("[A] POSA is an individual that would have had a bachelor's of science in the pharmaceutical sciences or related disciplines, including chemistry, and would have four to five years of experience developing intranasal drug products . . . . Such a POSA might also possess a higher level of formal education but fewer years of practical experience . . . . They would work with a team and rely in part on the knowledge of their skilled team members."); Sun Pharma Glob. FZE v. Lupid Ltd., No. 18-2213, 2021 WL 4473411, at *14 (D.N.J. Sept. 30, 2021) ("[T]he POSA would be part of an ophthalmic development team, either with years of experience designing formulations or with equivalent experience conducting clinical trials."); Takeda Pharm. Co. v. Mylan Inc., No. 13-CV-04001, 2014 WL 5862134, at *16 (N.D. Cal. Nov. 11, 2014) ("A person of ordinary skill in this art would also have 'a bachelor's degree in chemistry, chemical engineering, or related disciplines, with a minimum of three years' experience in the pharmaceutical industry . . .' and '[s]uch a person would have either personal knowledge or ha[ve] access to a team with knowledge regarding design of dosage forms.'") (alteration in original); Onyx Therapeutics, Inc. v. Cipla Ltd., 613 F. Supp. 3d 817, 829–30 (D. Del. 2020) ("[A POSA] with regard to the Asserted Patents would be a person having a doctoral degree in a discipline such as organic or medicinal chemistry, pharmacology, enzymology, pharmaceutical sciences, or related disciplines . . . working together with others, including at least, medicinal chemists, preclinical researchers, formulators, and medical doctors in a multidisciplinary team, to solve a given problem.").

80. 930 F.3d 1325, 1331–33 (Fed. Cir. 2019).

81. Reckitt Benckiser Pharms. Inc. v. Dr. Reddy's Lab'ys S.A., No. CV 14-1451, 2017 WL 3837312, at *14 (D. Del. Aug. 31, 2017).

82. *Indivior*, 930 F.3d at 1345.

83. *Id.*

2. Access to an Expert

A second way in which courts have expanded the traditional conception of the lone PHOSITA is to imagine that person with access to one or more experts, either in the same field or in others. Like the construction noted above, this version still limits the PHOSITA to an individual but clearly recognizes a collaborative element at play in the normal course of innovation in the field. The recent Federal Circuit decision in *McCoy v. HEAL Systems, LLC*[84] appeared to endorse this construction. In that case, McCoy held a patent on a mechanism and method for separating oil and gas in the oil drilling process.[85] Prior to the appeal, the U.S. Patent and Trademark Office's ("USPTO's") Patent Trial and Appeal Board ("PTAB") found the invention invalid as obvious, relying on HEAL Systems's proposed PHOSITA as a person with a degree in "mechanical, petroleum, or chemical engineering . . . [with] at least 3-4 years of experience" and, critically, "access to an expert" or the ability to "consult with other experts."[86] Access to these experts would, in the view of HEAL Systems's expert witness, "elevate [someone's] ability to solve [a] problem compared to lacking that access."[87]

On appeal, McCoy argued that the PTAB's construction of a PHOSITA was contrary to the clear language of the Patent Act requiring the PHOSITA to be of "ordinary" skill.[88] Access to an expert, in other words, would "convert a [PHOSITA] into an expert," and thus contravene the statute.[89] The Federal Circuit disagreed. The court noted that the PHOSITA "must be tailored to the practice in the art," and that "reliance on another type of expert, if not routine in the art, might not be appropriate."[90] In petroleum engineering, however, it was "common for [PHOSITAs] to rely on experts" and a PHOSITA "would have been trained and encouraged to do so."[91] Since access to an expert was routine for engineers of ordinary skill, the court found that the PTAB's construction was not improper.[92] While a "team" is

84. 850 F. App'x 785 (Fed. Cir. 2021).

85. *Id.* at 786.

86. HEAL Sys., LLC v. Echometer Co., No. 2018-01409, 2019 WL 12424525 (P.T.A.B. Dec. 30, 2019). HEAL's proposed representative experts would have skills in "well completion technology, deliquification, artificial lift, and gas separation." Brief for Appellee at 25, McCoy v. HEAL Sys., LLC, 850 F. App'x 785 (Fed. Cir. 2021) (No. 2020-1484), 2020 WL 5430840, at *36–37.

87. Opening Brief for Appellant at 27, *McCoy*, 850 F. App'x 785 (No. 2020-1484), 2020 WL 2847848, at *26–27.

88. *McCoy*, 850 F. App'x at 787.

89. *Id. McCoy* termed this expanded conception of a PHOSITA as a "PHOSITA plus expert." Opening Brief for Appellant, *supra* note 87, at 27.

90. *McCoy*, 850 F. App'x at 788.

91. *Id.*

92. *Id.*

not mentioned, this clearly functions as an expansion of the knowledge base and skills of an individual in a way similar to the "member of a team" formulation.

3. A Team Itself

A third category of recent cases involves an even starker expansion of the traditional construct. In some rare instances, courts have appeared to abandon the notion of the individual PHOSITA altogether and instead describe the theoretical bearer of ordinary skill as a team itself. Courts have described these teams at a similar level of detail as they occasionally do for an individual, including the number of team members, their respective fields, and their education level. Echoing *Daiichi Sankyo*, the pattern in most of these cases is for the hypothetical team to mirror the actual team of inventors who developed the invention. In the 2020 district court case *Cephalon, Inc. v. Slayback Pharma Ltd.*,[93] for example, the court determined that the PHOSITA was a "team of individuals working together to formulate a liquid injectable drug product."[94] This theoretical team "would have included individuals with doctoral degrees in chemistry, biochemistry, pharmaceutics, pharmaceutical sciences, chemical engineering, biochemical engineering or related fields, with at least two years of post-graduate experience in developing liquid injectable drug products."[95] Stretching the traditional concept even further, the court noted that the "team also would have had access to an individual with a medical degree with experience in treating patients" with the type of cancer that the invention at issue was designed to treat.[96] Other cases in this category focus on the same attributes.[97]

93. 456 F. Supp. 3d 594 (D. Del. 2020).

94. *Id.* at 603.

95. *Id.*

96. *Id.*

97. *See, e.g.*, Endo Pharms. Sols. Inc. v. Custopharm, Inc., 234 F. Supp. 3d 587, 598 (D. Del. 2017) ("The parties generally agree that the person of ordinary skill in the art would consist of a team made up of a pharmacokineticist, a clinician, and a formulation scientist."); Univ. of Rochester v. G.D. Searle & Co., 249 F. Supp. 2d 216, 228 n.6 (W.D.N.Y. 2003) ("'[O]ne' of ordinary skill in the art to which the '850 patent pertains is a team of scientists, with skills in medicinal chemistry, molecular biology, biochemistry, and pharmacology."); OrthoPediatrics Corp. v. Wishbone Med., Inc., No. 20-CV-929, 2022 WL 4978169, at *5 (N.D. Ind. Oct. 4, 2022) ("The Court notes at the outset that, like the Plaintiffs, it agrees with the Defendants that a P[H]OSITA can be a team of individuals instead of one individual."). *But see* Otsuka Pharm. Co. v. Sandoz, Inc., No. 07-CV-01000, 2010 WL 4596324, at *7 (D.N.J. Nov. 15, 2010) (rejecting the notion that a PHOSITA "must possess all of the attributes of a multi-member team" because "[the] fields of medicinal chemistry and pharmacology are inherently multi-disciplinary, and it is therefore sufficient to consider the skilled artisan to be one having a degree in medicinal chemistry, pharmacology, or a related field with experience in drug research and development").

For the reasons we note in Part IV below, we believe a team itself — specifically, one of ordinary skill — is the most accurate and useful way to construe the benchmark against which most patents can be assessed. However, what is striking about these rare instances is how little the distinction between an individual and a team has factored into courts' ultimate analyses. We are aware of no case in which a court has acknowledged, even implicitly, that a team-based conception of the PHOSITA meaningfully impacts any outcome. Alternatively, some courts describe the PHOSITA as "an individual or team," as if the distinction were completely immaterial.[98] We are aware of no case in any of these three categories where the result hinged on whether the court adopted an individual- or team-based view of the PHOSITA.[99]

While the overwhelming majority of cases retain the traditional PHOSITA-as-individual, a small number of cases have departed from this conception to accommodate a more group-based model of innovation, usually involving fields in which collaborative innovation is more prevalent. However, even when these departures are made, courts have appeared to treat the team-based conception as similar enough to the standard view as to make no difference in their ultimate analyses. The team-based PHOSITA is thus both underused and underdeveloped; it rarely appears, and when it does, it seems to have little to no impact. We believe that this is misguided. The alternative PHOSITA-as-team should, we argue, be used in the majority of patent cases, and the application of the concept should make a substantial difference analytically. To ground this argument, we turn away from legal fictions and toward innovation as it plays out in reality.

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98. *See, e.g.*, Sanofi-Aventis U.S. LLC v. Fresenius Kabi USA, LLC, No. CV14-7869, 2018 WL 9364037, at *32 (D.N.J. Apr. 25, 2018) ("[The] parties generally agree that the POSA would be an individual (or team) with a working knowledge of clinical oncology and training in medical oncology, and would have experience with cancer patients."); Novartis Pharms. Corp. v. Noven Pharms., Inc., 125 F. Supp. 3d 474, 479 (D. Del. 2015) ("The PHOSITA is an individual, or team of individuals, with an advanced degree in chemistry, pharmacy, or a related field with at least two years of practical experience, or a master's or bachelor's degree in those disciplines and at least four or six years of practical experience, respectively."); Pernix Ireland Pain DAC v. Alvogen Malta Operations Ltd., 323 F. Supp. 3d 566, 597 (D. Del. 2018) ("[A PHOSITA] would be a person or team of persons with a degree or degrees in the relevant fields such as chemistry, biology, pharmaceutics, or medicine, and work experience in formulating or administering pharmaceuticals . . . .").

99. In the Federal Circuit's decision in *McCoy*, for example, the court noted that the appellant "[did] not identify any instance where 'expert' knowledge was applied and led to an erroneous conclusion . . . . Although the Board agreed that a POSA would have access to an expert, this by itself does not necessarily mean that the Board made patentability determinations based on an expert level of skill in the art." McCoy v. HEAL Sys., LLC, 850 F. App'x 785, 789 (Fed. Cir. 2021).

III. INNOVATION IN THE REAL WORLD

When the seeds of the PHOSITA standard were planted in Hotchkiss in 1851, the "ordinary mechanic" was an appropriate benchmark against which to assess innovation. Indeed, in 1850, the typical inventor worked alone.[100] But since that time, the practice of innovation has evolved, while the legal standard for evaluating innovation has not. High-impact instances of innovation, as well as patent data, document multiple shifts in how new technology and knowledge are produced.[101] In short, the shift has been primarily from lone artisans skilled in a particular craft to teams cooperating across disciplinary boundaries.

A. How Innovation Has Evolved

During the nineteenth century, the lone inventor was the dominant source of innovation in the United States.[102] In the early Republic, lone inventors such as Eli Whitney and Samuel Colt were engineers as well as entrepreneurs.[103] As was typical of their era, they contributed to the creation of new machines and established manufactories to produce them.[104] Inventors of the time did not have much choice but to commercialize their own technologies. American manufacturing in the early nineteenth century was still artisanal; there was not a market for companies to license technologies and use them in combination or at scale.[105]

In the mid-nineteenth century, a market for trading in inventions began to emerge.[106] Individuals remained the primary inventors, but during this period individual inventors more frequently licensed the rights to their inventions to third parties, often manufacturing compa-

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100. *See infra* Data Appendix for details on analysis and sampling.

101. Stefan Wuchty, Benjamin F. Jones & Brian Uzzi, *The Increasing Dominance of Teams in Production of Knowledge*, 316 SCIENCE 1036, 1036 (2007).

102. *See, e.g.*, Naomi R. Lamoreaux & Kenneth Lee Sokoloff, *Introduction: The Organization and Finance of Innovation in American History*, *in* FINANCING INNOVATION IN THE UNITED STATES, 1870 TO THE PRESENT 1, 6 (Naomi R. Lamoreaux & Kenneth Lee Sokoloff eds., 2007); *see also infra* Data Appendix (a sample of U.S. patents from 1850 confirms these historical accounts with zero patents from 1850 with one or more citations having any co-inventors); *cf.* DAVID A. HOUNSHELL, FROM THE AMERICAN SYSTEM TO MASS PRODUCTION, 1800–1932: THE DEVELOPMENT OF MANUFACTURING TECHNOLOGY IN THE UNITED STATES 51 (1984) (discussing individual inventors who "set out to shape the distinctive American technological character").

103. HOUNSHELL, *supra* note 102, at 29–30, 46.

104. *Id.*

105. *See, e.g.*, Lamoreaux & Sokoloff, *supra* note 102, at 6; *cf.* HOUNSHELL, *supra* note 102, at 68 (describing the emergence of patent licensing and pooling arrangements in the mid-19th century).

106. *See* Lamoreaux & Sokoloff, *supra* note 102, at 4–5.

nies.[107] The market for licensing patents also helped inventors attract more capital to support their innovative process.[108] Due to the growth of this market for technology licensing, the late nineteenth century has been called the "golden era of the independent inventors."[109]

Independent inventor Thomas Blanchard's experience is typical of this era of innovation. When he patented an automated tack-making machine in 1817, he sold the licensing rights to make the machine.[110] He used the money from the licensing rights to purchase a facility where he could continue his inventing.[111] He later invented what would become known as the "Blanchard gun-stocking lathe," which represented a critical breakthrough in manufacturing technology: a machine tool that could make replaceable parts of non-standard shapes like gun stocks.[112] Blanchard sold these machines to the U.S. military through the Springfield, MA armory.[113] Although he used the armory's space and equipment, he remained an independent contractor and inventor throughout his life.[114] Part of Blanchard's career as an inventor, which spanned five decades, was to manage his patent portfolio through lawyers and on his own.[115] In one case, he lobbied Congress for extensions of his patents, reportedly using the machines he invented to carve busts of congressmen.[116] Inventors like Blanchard continued to thrive throughout the nineteenth century, but at the turn of the twentieth century, a new model was beginning to emerge.

The first industrial research and development operations appeared in the American chemicals manufacturing industry in the late nineteenth century at firms like Du Pont and Eastman Kodak.[117] However, the growth of industrial R&D activities in the United States did not accelerate until the first half of the twentieth century, when large corporations faced pressures to diversify their operations under antitrust scrutiny.[118] Investing in invention became a strategic path to diversification for large firms.

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107. *Id.*

108. *Id.*

109. THOMAS P. HUGHES, AMERICAN GENESIS: A CENTURY OF INVENTION AND TECHNOLOGICAL ENTHUSIASM, 1870–1970, at 15 (U. Chi. Press 2004) (1989).

110. CHARLES R. MORRIS, THE DAWN OF INNOVATION: THE FIRST AMERICAN INDUSTRIAL REVOLUTION 139 (1st ed. 2012).

111. *Id.*

112. *Id.* at 140; *see also* HOUNSHELL, *supra* note 102, at 35–38.

113. MORRIS, *supra* note 110, at 145.

114. *Id.*

115. *Id.*

116. *Id.* at 146.

117. *See* DAVID C. MOWERY & NATHAN ROSENBERG, PATHS OF INNOVATION: TECHNOLOGICAL CHANGE IN 20TH-CENTURY AMERICA 13–15, 22 (1998).

118. *Id.*

The transition from Thomas Edison's "invention factory" of the late nineteenth century to Bell Labs' "idea factory" of the early twentieth century represents an illustrative turning point from individual inventor to professional R&D operation. For much of his career, Edison operated in practice as an independent inventor, following his apparent preference.[119] His laboratories in New Jersey employed technicians and scientists to help operationalize his inventions, but these individuals were employed to follow Edison's instructions.[120] Edison described the power dynamic: "I can always hire mathematicians, but they can't hire me."[121]

When Bell Labs was established in 1925 (also in New Jersey), it employed scientists in a professionalized environment focused on collaboration to identify and solve shared problems.[122] It started with a budget of approximately $187 million (2024 dollars) and employed 2,000 scientists in its early years.[123] The president of Bell Labs, Frank Jewett, described the thesis behind the new operation. He saw it as "an instrument which can bring to bear an aggregate of creative force on any particular problem which is infinitely greater than any force which can be conceived of as residing in the intellectual capacity of an individual."[124]

The recognition that teams could be more productive engines of innovation began to spread, along with the professionalization of R&D labs. In 1921, there were only approximately 2,775 engineers and scientists employed at corporate R&D laboratories.[125] By 1940, the number had increased by more than an order of magnitude to 27,777, and it jumped yet again after the Second World War, reaching 45,941 by 1946 and approximately 300,000 by 1962.[126] The growth of organized science was not limited to the private sector. For example, university labs grew as well.[127]

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119. Thomas P. Hughes, *The Era of Independent Inventors*, *in* 3 SCIENCE IN REFLECTION: THE ISRAEL COLLOQUIUM: STUDIES IN HISTORY, PHILOSOPHY, AND SOCIOLOGY OF SCIENCE 151, 154 (Edna Ullmann-Margalit ed., 1988).

120. JON GERTNER, THE IDEA FACTORY: BELL LABS AND THE GREAT AGE OF AMERICAN INNOVATION 12–13 (2012).

121. *Id.*

122. *Id*. at 31.

123. *Id.*

124. *Id.* at 32–33. Jewett's notion of teams producing higher quality innovations than individuals could have challenged the prevailing wisdom of the time. In a series of essays first published in 1931, F. Scott Fitzgerald includes the quip, "no grand idea was ever born in a conference, but a lot of foolish ideas have died there." F. SCOTT FITZGERALD, THE CRACK-UP 123 (Edmund Wilson ed., New Directions Publ'g 2009) (1945). It reflects the notion that the coordination and compromise required in teamwork may have a cooling effect on radical innovation.

125. MOWERY & ROSENBERG, *supra* note 117, at 22.

126. *Id.* at 22, 38.

127. *Id.* at 35.

After the Second World War, there was also a well-documented explosion of government R&D spending that supported the growth of university research labs. Academic research in the United States more than quadrupled between 1935 and 1960, growing from $500 million to $2.4 billion.[128] Over time, universities and corporate research labs developed complementary functions. University labs focused typically on basic research, whereas corporate labs emphasized development.[129] Research shows that corporate R&D activity has even co-located near related university research to take advantage of knowledge spillovers from universities.[130]

By the late twentieth century, as patent data and previous scholarship show, the agent driving innovation was no longer the lone inventor.[131] It became and remains the research laboratory consisting of teams of engineers and scientists working on coordinated technological projects.[132] The purpose of these research laboratories is often to engineer complex systems that draw on a variety of knowledge and multiple fields of expertise.[133] In contrast to the independent inventor, who may have relied on flashes of genius, innovation in a laboratory setting relies on coordinating diverse bodies of knowledge to solve a problem.[134] Patenting data reflects these trends, showing that patents have increasingly included multiple inventors working on technologies that cut across multiple categories.

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128. *Id.*

129. *Id.* at 31.

130. *See, e.g.*, David B. Audretsch & Maryann P. Feldman, *Knowledge Spillovers and the Geography of Innovation*, *in* 4 HANDBOOK OF REG'L. & URB. ECON. 2713, 2727 (J. Vernn Henderson & Jacques-François Thisse eds., 2004); David B. Audretsch, Erik E. Lehmann & Susanne Warning, *University Spillovers and New Firm Location*, 34 RSCH. POL'Y 1113, 1120–21 (2005); *cf.* Stefano Breschi & Francesco Lissoni, *Knowledge Spillovers and Local Innovation Systems: A Critical Survey*, 10 INDUS. & CORP. CHANGE 975, 981–82 (2001).

131. Mohammad Ahmadpoor & Benjamin F. Jones, *Decoding Team and Individual Impact in Science and Invention*, 116 PROC. NAT'L ACAD. SCI. 13885, 13885 (2019); Benjamin F. Jones, *The Rise of Research Teams: Benefits and Costs in Economics*, 35 J. ECON. PERSPS. 191, 191–97 (2021) [hereinafter Jones, *The Rise of Research Teams*]; Benjamin F. Jones, *The Burden of Knowledge and the "Death of the Renaissance Man": Is Innovation Getting Harder?*, 76 REV. ECON. STUD. 283, 309 (2009) [hereinafter Jones, *The Burden of Knowledge*].

132. *See* Jones, *The Burden of Knowledge*, *supra* note 131, at 309.

133. *See* Hyejin Youn, Deborah Strumsky, Luis M. A. Bettencourt & José Lobo, *Invention as a Combinatorial Process: Evidence from US Patents*, 12 J. ROYAL SOC'Y INTERFACE 1, 1–2 (2015).

134. Jones, *The Rise of Research Teams*, *supra* note 131, at 201; Wuchty et al., *supra* note 101, at 1036–37; Youn et al., *supra* note 133; *see also* ROBERT P. MERGES, AMERICAN PATENT LAW: A BUSINESS AND ECONOMIC HISTORY 213–14 (2023) (discussing the rise of cross-disciplinary corporate research at GE Research and its competitors).

B. Patent Data Showing Teams of Inventors Across Multiple Fields

Today, the vast majority of innovation that results in patents occurs in teams of multiple inventors.[135] Among patents granted in 2022 with at least one citation, seventy-five percent have at least two inventors and thirty-four percent have at least four inventors.[136] Moreover, more than half of those patents are classified with multiple different Cooperative Patent Classification ("CPC") codes, indicating they are relevant to different technology domains.[137] This data mirrors historical and empirical accounts of the evolution of the innovation process.[138] Both the prominence of teams and of multidisciplinary patents have increased substantially in the past half-century, even after the rise of industrial R&D.

Patent data since the nineteenth century reflects the evolution of the innovation paradigm from the lone inventor to the inventing team. In 1850, there was only one patent with two inventors among the more than nine hundred patents with one citation that year. By 1900, patenting in teams was still a rarity, with only ten percent of patents having more than one inventor and ninety-nine percent of patents having fewer than three inventors. The rapid growth of patents with multiple inventors began after 1950 and accelerated after 1970. In 1970, only approximately one in three patents had multiple inventors. By 1990, fifty-two percent of patents had multiple inventors, and by 2020 the share of patents with multiple inventors was seventy-five percent, and the average number of inventors per patent was three. Some patents listed more than thirty inventors.

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135. *See infra* Data Appendix.

136. *Id.*

137. *Id.*

138. *See generally* Ding-wei Huang, *Temporal Evolution of Multi-Author Papers in Basic Sciences from 1960 to 2010*, 105 SCIENTOMETRICS 2137, 2146 (2015); Wuchty et al., supra note 101; Youn et al., supra note 133; Ahmadpoor & Jones, supra note 131.

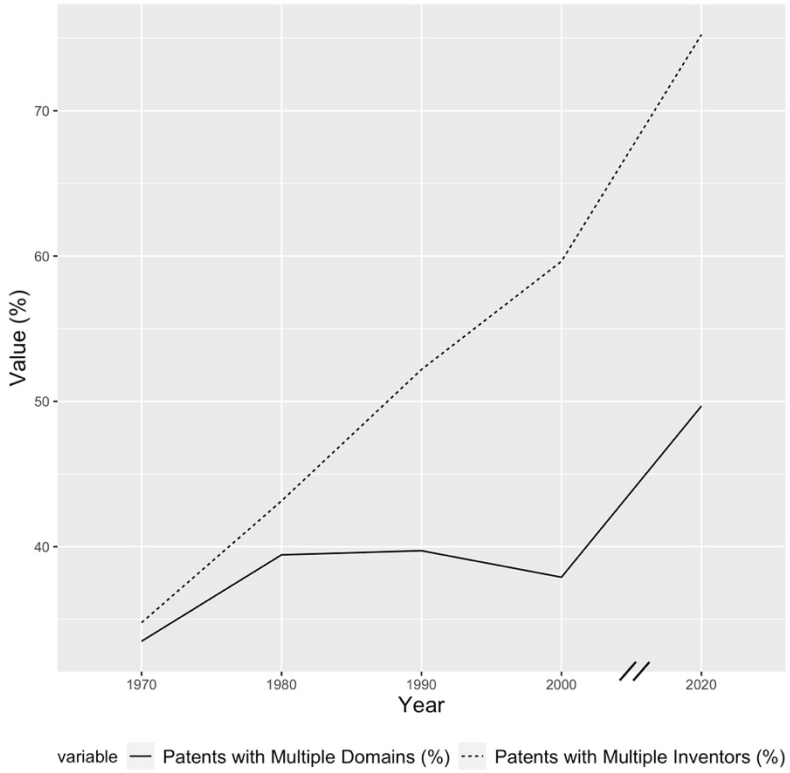

Figure 1: Patents with Multiple Inventors and Technology Domains

Patenting across technology domains has followed a similar pattern, although the growth of what we call multidisciplinary patenting started slightly later than patenting in teams. Between 1970 and 2000, the share of patents citing multiple technology domains was mostly steady. In 1970, forty percent of all patents with at least one citation included multiple three-digit CPC codes. In 2000, the share of patents including multiple three-digit CPC codes was forty-five percent. However, between 2000 and 2020, the share of patents with multiple three-digit CPC codes jumped to sixty percent.

These patterns — the growth of invention in teams and across disciplines — are consistent with economics and management research on the process of innovation. Studies show that the highest impact inventions of the twentieth century emerged from teams,

which have become more prominent in patenting and academic publishing.[139]

There are various explanations for why teams have become the more popular and higher impact source of innovation. Perhaps the most obvious is that teams can combine diverse expertise and specialization that an individual inventor might not be capable of possessing on their own.[140] This perspective is consistent with research suggesting that invention and innovation are "combinatorial processes."[141]

There also have been suggestions that teams are beneficial for the process of critical feedback and deliberation that they can facilitate. An influential study of collaboration in science suggests that multi-authored papers may be more successful at getting published and cited because the team environment provides an opportunity for "cross-checking" and "internal refereeing," which enhance the quality of the work produced.[142]

Finally, there is a structural reason driving the growth of teams and their impact. The technical challenges that academic science and industrial R&D have come to address are increasingly complex and more frequently require collaboration across disciplines.[143] This phenomenon has been coined "the burden of knowledge."[144] As technology and scientific knowledge have advanced, the level of expertise and the complexity and cost of research to make further advances has increased as well. This structural change in the nature of knowledge production helps explain the rise of teams, as well as the role of teams in producing the highest impact inventions.[145]

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139. *See* Wuchty et al., *supra* note 101, at 1036–37; Jones, *The Rise of Research Teams*, *supra* note 131, at 191–92; Ahmadpoor & Jones, *supra* note 131, at 13885; Jones, *The Burden of Knowledge*, *supra* note 131, at 285; Huang, *supra* note 138, at 2146.

140. Roger Guimerà, Brian Uzzi, Jarrett Spiro & Luís A. Nunes Amaral, *Team Assembly Mechanisms Determine Collaboration Network Structure and Team Performance*, 308 SCIENCE 697, 698–99 (2005); Tian Heong Chan, Jürgen Mihm & Manuel Sosa, *Revisiting the Role of Collaboration in Creating Breakthrough Inventions* 3 (INSEAD, Working Paper No. 2019/46/TOM, 2019), https://sites.insead.edu/facultyresearch/research/doc.cfm?did=65714 [https://perma.cc/ZEH2-QBMR].

141. Youn et al., *supra* note 133, at 2.

142. M. D. Gordon, *A Critical Reassessment of Inferred Relations Between Multiple Authorship, Scientific Collaboration, the Production of Papers and Their Acceptance for Publication*, 2 SCIENTOMETRICS 193, 198 (1980).

143. Wuchty et al., *supra* note 101, at 1037; Michaël Bikard, Fiona Murray & Joshua S. Gans, *Exploring Trade-Offs in the Organization of Scientific Work: Collaboration and Scientific Reward*, 61 MGMT. SCI. 1473, 1473 (2015).

144. *See* Jones, *The Burden of Knowledge*, *supra* note 131, at 285.

145. There are still important caveats to the dominance of teams in the scientific research and invention enterprise with some research arguing for the continued role of individuals in some invention domains, as well as the tradeoffs associated with teamwork, particularly in academic research. *See, e.g.*, Chan et al., *supra* note 140, at 1; Bikard et al., *supra* note 143, at 1476; Jones, *The Rise of Research Teams*, *supra* note 131, at 192–93; Tian Heong Chan, Jürgen Mihm & Manuel Sosa, *When Individuals Are More Innovative Than Teams*, HARV. BUS. REV. (Dec. 31, 2019), https://hbr.org/2019/12/when-individuals-are-more-innovative-than-teams [https://perma.cc/V5HK-3XNA].

The burden of knowledge argument can also help explain the growth of multidisciplinary patents. It is plausible that in an increasingly complex R&D environment, where the problems to be addressed require additional baseline knowledge, research teams are more commonly required to draw on expertise from different fields. These teams may also begin to address convergent problems at the intersection of multiple fields, which would be reflected in patents that cite multiple CPC codes.

In the modern R&D environment, the "ordinary mechanic" would be like an alien construct transported from a bygone era. Even research findings that would be obvious to a skilled laboratory team would not be obvious to the PHOSITA because scientific teams possess a wide variety of skills in multiple arts, which they aggregate through coordination.

C. The Problem of the Mismatch

There is clearly a mismatch between the construct of a PHOSITA as an individual with specific expertise and the reality of modern invention as achieved by teams with multidisciplinary expertise. The gap between doctrine and reality is a problem because (1) patent examiners and courts have relied on the PHOSITA as a realistic benchmark to assess obviousness; (2) what would be obvious to multiple people with various skills in the arts would not be obvious to a PHOSITA; and (3) using a PHOSITA to assess team inventions introduces avoidable practical challenges for courts adjudicating patent disputes.

First, the PHOSITA doctrine as it stands asks patent examiners and judges to analyze the obviousness of a patent through an increasingly unrealistic lens. Courts have frequently relied on a PHOSITA with well-defined characteristics as a benchmark for assessing the obviousness of various inventions.[146] If the proposed invention is indeed obvious, a PHOSITA should be able to devise a similar technology in the right conditions. But in cases of technologies invented by large teams with diverse expertise, imagining a comparable PHOSITA would require twists of logic, such as imagining that the PHOSITA had degrees in various fields and could synthesize their core findings. The findings in recent cases such as *ProStrakan*, which imagine the PHOSITA as a member of a team, appear to be responding to this limitation.[147] Given the variety of expertise required to produce the invention, there is no practical individual PHOSITA to serve as a benchmark for obviousness. It is precisely the increasing complexity

146. *See supra* Section II.B.

147. ProStrakan, Inc. v. Actavis Lab'ys UT, Inc., No. 16-CV-00044, 2018 WL 11363829, at *38 (E.D. Tex. Sept. 28, 2018).

of the scientific enterprise that has led to the growing share of teams producing new knowledge and inventions. Thus, it is a problem that the "burden of knowledge" for invention has grown, but the standard of the PHOSITA has not changed.

Moreover, the PHOSITA as a "member of a team" construction in recent cases is insufficient to address the problem. What may be non-obvious to an individual member of a team might be obvious to that individual if they are actively collaborating with a team possessing various expertise. Given the importance of coordination and collaboration in the process of modern innovation, considering what might be obvious to an individual discounts what individuals with complementary expertise might gain from one another without developing anything inventive. The standard of obviousness, then, should assess what a team might recognize as obvious in the course of their collaboration as opposed to what an individual member of a team might consider obvious in light of their expertise.[148]

Second, patent examiners assuming the perspective of a PHOSITA to assess the obviousness of patents with multiple co-inventors from multiple fields should be more likely to assess the patent as non-obvious than if they were assuming the perspective of a team with expertise in multiple fields similar to the inventors' fields. The gulf between the PHOSITA standard and the reality of multiple inventors could thus create a specific incentive to apply for basic patents in multidisciplinary areas where collaboration has been rare. If the standard of obviousness is the PHOSITA, then the goal of the inventor would be to convene a team that could produce inventions non-obvious to the PHOSITA, even if they would not represent a scientific or technological advancement for those multiple fields. The practical effect could lead to over-patenting in areas of complex technologies such as biotechnology and artificial intelligence, concentrating monopoly power among actors with the resources to assemble large teams with diverse skills. The gap between reality and the current standard risks rewarding convening diverse teams rather than true inventive activity that pushes forward the scientific frontier.

Third, the PHOSITA standard introduces practical challenges that an alternative doctrine could avoid. A single patent examiner is asked to assume the perspective of the PHOSITA but could not practically assess the obviousness of a patent from the perspective of a PHOSITA

148. Empirical studies of team-based patenting provide supporting evidence. A 2018 study of "team-specific capital" examined changes to a team's productivity when one member dies prematurely. The study found that the team's long-term inventiveness and career earnings decrease after the premature deaths of one of its members. This research indicates that the benefits of teamwork accumulate with the experience of a team and are not carried with one individual. Xavier Jaravel, Neviana Petkova & Alex Bell, *Team-Specific Capital and Innovation*, 108 AM. ECON. REV. 1034, 1035–36 (2018).

with multiple areas of expertise in sixty percent of the patents they examine (the share of patents with multiple three-digit CPC codes in 2020).[149] Similarly, judges relying on expert witness testimony could not practically rely on an individual expert to assess the obviousness of an invention generated by a broad multidisciplinary team. The problem of relying on individual witnesses to represent the PHOSITA manifested in *Daiichi*, where the case hinged on the sophistication of the PHOSITA.[150] A new standard focused on teams as the unit of analysis for inventions would allow patent examiners and judges to rely on teams of individuals with relevant areas of expertise to assess the obviousness of an invention.

Fundamentally, the law should be built on constructs that aim to reflect reality. Legal constructs that fail to evolve and bear some meaningful relation to the real world are both practically and theoretically problematic. Consider, for example, the "reasonable person" in tort law. Tort law's "ghost" is not, of course, an individual person in the strict sense of that word: other natural and legal persons, including corporate entities, can bear liability as tortfeasors. The standard has evolved over time to accommodate new forms of risk-bearing activity in the real world.[151] The central emphasis of tort law is on the concept of reasonability, and the reasonable person construct serves to bring that concept to fruition. Without such a realistic construct, the standard of reasonability would be barely operable in today's complex, multi-agent world. Similarly, a patent law built on an outmoded conception of the agent of innovation cannot serve as a useful and theoretically consistent model for the concept of inventiveness, the idea at the center of patentability determinations. Like tort law's reasonable person, patent law's PHOSITA must also evolve.

IV. THOSITA: AN ALTERNATIVE LEGAL CONSTRUCT

The standard PHOSITA construct of inventor as individual is a poor reflection of real innovation and a problematic doctrinal anchor. The alternative, as we argue in this Part, is to embrace reality and adopt a more accurate standard accommodating the group-based element of innovation. The team having ordinary skills in the arts (or

149. *See infra* Data Appendix.

150. Daiichi Sankyo Co. v. Apotex, Inc., 501 F.3d 1254, 1256 (Fed. Cir. 2007) (quoting Env't Designs, Ltd. v. Union Oil Co., 713 F.2d 693, 696 (Fed. Cir. 1983)).

151. For discussions on the evolution of the reasonable person standard, see generally Michael J. De Vinne, *The Reasonable Person as a Living Fossil*, 37 LITIGATION 15 (2010) (discussing the historical evolution of the standard from a person with some basic awareness of utility to an actively calculating cost-benefit analyst); Mayo Moran, *The Reasonable Person: A Conceptual Biography in Comparative Perspective*, 14 LEWIS & CLARK L. REV. 1233, 1275–83 (2010) (describing the expansion of the reasonable person standard beyond tort law into other fields of both private and public law).

"THOSITA"), we suggest, is a more effective construct for the majority of patentable inventions. The THOSITA could be introduced into the patent system through multiple mechanisms, including immediate judicial adoption, legislative reform, and institutional changes at the USPTO. By adopting this alternative benchmark, the law would not only better reflect the way innovation actually takes place, but it would also shift the patent system toward more desirable outcomes.

A. Team Having Ordinary Skills in the Arts

Our proposed THOSITA standard establishes the unit of analysis in patent law as (1) a team of individuals, (2) of a size consistent with teams inventing similar technologies, and (3) representing ordinary skills commonly found in the invention of related technologies. The process of identifying a THOSITA for a given invention would be empirical, leading patent examiners and judges to determine the most common team for this type of invention based on the patent data available. The empirical process would follow three steps.

First, consider the typical number of inventors for an invention of this type. Based on the technology category for the invention, an examiner or judge could consult aggregate patent data to determine how many people would constitute the typical team.[152] For example, the patent in question in *Daiichi*, "Topical preparation for treating otopathy,"[153] is classified in technology category A61, which covers instruments for surgery and diagnosis.[154] The median number of inventors for technologies of that type is three.[155] The THOSITA in this case would have three people.[156]

Second, what technical skills are most commonly represented in those teams? Patent data can indicate disciplines or areas of expertise most commonly represented in a particular technology area. For example, some technology areas might be dominated by one discipline, whereas others will commonly bring together two or three. The THOSITA should reflect the median skills represented in patents of similar technologies. A patent examiner or judge might assess similar

152. *See infra* Data Appendix.

153. Daiichi Pharm. Co. v. Apotex Inc., 441 F. Supp. 2d 672, 675 (D.N.J. 2006).

154. *CPC Section A*, U.S. PAT. & TRADEMARK OFF., https://www.uspto.gov/web/patents/classification/cpc/html/cpc-A.html [https://perma.cc/E7EQ-5VDV].

155. *See infra* Data Appendix.

156. In some cases, primary CPC code might not be the most appropriate category on which to base the team size. Another approach to assessment would be the patents cited in the patent application, or patents in all the CPC codes that were cited in the patent application. In either of these cases, the primary standard is clear: the size of the team should be based empirically on an assessment of the typical or median team for technologies of that type.

technologies based on other patents of the same primary CPC code or patents that the applicant has cited.

Although the skills and disciplines are more challenging to read directly from available patent data, scholars and examiners can use samples of inventors to understand which disciplines are most commonly represented in different technology categories, as well as which technology categories are most likely to fit together.

In the *Daiichi* example, patents for surgical and diagnostic instruments are also likely to have another CPC code. In 2020, sixty percent of inventions with a CPC Code A61 also had at least one other associated three-digit CPC code.[157] The most common of these is C07, or organic chemistry, which was associated with sixteen percent of all patents in the A61 category.[158] The relationship between these two fields suggests that in addition to medical expertise, the THOSITA may also require expertise in chemistry.[159]

Third, given their skills and access to relevant prior art, what would the THOSITA consider obvious? Similar to the analysis of obviousness from the perspective of the PHOSITA, a THOSITA analysis might require consultation with relevant experts or background literature representing the perspectives of team members. Perhaps most significantly, a THOSITA analysis might require multiple examiners or expert witnesses to consult with one another to replicate the process of discussion and deliberation that a THOSITA might follow to determine whether a technology is obvious. We discuss these possibilities further in the following Section.

As presented, the THOSITA standard raises two important questions about how it departs from existing patent doctrine. First, why is the appropriate unit of analysis the "team itself" and not an "individual member of a team" or an individual with "access to experts" as judges have alternatively discussed? Our core argument is that the THOSITA, as defined, is the closest approximation of the invention process as it typically happens in a given technology area.[160] The process is usually one of individuals with different skills and professional background engaging in a process of discussion, deliberation, and knowledge creation to produce a new technology. In discussing and deliberating — but not producing new knowledge — the team can likely identify some technologies and ideas as obvious that an indi-

157. *See infra* Data Appendix.

158. *See infra* Data Appendix.

159. When it is unclear whether the typical team might represent an additional discipline — chemistry, for example — the THOSITA should be constructed to include the skills associated with the additional discipline(s). We propose erring on the side of multidisciplinarity both because (1) it is unlikely to change the outcome substantially, and (2) it raises the bar of obviousness such that patents would not be granted that would be obvious had one more person been added to the THOSITA.

160. *See, e.g.*, Jones, *The Burden of Knowledge*, *supra* note 131, at 283–84.

vidual member of the team — or an individual with access to experts — would not consider obvious.

One might argue that the PHOSITA standard is still relevant despite the prevalence of team-based inventions since judges can merely consider a PHOSITA as a member of an inventing team, or an individual with access to expertise as if they were on a multidisciplinary team. However, the assumptions required to accept either of these individual standards are unrealistic. For an "individual member of a team" to be the appropriate standard, each individual member of a patenting team would need to recognize as obvious every technology that the team together would recognize as obvious. In teams with varying skills and disciplinary backgrounds, this assumption is unrealistic since the purpose of convening such teams is to combine expertise and skills to produce knowledge that no member could produce on their own. An individual member of the team's knowledge would be a subset of the knowledge that is assembled by a team after discussion and deliberation.

Judges have also considered an individual with "access to experts."[161] For this formulation to be the appropriate standard, an individual should be able to determine the obviousness of a patent as long as they can confer with individuals of other expertise. Although this might seem similar to the benefits of having a "team itself," it is suboptimal. For example, if the focus is on the individual accessing experts, the individual would still need to know what questions to ask the experts and how to utilize their expertise. The limitations of the individual's expertise would still render some technologies non-obvious to the individual that would be obvious to the THOSITA.

The second question raised by the THOSITA standard is whether the THOSITA should reflect the team applying for the patent or the typical or median team applying for patents of similar technologies. Historically, judges have drawn on elements of each. Some analyses have constructed a PHOSITA with education and skill typical of an inventor in the technology area in question, as in the case of *Daiichi* at the district court level.[162] Others have relied on the characteristics of the inventor (or inventors) in terms of education and expertise to determine the characteristics of the PHOSITA, as in *Daiichi* at the Federal Circuit.[163]

The THOSITA standard we propose asks judges and patent examiners to construct the THOSITA based on the median inventors for a technology area rather than the specific inventors in a patent application. Deriving the characteristics of a PHOSITA or THOSITA from a specific inventor is a problem when the inventor may have an atypical

161. *See supra* Section II.C.2.
162. *See* Daiichi Pharm. Co. v. Apotex, Inc., 380 F. Supp. 2d 478, 485 (D.N.J. 2005).
163. *See* Daiichi Sankyo Co. v. Apotex, Inc., 501 F.3d 1254, 1257 (Fed. Cir. 2007).

background for inventing in a particular technology area. For example, if a chemist and a physicist invent in a technology area typically dominated by materials scientists, the standard of obviousness should be determined by what is obvious to the median team of materials scientists. Similarly, if an individual inventor applies for a patent in a technology area where the typical inventors are teams, the individual should still be held to the same standard of the median inventor. Individual applicants should not be held to a lower standard of non-obviousness than teams aiming to patent a similar technology.

The THOSITA construct may benefit from a checklist of factors for judges and examiners to consider in determining the skills of the THOSITA, as well as the range of arts in which they possess those skills. The list developed in *Environmental Designs* can serve as a basis for the list of factors for determining the THOSITA.[164] The key difference in our list is that the factors would be used to determine the skill level for each member of the THOSITA, including, for example: (1) the median level of education in the member's profession, (2) the median level of experience in their profession, and (3) their median familiarity with related disciplines, such as those of the other members of the THOSITA. The third factor is critical because it can help determine how much new knowledge team members can be expected to gain from one another.

The THOSITA would also require a generalizable concept or image similar to Judge Rich's famous image of the individual inventor at his lab bench with prior art on the wall. For the THOSITA, the image would be a team of individuals around a conference room table, each with their laptops connected to the Internet, able to access prior art from their respective fields and translate it — as well as their respective skills would allow — to the rest of the group. These individuals would be in conversation, bouncing ideas off one another in an iterative process of deliberation. With this image in mind, the examiner or judge can ask whether this team would have found the invention in question obvious.

B. Implementing the Standard

The THOSITA construct could be imported into the patent system in several ways. First, judges and examiners may already be free to use the THOSITA as an alternative to the traditional construct under the Patent Act as it is currently worded. Though § 103 and § 112(a) appear to limit the benchmark to a "person,"[165] an exercise in statuto-

164. Env't Designs, Ltd. v. Union Oil Co., 713 F.2d 693, 696 (Fed. Cir. 1983) (citing Orthopedic Equip. Co. v. All Orthopedic Appliances, Inc., 707 F.2d 1376, 1381–82 (Fed. Cir. 1983)).

165. 35 U.S.C. §§ 103, 112(a).

ry interpretation might open the term up beyond a narrow reading. For example, § 103 and § 112(a)'s "person" might be read as the standard agent of innovation rather than an actual individual person.[166] While this agent might have been an individual person in the past — for example, when the Patent Act was first enacted in 1952 — the agent has clearly evolved since, as we describe above. Though this is outside the scope of this Article, one might seek to better understand the intent of Giles Rich, Pasquale Federico, and the drafters of the Patent Act when choosing the language of these sections.[167] Barring this type of evidence, a living document approach to interpreting the Patent Act might therefore ask who the standard agent of innovation is today and would want to use a team-based construct to better reflect the new reality.

As we detailed in Section II.C, courts are already using a team-based standard for "person," though they have not treated the distinction as important.[168] Clearly, then, many courts already see the language in § 103 and § 112(a) as manipulable enough to accommodate a more expansive conception of "person." For those courts that have endorsed a PHOSITA as a "member of a team" or as an individual with "access to an expert," the move to a full embrace of the THOSITA alternative is, we think, a minor conceptual shift.[169] Courts that have already conceptualized the PHOSITA as a "team" or "person or team" appear to be already there — they just have not taken the difference seriously.[170] In any event, the emerging caselaw should bolster a more liberal reading of "person" moving forward.

If courts are wedded to a narrower reading, then legislative reform might be in order. Adding in "or team" to both § 103 and § 112(a) would probably be most effective, since this would give examiners and judges the option of using a PHOSITA or THOSITA standard depending on the number of inventors listed or on the prevalence of collaboration in the relevant field of invention. Alternatively, the USPTO might issue new guidance to examiners without any legis-

166. Indeed, other federal statutes, including many of those that predate the 1952 Patent Act, explicitly note that "person" could include entities beyond an individual. *See, e.g.*, Sherman Antitrust Act of 1890, 15 U.S.C. § 7 ("The word 'person,' or 'persons,' wherever used in sections 1 to 7 of this title shall be deemed to include corporations and associations existing under or authorized by the laws of either the United States, the laws of any of the Territories, the laws of any State, or the laws of any foreign country."); *see also* 18 U.S.C. § 2510(6) ("'[P]erson' means any employee, or agent of the United States or any State or political subdivision thereof, and any individual, partnership, association, joint stock company, trust, or corporation.").

167. Rich and Federico clearly intended, in part, to replicate language that had already emerged in the caselaw stretching back to *Earle v. Sawyer*. *See supra* Section II.A.

168. *See supra* Section II.C.

169. *See supra* Section II.C.1–2.

170. *See supra* Section II.C.3.

lative changes permitting them to follow the lead of the minority of cases that have begun to implement a team-based standard.

Though choosing between multiple constructs depending on the invention might seem to complicate things for examiners and judges, the THOSITA standard would also bring more clarity and predictability to this area of the patent law. Courts would no longer need to perform the mental gymnastics of reducing an actual team of inventors to an individual with skills representative of the entire team — they would instead envision the THOSITA as likely quite close to the actual team of inventors before them. Litigants would also have less to quibble about on this issue since it should be more straightforward to deduce from the real-world circumstances what the appropriate THOSITA should look like.

One component of implementation that might prove difficult is the evidentiary source used to arrive at the appropriate THOSITA for a given invention. The dominant practice for the PHOSITA standard is to hear expert testimony. Invariably, an expert witness in a given case is an individual person with expertise in the same field as the invention or with skills and training similar to the inventor. Translating this practice for the THOSITA alternative, we suggest that the new expert witness should perhaps be a group of individuals — a team of witnesses — mirroring the team that created the invention. Another possibility would be to hear testimony from an individual with expertise not in the technical field of the invention but rather in the collaborative aspects of innovation. This might be a group psychologist or even a social scientist. Such a person might provide insight on how a group of individuals with a given set of skills would amount to more than the sum of their parts in the process of generating ideas together.

Finally, there are potential institutional changes at the USPTO that could be explored. One possibility is when an examiner determines that a THOSITA standard is appropriate for an application, the examiner could then share the application with other examiners, either with the same field of focus or with different fields matching the team that actually produced the invention. This team of examiners could then work together to determine questions of obviousness, enablement, and utility. By better mirroring the team applying for a patent or the typical team found in the relevant field, the examiner team might be able to make more accurate assessments of patentability. There may be other positive collaborative features of the examination process that might emerge from this institutional change. For example, it is also possible that team-based examination — much like team-based innovation — can speed up the deliberative process and overall timeline of patent applications.

C. A THOSITA-Based Patent System

What effects might the embrace of a THOSITA alternative have on the patent law and the innovation system more broadly? First, the standard for patentability would likely be heightened relative to what it is now. Generally speaking, a patent law built on the THOSITA as its central legal construct would result in more inventions being found obvious under § 103. This is because, as we discussed above, what may not be obvious to an individual inventor may be obvious to a team — the result of the elevated capacities that emerge from group-based synthesis and collaboration. The level of skill embodied in an ordinary team is higher, broader in scope, and more readily mobilized toward innovation than the skill of an ordinary individual working in the same field.[171]

One way in which the § 103 hurdle would be raised is through the expansion of the scope of analogous art brought into the obviousness determination. Under the current approach, the analogous art taken into account in § 103 determinations is the collective set of prior art references that a PHOSITA would reasonably be expected to be aware of and to have consulted in the course of the inventive process. This approach recognizes that a PHOSITA cannot know every prior art reference in every field, only the fields within reasonable proximity to the PHOSITA's own field. Courts have operationalized this principle doctrinally by limiting the relevant analogous art to prior art that is either (1) within the same field of endeavor as the invention; or (2) from a different field of endeavor, but reasonably pertinent to the same problem as that addressed by the invention.[172]

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171. We note, however, that the implementation of the THOSITA construct might have the reverse effect on the enablement standard than on the obviousness standard — that is, the alternative construct might actually lower the standard for enablement. The reason why is intuitive: since a THOSITA would be a faster learner and a more efficient experimenter than a PHOSITA, a THOSITA would require less disclosure in a patent to make or use the invention. Additionally, the use of the THOSITA alternative might also raise the assumed baseline knowledge in the relevant field of analysis, which would require less to be disclosed in order to satisfy the enablement standard. *See* Timothy R. Holbrook, *Patent Disclosures and Time*, 69 VAND. L. REV. 1459, 1468 (2016) ("Because enablement is based not only on the prior art disclosure but also on the knowledge of the PHOSITA, the teaching of a prior art reference is an ever-moving target, as the PHOSITA's knowledge grows over time."). The Supreme Court's recent decision in *Amgen Inc. v. Sanofi*, 598 U.S. 594 (2023), however, indicates that enablement jurisprudence is likely headed in a more demanding direction. *See id.* at 610; *see also* Dennis Crouch, *Enabled to Claim the Unknown? Federal Circuit Applies* Amgen v. Sanofi *to Invalidate Broad Antibody Claims*, PATENTLY-O (Sept. 20, 2023), https://patentlyo.com/patent/2023/09/enabled-invalidate-antibody.html [https://perma.cc/4FG6-Z6PC].

172. This formulation was originally developed in *In re* Wood, 599 F.2d 1032, 1036 (C.C.P.A. 1979), and has since been recited by many cases dealing with the appropriate scope of analogous art. *See, e.g.*, *In re* Bigio, 381 F.3d 1320, 1325 (Fed. Cir. 2004); *In re* Clay, 966 F.2d 656, 658–59 (Fed. Cir. 1992).

For either part of this test, the use of a THOSITA standard would seem to expand the analogous art. First, for multidisciplinary teams, the "field of endeavor" might be conceptualized more broadly and thereby include more prior art. And second, a team of people working together would reasonably be expected to be aware of more prior art from different fields — again, particularly for multidisciplinary teams. A multidisciplinary team representing a diverse set of fields would be aware of prior art far beyond the scope of an individual's view, even if that individual is imagined to have training in several fields. If more analogous art is allowed to enter into the obviousness determination, it is more likely that an examiner or judge would find the invention in question obvious.

Beyond the expanded awareness of more pieces of prior art in more fields, a THOSITA might also be expected to draw from prior art that a PHOSITA might be aware of as part of the "common knowledge" but would not think to consider in solving a given problem. Consider, for example, *Circuit Check Inc. v. QXQ Inc*,[173] a Federal Circuit decision from 2015. In that case, the patents at issue disclosed a device for testing circuit boards in electronic devices.[174] Accused infringer QXQ put forward three prior art references that should have been factored into the non-obviousness analysis.[175] These three references were seemingly far afield from electronic devices: They included a method of rock carving, a technique used to engrave signage, and a common machining technique.[176] Collectively, however, these techniques were relatively well-known to or easily accessed by anyone working in the field.[177] The district court had sided with QXQ, but the Federal Circuit reversed, asserting that the "question is not whether simple concepts such as rock carvings, engraved signage, or [machining] are within the knowledge of lay people or even within the knowledge of a [PHOSITA]."[178] Instead, the question was "whether an inventor would look to this particular art to solve the particular problem at hand."[179] This is essentially a question of creativity rather than knowledge: The court held that a PHOSITA would not have thought to look to those references, even if that PHOSITA would have been generally aware of them in the process of developing Circuit Check's invention.[180]

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173. 795 F.3d 1331 (Fed. Cir. 2015).
174. *Id.* at 1333.
175. *Id.*
176. *Id.* at 1333–34.
177. *Id.* at 1335 (describing these techniques as falling within the "common knowledge" of the field).
178. *Id.* at 1333.
179. *Id.* at 1335.
180. *Id.* at 1336.

Would a THOSITA behave differently? Perhaps. If Circuit Check's invention had been developed by a team rather than an individual, and if that team had as one of its members a machinist or engraver, then QXQ's argument would certainly appear more convincing. But even if the team were made up solely of electronics specialists, those people working together to solve a common problem might have suggested consulting one of the three references asserted by QXQ. In the course of team-based deliberation, it seems more likely that members would bounce ideas off of one another to the extent that at some point, one or more members of the team would consider drawing from the lay knowledge embodied in QXQ's three references. It might be reasonable, therefore, to expect a team to hit upon a method of rock carving when developing ideas for testing circuit boards.

This example serves to illustrate a broader principle at work: a THOSITA in any field would generally be expected to better synthesize information, envision a broader range of potential solutions, and combine preexisting ideas into new ones than a PHOSITA in the same field. Simply put, a THOSITA would be more innovative than its PHOSITA counterpart. This underlying characteristic would operate independently of the issue of analogous art scope. Regardless of the prior art that a THOSITA would be expected to have at its disposal, the THOSITA would be better at using that prior art to come up with a new idea. The adoption of this standard would therefore likely raise the standard of patentability — again, primarily through the § 103 hurdle — due to this additional characteristic. Just as the *KSR* court sought to elevate the creative and synthetic capacity of the PHOSITA — from an "automaton" to a more active problem-solver[181] — the use of the THOSITA would represent a further shift toward an even more innovative standard.

Who, then, would be able to secure a patent in a THOSITA-based patent system? While the bar for patentability would be raised, patents would still be attainable for teams that come up with inventions not obvious to the THOSITA in their field. The successful applicant would therefore become the team of extraordinary skill. Such a team would be able to innovate beyond the range of both the THOSITA and PHOSITA, a result of the team's effectiveness in collaboration or unique blend of backgrounds and perspectives. The ideas that these extraordinary teams come up with might therefore be more likely to be radical or "blue-skies" than the more incremental innovations that the person of extraordinary skill could develop.[182] The ongoing de-

181. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

182. The term "blue-skies" research refers to research that is typically less constrained by short-term goals and is more "curiosity-driven," and therefore more likely to result in more

cline of "disruptive innovation" has been well documented and is looked at as one of the causes of slower economic growth and productivity rates in recent years.[183] One major benefit of the THOSITA standard, then, might be a move away from patent quantity, since it would be more difficult to secure a patent, and toward patent quality, where the kinds of ideas being patented are more likely to have a greater impact on the economy and society.

While a THOSITA-based patent system might help generate higher impact ideas, it would also implicitly reward a different form of innovative work than that which the current construct emphasizes. Under the PHOSITA-based framework, an inventor — or, more likely, inventors — obtains a patent for some innovative breakthrough they achieve by applying their ingenuity to the prior art. There is something personal about the reward of a patent; it recognizes the inventors' responsibility for their creation and the disclosure of that creation to the world. In a THOSITA-based patent system, extraordinary teams and their members would still be recognized as named inventors, but the true source of the innovation would be more elusive. Ideas from group-based work, as we have discussed above, often emerge out of team collaboration in a way that cannot be reduced to individual contributions: The "extraordinary team" is one that becomes more than the sum of its parts.

Perhaps the most important innovative work in a THOSITA-based system, then, would be the role of the convener of the extraordinary team. Those responsible for identifying, organizing, and managing teams that can outperform THOSITAs are, in some basic sense, responsible for the ideas that result from these collaborations. Putting the right team together might be the nearest equivalent of the "aha moment" that we currently claim to value most in the PHOSITA-based framework. We can therefore think of the shift to a THOSITA standard as also implying a fundamental shift in what kinds of innovative activity the patent system most seeks to encourage. The essential activity that drives innovation would be found upstream of the innovation itself. Perhaps under this alternative framework the convener would replace the genius as the innovation system's most important player.

Finally, we suggest that the THOSITA standard may bear relevance to an emerging controversy in patent law: inventions augmented by artificial intelligence ("AI"). Recent scholarship and policy debates have entertained the possibility of recognizing AI programs as

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radical discovery. *See* Belinda Linden, *Basic Blue Skies Research in the UK: Are We Losing Out?*, J. BIOMEDICAL DISCOVERY & COLLABORATION, Feb. 28, 2008, at 1, 2.

183. *See, e.g.*, Michael Park, Erin Leahey & Russell J. Funk, *Papers and Patents Are Becoming Less Disruptive Over Time*, 613 NATURE 138, 142 (2023).

inventors able to secure patents.[184] Under the current law of inventorship, only individual human inventors qualify for patent protection.[185] But what about a human being — or team of human beings — working with AI in the inventive process? How might this change standards like non-obviousness through the PHOSITA construct?[186] The addition of an innovation-oriented AI helper to a team might be equivalent to just adding another team member, which could be dealt with using the THOSITA as we have described it. In individual-dominated fields, however, perhaps the use of AI by a lone inventor might also be equivalent to a team, which would mean the THOSITA standard would be more appropriate than the traditional construct. If AI inventors become capable enough, perhaps a "THOSITA-plus" standard might be necessary, raising the bar even further to reflect these heightened capabilities.

V. CONCLUSION

Patent law's central doctrinal construct, the PHOSITA, is rooted in an outmoded conception of how invention is achieved. As our review of the history of innovation and our empirical findings suggest, most contemporary inventions result from the collaborative effort of groups, a trend that has intensified over time. Further, these groups are now often multidisciplinary, with team members contributing skills from diverse technological fields. The actual agent of innovation is now a team, and often one that is able to draw upon expertise from across disciplines. Patent law remains largely stuck in the past, however, with examiners and judges still taking the "person" in the PHOSITA construct to mean an individual inventor. Since teams are much more capable innovators than individuals, this disconnect carries troublesome implications for applications of PHOSITA, with the obviousness standard being the most critical.

We therefore make the case for an alternative construct, the THOSITA. This alternative approach could effectively address the theoretical and practical shortcomings of the PHOSITA model. Per-

184. *See, e.g.*, Steve Lohr, *Can A.I. Invent?*, N.Y. TIMES (July 15, 2023), https://www.nytimes.com/2023/07/15/technology/ai-inventor-patents.html [https://perma.cc/U947-QDN3].

185. *See, e.g.*, John Villasenor, *Reconceptualizing Conception: Making Room for Artificial Intelligence Inventions*, 39 SANTA CLARA HIGH TECH. L.J. 197, 208 (2023); *see also* Inventorship Guidance for AI-Assisted Inventions, 89 Fed. Reg. 10,043 (Feb. 13, 2024).

186. *See, e.g.*, Ryan Abbott, *Everything Is Obvious*, 66 UCLA L. REV. 2, 5–6 (2019) (suggesting that the rise of machine-augmented innovation should gradually raise the obviousness standard to the point where it would no longer be possible to patent any idea); Shuang Liu, *A Helper for Patenting the "Unpredictable": Artificial Intelligence*, 23 MINN. J.L. SCI. & TECH. 671, 721–23 (2022); Connor Romm, *Putting the Person in PHOSITA: The Human's Obvious Role in the Artificial Intelligence Era*, 62 B.C. L. REV. 1413, 1442 (2021).

haps more importantly, it would better mirror the real-world innovation process. The use of the THOSITA standard could even motivate new kinds of innovative activity and better support the kind of disruptive, high-impact inventions that have been in decline for some time. It is time for patent law to relinquish the now-mythical concept of the solitary inventor and adopt a standard that recognizes the true agent of modern technological advancement — the collaborative team.

DATA APPENDIX

The authors analyzed patent data from The Lens (Lens.org), which maintains a publicly accessible database of patents with downloadable metadata, such as the patent date, inventor, and short description.[187] They downloaded patent data from The Lens because (1) it is public, making analysis easy to replicate, and (2) it includes with its data variables that allow users to measure the number of inventors and the fields of their inventions over time using CPC codes. The Lens patent data has been previously cited in peer-reviewed publications in leading journals.[188]

The authors chose a subset of the universe of patent data to sample: patents with at least one citation during decennial years, including 1850, 1900, 1950, 1960, 1970, 1980, 1990, 2000, 2010, and 2020. They sampled only patents with at least one citation during these periods. The analysis considers a citation as a proxy for a patent's minimal level of impact (although the authors maintain that patents without citations can have impact on a field of technology as well).

Metadata for each patent includes a unique Lens ID, names of inventors, effective date, CPC codes of the patent, title, abstract, number of patents cited, and number of patents citing. The data includes 542,311 rows, each representing a patent, and 33 columns, each capturing a feature of the patent. The raw data is accessible online: https://drive.google.com/drive/u/2/folders/1q1USJ0_yS0rYY3KcgFuV-j0sNzboT6p2.

Year	Inventors	Cited.by.Patent.Count	CPCs
2000	HORSTMANN CAY S	249	2
2000	WEIANT JR MONROE A;;RYAN JR FREDERICK W	77	10
2000	HUFF CHARLES A	66	6
2000	LO CHI-FUNG;;DRAPER DARRYL;;HOO HUNG-LEE;;GILMAN PAUL S	43	7
2000	PENG YUAN-CHING;;CHEN LIH-JUANN;;YANG YU-RU;;HSIEH WIN-YI;;HSIEH YONG-FEN	21	4
2000	SAXON ANDREW;;ZHANG KE;;MAX EDWARD E;;LYCZAK JEFFREY B;;MORRISON SHERIE L	13	6
2000	DOWNEY WALTER J	64	6
2000	GRONEMEYER STEVEN A	57	6
2000	SCHWEITZER JR EDMUND O	44	6
2000	YOSHINARI JIRO;;KOSUDA MASANORI;;SHINGAI HIROSHI;;MIYAZAKI SHINJI	18	8
2000	IDO YASUO	4	1

Figure 1: An Expert of the Relevant Data

187. Osmat Azzam Jefferson, Deniz Koellhofer, Ben Warren & Richard Jefferson, *The Lens MetaRecord and LensID: An Open Identifier System for Aggregated Metadata and Versioning of Knowledge Artefacts*, LIS SCHOLARSHIP ARCHIVE (Nov. 24, 2019), https://osf.io/t56yh [https://perma.cc/4YGL-E6PL].

188. Osmat A. Jefferson, Adam Jaffe, Doug Ashton, Ben Warren, Deniz Koellhofer, Uwe Dulleck et al., *Mapping the Global Influence of Published Research on Industry and Innovation*, 36 NATURE BIOTECHNOLOGY 31 (2018).

The authors used patent data in this Article to demonstrate the evolution of single inventor patents and single discipline patents over time. The goal was to measure the number of inventors and the number of disciplines in individual patents over time. Measuring the number of inventors was straightforward. Using the "inventors" column in the data, we were able to identify the number of inventors by counting the frequency of semicolons (";") because these separated inventors in the data. If there is at least one semicolon, there are multiple inventors.

Determining multidisciplinarity was more complicated since there are different levels of specificity. To determine multidisciplinarity, the authors focused on CPC codes, which represent the technology area of the patent. Each patent has a series of 10-digit CPC codes. The analysis approaches CPC codes in two ways: First, the authors generated a list of three-character CPC codes for each patent (e.g., C01), deleted repeat codes, and counted unique instances of CPC codes. The number of three-digit codes signifies some multidisciplinarity within a larger field. For example, a patent with C01 and C04 codes would signify relevance to inorganic chemistry as well as relevance to cements, concretes, and ceramics.

A second, more stringent test for multidisciplinarity examines whether patents are classified in at least two different CPC letter families, such as C ("Chemistry; Metallurgy") and G ("Physics"). Figure 1, which refers to patents in multiple technology domains, includes patents with multiple unique CPC letter families, the stricter test of multidisciplinarity. The solid line signifies the share of patents that include CPC codes in two or more technology families.