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Lean Startup as an Entrepreneurial Strategy: Limitations, Outcomes and Learnings for Practitioners

John M. York[1,2]*, Jonathan L. York[3] and Philip Powell[4]

[1]Institute for the Global Entrepreneur at the Jacobs School of Engineering and the Rady School of Management, University of California, San Diego
[2]Cranfield School of Management, Cranfield University
[3]Orfalea College of Business at the California Polytechnic State University, San Luis Obispo
[4]Kelley School of Business at Indiana University, Indianapolis, IN

Abstract

Purpose: This paper aims to address threecore questions around (1) what limitations exit with the methodology and/or its use; (2) what is the methodology's impact on performance outcomes; and (3) what learnings can practitioners and educators employ as part of the startup efforts.

Methodology: A review of available peer and non-peer review literature relevant to the lean startup methodology, its limitations (pitfalls, fallacies, problems), and outcomes to address the core questions.

Findings: This review identifies limitations with the methodology in several areas: business sector fit; issues associated with customer discovery; experimentation; iterating/pivoting; and the minimum viable product. Limitations may be related to the methodology, the incomplete understanding of its fundamental components, inconsistent (and non-rigorous) use of the methodology, and the inability to address risks (e.g., technological) beyond resolving market uncertainty. Also, experience related to outcomes with the lean startup reveals mixed findings due to the diverse methods, populations, and endpoints used. Such facets underly the mix of experiences seen in both the peer and non-peer review literature. This review identifies that rigorous implementation leads to statistically significant ($P<0.05$) outcome differences (e.g., discarding poor ideas, number of pivots, and revenue realization).

Practical Implications: Practitioners and educators should consider educational, implementation, business sector, outside influences, outcomes, and investor preferences to use the methodology.

Originality: This paper provides one of the first extensive literature reviews to examine what limits exist, where, and whether these are associated with the methodology or due to user, cultural, or business sector considerations. It also provides several relevant learnings for practitioners and educators to consider when using the methodology.

Conclusions: Current evidence indicates that multiple issues do exist. Such limits are related to the methodology's inherent structure and user, sector, and external influence considerations. Further, outcomes vary based on study methods, variables, populations, business verticals, and implementation. Practitioners should consider some of the recommendations offered when utilizing this methodology to optimize their experience and outcomes.

Keywords: Entrepreneurship strategy • Entrepreneurial outcomes • Hypothesis-driven entrepreneurship • Lean startup (startup) • Lean startup (start-up) limits (limitations) (pitfalls) (boundaries) • Minimum viable product • Practical entrepreneurial learnings • Startup practices

Introduction

It is a minority of cases in which entrepreneurs succeed because they can adequately define the conceptat the beginning of their startup journey. Further, it is a rare circumstance in which these individuals achieve an acceptable product/market fit (P/MF) between the opportunity and their value proposition [1].

Such outcomes are due to (1) the lack of customer input on research and development, and (2) the limited market research performed before developing the product or service [1]. This reality is because many entrepreneurs advance their business ideas forward without a clear understanding of their industries, competition, and customers. Consequently, they misread their markets, which leads to the introduction of products that are either not needed or not simple enough for application [1]. Furthermore, many startups lack a structured process to discover and understand markets, identify customers, and validate hypotheses during the firm's gestational stage [2]. As a result, customers do not engage with or purchase these products. Hence, these startups fail to identify and address critical customer challenges that lead to P/MF; this failure preempts firms from investment and scaling effectively [3].

The lean startup embodies a popular approach to help entrepreneurs address market uncertainty and improve their success odds. Eric Ries enjoys book sales of over one million copies [4]. The tech startup community in Silicon Valley, the National Science Foundation (NSF) Innovation Corps™ (I-Corps™) program, and numerous universities use the methodology [5-7]. Corporations (e.g., Dropbox, General Electric, Intuit, and Proctor and Gamble) employ this approach to identifying innovative products and business models [8,9]. Lean startup meetups globally engage 20,000 regular participants [10].

In considering the lean startup's attention, this paper aims to explore three critical questions around (1) what limitations exit with the methodology and/or its use; (2) what is the methodology's impact on performance outcomes; and (3) what learnings can practitioners and educators employ as part of the startup efforts. This paper's flow starts with a brief introduction to the methodology, then unpacking the evidence and insights addressing the first two queries, and applying learnings to address the third question.

Research questions and search/review methods

The authors engaged multiple sources to identify relevant literature concerning the lean startup, its limits, outcomes, and applications. These included published peer-review papers, non-peer review documents, including practitioner

***Address for Correspondence:** John M York, Institute for the Global Entrepreneur at the Jacobs School of Engineering and the Rady School of Management, University of California, San Diego, Cranfield School of Management, Cranfield University, Tel: +18052382485; E-mail: johnyork@akitabiomedical.com*

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publications (e.g., *Harvard Business Review*, *Sloan Management Review*, *Rotman Management Magazine*), graduate theses, business publications, blogs, and books, and non-peer-reviewed web content. Electronic databases reviewed included ABI/Inform, EBSCO, JSTOR, Google [and Google Scholar], ProQuest Dissertations and Theses, Science Direct, and Web of Science.

The search strategy started with the use of keywords relating to the lean startup. These included "lean (or agile)", "lean (or agile) entrepreneur", "lean (or agile) entrepreneurship", "lean (or agile) start*up (startup, startup)", "lean (or agile) venture". For the first question, the strategy added modifiers to "lean start*up*", including "barrier*", "challenge*", "disadvantage", "drawback*", "issue*," hurdle*", "limit*," limitation*", "pitfall", or "problem*". For the second question, the strategy added the following terms, such as "failure", "impact", "new venture performance", "outcomes", "performance", and "success" to the search string. There were no specific search strings used for the third question since the investigation would inform our response and recommendations to address it.

A broad search captured 300 citations, as late as the end of 2019, that included the lean startup in the title or abstract. The search concerning the first and second questions led to 250 citations that included the lean startup in the title or abstract to examine further. From the search results, the authors' choice of citations depended on their knowledge related to entrepreneurship, startups, and the lean startup practices to extract value from a source's content. These included published peer-review papers and non-peer review documents (e.g., graduate theses, business publications, blogs, and non-peer-reviewed web content). A closer examination led to identifying a limited number of publications that specifically looked at the lean startup and its limitations to address the first question and the lean startup and outcomes to address the second query.

Due to the limited peer-review papers drawn from this initial effort, the research included citations from non-peer review pieces. Most of the publications involved those from advocates and practitioners describing the methodology. These works were predominantly in the non-peer review space and included trade publications and blogs describing the methodology. Furthermore, the review employed a "snowball" approach involving identifying additional citations from relevant references from articles reviewed from the initial search and did not appear. The authors examined such articles for relevance based on the specific research questions and knowledge related to entrepreneurship, startups, and lean startup practices to extract value from a source's content. The authors reviewed these pieces and included those that provided relevant data to address the research questions.

Lean startup

The lean startup, a term Eric Ries coined, describes a scientific (or hypothesis-driven) methodology for developing businesses and products. The approach aims to shorten the product development cycle by adopting a combination of hypothesis-driven experimentation, iterative product releases, validated learning, and customer feedback [11,12].

The lean startup draws on the Toyota Production System and agile software development [13,14]. Furthermore, its foundation includes several academic theories bricolage, business model, creation and discovery, dynamic capabilities, effectuation, organizational learning, and real options [15-27]. Finally, this methodology stands on scientific literature support, ranging from moderate (for experimentation and minimum viable product [MVP]), to robust (for effectuation and iteration), to very strong (for customer involvement) [12].

Several components define the methodology. The first involves customer discovery, where the startup focuses on identifying the customer, his/her needs, repeatable business model, and product/market fit P/MF. Discovery involves direct customer conversations, with the entrepreneur "getting out of the building" ("GOOB") to understand criticalissues and confirm the customer's problem or "job-to-do" [8,28-30]. The entrepreneur's job is to get inside the customer's head to discover and validate the problem and determine whether one's proposed solution might work. Such insights can speed the construction and validation of an MVP and a scalable business model.

The next piece involves experimentation [11,19,29]. Ries [29] fashions the lean startup as a scientific approach using hypothesis testing to provide validated learning to guide decisions. This phase involves the running of experiments and the "build-measure-learn" (BML) cycle [11,29].

Essential to this process is the minimum viable product (MVP) to get the customer's job done.This MVP enables the firm to launch sooner and reach early evangelists to get the product's initial input [11]. Ries defines it as the product version that can drive a BML cycle turn with the most minimal effort and development time but requires extra work for one to measure its impact [29]. The MVP should contain a "bare-bones" set of features and capabilities to measure its traction in the market [31]. Finally, it allows the firm to trial its riskiest assumptions and shortening the feedback time [32]. Tied to experimentation is innovation accounting. Having a metric-based evaluation helps to measure progress and validate learning. It defines actionable metrics linked to a specific business model [33]. Startups test their hypotheses and use quantitative metrics to evaluate progress. Examples include thresholds (e.g., a Kickstarter target), web landing page engagement (e.g., click-through rates, sign-ups), A/B tests (comparison of two versions of a product or communication), and MVP responses (e.g., willingness to pay).

The final piece involves iterations and pivots in the product's design and the firm's business model based on experimentation. Scholars also characterize the lean startup as an adaptive strategy [34,35] due to these two actions. Iterations require minor changes to the MVP or business model. Pivoting involves a more substantial course correction from the initial hypothesis and MVP to new ones around the product, strategy, and growth engine. Learnings from customer interviews provide qualitative data, and hypothesis testing supplies quantitative data to drive these actions.

Several canvases support the lean startup. These frameworks allow the entrepreneur to chart out hypotheses and changes related to value propositions, MVP characteristics, and business models. Osterwalder and Pigneur [36,37] provide the value proposition and the business model canvases. The first canvas defines the value proposition (and minimum features for an MVP) based on customer needs. The second canvas outlines the business model based on nine pieces that define value creation/extraction and operations/efficiency. Maurya [38] offers a third, named the lean canvas. It helps entrepreneurs to deconstruct their ideas into their essential assumptions and breaks it into product and market sections [39].

What are the Limitations of the Lean Startup Methodology and Its use as an Entrepreneurial Strategy?

Exploring this question led to the identification of several notable areas that highlight the methodology's limits. Such limits include those (1) inherent to the methodology, (2) related to appropriate knowledge and utilization by practitioners, and (3) boundaries conditions (or relate to fit with specific business verticals). The following areas (customer discovery, minimum viable product, experimentation, iteration/pivoting, and boundary conditions) will examine various experiences that highlight such limitations (Figure 1).

Customer discovery

Customer discovery is an antecedent to the lean startup, and practitioners use it as part of the approach [8,18,28,34]. Essential to customer discovery is the interviewing of customers. However, this process is fraught with problems and biases. Poor implementation of the interview methodology and subsequent analysis can undermine customer discovery efforts.

In a recent *Long Range Planning* paper, Felin et al. [40] challenge the practice of customer discovery. They question the ideal timing, product type, sectors, and the emphasis on customers in the early phase [40]. These scholars contest the assumption that the customer knows what she/he wants due to hidden or

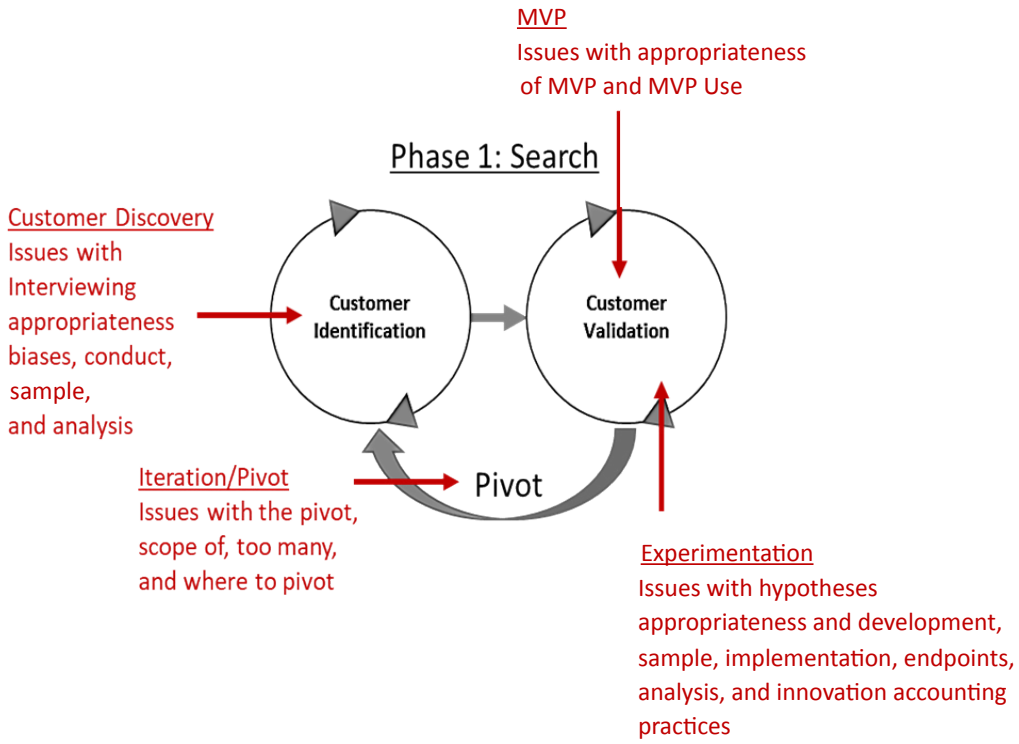

Figure 1. Limitation areas with LS.

unexpressed needs. They raise issues concerning what data in observations are most relevant or not [40]. They observe that available feedback can teach startups the wrong lessons and lead to both a myopic view and dangerous traps [40].

Two other academic groups identify customer biases in the interviewing process that pose a significant risk to customer discovery [41,42]. York and Danes [42] explain that many entrepreneurs, who rely upon a subjective view and limited data, fail to obtain or notice available information critical for making a proper decision. Also, they identify multiple interviewing biases. These include selection (i.e., friends and family), confirmation (i.e., leading, confirmatory, and closed-ended questions), overconfidence (i.e., overestimating one's knowledge, skills, and data), optimism (i.e., extreme positivity), representativeness (i.e., generalize findings from small samples), and acquiescence (i.e., respondents providing answers they think the entrepreneur wants to hear) [42].

Chen et al. [41] add further perspectives on interview biases. For face-to-face interviews, they cite issues with generating saliency (i.e., highlighting the most noteworthy points) and vividness (i.e., producing powerful feelings or defined images in one's mind); providing inappropriate cues (i.e., misleading or inconsistent body language); and using inappropriate analogies (i.e., making comparisons between two items to describe a point) [41]. Specific to consecutive interactions, these authors raise concerns around the contextual considerations related to recency (i.e., proximity in time from the analysis), primacy (i.e., the effect of rank, office, or being first and foremost), and contrast (i.e., state of being strikingly different from something else [41,43]. Their next considers issues with large samples, including the effects of over confidence, redundancy (i.e., duplication), and dilution (i.e., the state of diluting something such as a signal) [41,43]. These scholars' final point considers biased processing (i.e., the irrational or illogically process of information) by the entrepreneur [41,44].

Croll and Yoskovitz [33] provide an additional perspective suggesting that interview subjects might also have their own cognitive biases due to different expectations and frame-of-reference. This point is critical because entrepreneurs need to interpret customer feedback with such insights in mind. Additionally, they reinforce Blank's points regarding the need to conduct many interviews extending to over one hundred that the NSF I-CORPS™ requires [7, 28].

Furthermore, the ability to obtain a suitable customer sample and the right customers can be a challenge. In their case study in Indonesia, Nirwan and Dhewanto [45] notice the entrepreneur's ability to access customers makes it difficult to capture customer feedback and confirm hypotheses. Chassagne [46] observes this barrier with Brazilian entrepreneurs as well. He observes that entrepreneurs encounter difficulties implementing the "get out of the building" phase. Such problems may represent a mindset, timing, or resource limitation that precludes the entrepreneur from generating a reasonable sample translating to meaningful feedback and insights.

Interestingly, both Nirwan and Dhewanto [46] and Gustafsson and Qvillberg [47] add that there is difficulty in honing in on an opportunity due to the high variation and complexity in customer discovery processes. Such observations might suggest that these entrepreneurs' interviewing efforts might not have been enough to identify the real needs or that their biases around their product or business limited these engagements. Alternatively, they might indicate limited or no market opportunity at the outset.

Finally, Ng [32] observes that entrepreneurs tend to ask the wrong questions. She explains that they conduct poor interviews during discovery because they focus on selling the product instead of investigating current customer behaviors and gaining insights to find an appropriate solution. This consultant adds that they talk too much, ask leading questions, and fail to dig deeper. These observations emphasize that the interviewer's goals should be to understand the customer, explore needs, and not validate (or promote) a value proposition.

Minimum viable product

Felin et al. [40] challenge whether firms should engage customers in their early stages using the MVP. They contest whether the MVP interaction would provide a usable and reliable signal in the nascent product, strategy, and business model development process [40]. They question why customers would better understand a future product's viability and whether such interactions would generate transformative and novel products [40].

Heitmann [48] argues that bringing an inferior, unfinished product to the market (e.g., "buggy" software) leads to a considerable percentage of dissatisfied customers. He cites LeBoeuf [49], who indicates that 96% of dissatisfied customers will not share any feedback on the startup because of the MVP's incompleteness. He continues that adding and testing new features can lead to unnecessary testing loops that waste money and time. This author proposes

that entrepreneurs focus upon the concept of a "minimum desirable product," one to cause enough satisfaction and desire for the customer to stay interested and not abandon [48].

From an academic vantage, Frederickson, and Brem [12] identify the entrepreneur's problem of stoically adhering to an idea, product, or theory. This point illustrates what Felin and colleagues [48] describe as more of a "supply-side" approach that does not require the customer perspective. Frederickson and Brem [12] explain that limited resources might set a boundary condition exploring alternative or broader solution spaces. They also identify this problem to exist with entrepreneurs who employ more of a "causal" rather than an "effectual" thinking approach from the start [12]. To this end, these scholars add that these type of entrepreneurs see the solution from the start and, thus, limit their options and end up with an extremely narrow set of solution options [12]. Hence, these authors conclude that such a narrow perspective limits the entrepreneur's ability to identify solutions that might address the customer and market need more effectively [12]. Thus, such entrepreneurs do not adopt the lean startup's methods and implement them properly in their value creation efforts.

Other academics note problems in designing and developing the MVP. Ghezzi [18] reports this issue from a survey of 272 mobile startups along with follow-up interviews. In this study, while 62% of survey respondents indicate the MVP as a vital concept, 82% express defining and designing an MVP as one of Lean startups' disadvantages. In examining the verbatims from his qualitative interviews, this scholar identifies the complexity of what the MVP is as a factor, especially in more sophisticated spaces such as artificial intelligence [18]. Further, from these interviews, he learns that the ability or inability to craft an appropriate MVP, prioritize tests around it, and the business-to-business setting are problematic areas [18].

Interestingly, Warberg and Thorup [50] share issues in the MVP development process. In examining software startups in Scandinavia, they identify several technical challenges associated with the MVP. They observe that the lean startup devalues the proper architecture in the software (i.e., "junk code"). Further, it creates unnecessary waste in the software because of the need to rewrite and clean up software because of too simplistic code at the outset. Finally, they add that the lean startup hinders the development of innovative solutions in the software. They note that the emphasis on rapidly launching a product can eclipse the product's overall quality or creativity [50]. To illustrate this point, they quote Cohn who emphasizes that by using a related software development methodology, scrum in agile, teams begin with a safer approach and never attempt any "wild ideas" which could translate an innovative solution [50,51]. To this end, they suggest an emphasis on innovation as an essential activity to accompany lean startup.

Other consultants reiterate the challenge of implementing the MVP in practice. In describing the case example involving ThingShare (a platform for peer-to-peer video game renting), Kortmann adds to the above concerns by questioning whether his company "launched" the product too early. He explains that while his firm had invested time and expense to market with more than an MVP, it short-changes its early adopters. He suggests redefining a viable MVP– a product that did not need any more features provides revenue and profitability, and engages a critical mass of customers [52].

Furthermore, Ng [32] suggests that startups dismiss the need for building an MVP. Instead, she observes that they had preset ideas. In many ways, this practice is common, especially in engineering and science, and can be problematic. Finneran [53] raises similar concerns. He challenges releasing an inferior product or service that customers would pay to enable the startup's learning process. This consultant adds that his customers prefer a more polished product; they do not want to invest their time or efforts in evaluating an MVP.

Adding to these insights, Rao [54] shares the Indian experience regarding MVP problems. He explains that the MVP might not encompass the essential intellectual property (IP) protection needed because it has not finalized the product and cannot secure a definitive patent application [54]. Rao adds that Indian entrepreneurs engage demanding customers who were familiar with Western 'ready-made' products and well on their way down the adoption and commercialization curve. He continues that such customers are not familiar with innovative early-stage products locally and reject an inexpensive MVP. Hence, this author finds that the entrepreneur ends up with a more developed product and enters the Indian market only after success abroad [54]. The cultural uniqueness or more the natural preferences of consumers in an emerging economy, such as India's, might explain Rao's observations.

Like Rao in India, Nirwan and Dhewanto [45] observe similar behaviors in Indonesia. They find that the MVP is challenging to implement due to customer expectations, perceptions, and confusion, especially in a market with multiple competitors. While these authors acknowledge that MVP's purpose is to create a minimum product to capture customer interest, they find that the startups do not want to create an inferior product in a market. Nonetheless, they observe that such firms cannot afford to go too far in developing a full product due to available capital. Interestingly, Chassagne [46] notices similar issues that force startups in Brazil to "run fat" rather than "lean" with an MVP due to the size of the market and the high level of competition. Thus, this Brazilian experience, along with those in Indonesia and India, suggests two vital considerations. These include (1) cultural issues involved with customers embracing the MVP; and (2) the perspective that firms in these countries need to get it right on the first launch.

Experimentation

The most problematic lean startup practice appears to involve that of experimentation. Felin and colleagues [40] contest that a hypothesis must be more than just a guess and that the lean startup practice distorts the development of meaningful hypotheses [40]. They argue for entrepreneurs to pursue a more scientific, theoretical, and logical approach [40,55]. Furthermore, these authors opine that some of the most valuable ideas might not lead to experimentation in the lean startup practice [40]. They raise concerns using step-wise experiments, which use early adopters and the rapid testing of ideas or products. They argue that this approach creates only incremental value. These authors highlight experimental composition and design and what types would be most critical to lead to a breakthrough product of value as problematic areas. They question whether startup founders can visualize the unknown future versus present realities. These scholars continue that this experimentation process would not yield reliable and predictive information that would translate to a meaningful product or venture.

In his mixed methods study involving 227 startup teams, Ghezzi [18] highlights experimentation issues. He observes that 52% of their survey indicate that defining testing priorities and designing tests are challenges [18]. He cites that 69% of the respondents identify and engage early evangelists and trial users to test the MVP as a disadvantage [18]. To reinforce these survey findings, this scholar shares several verbatims from entrepreneur interviews. Some of the issues include getting agreement between the founder and his/her team on statements to test, prioritize tests, design appropriate tests around an MVP, tests around a purchase action, and hold off from willingness to pay inquiries [18]. He also shares perspectives around the amount of time and effort in getting the testing process refined enough to provide useful information and frustrations about not learning anything from an experiment [18]. He also finds a wide range of expenses in running tests ($19,000 to $180,000, mean $34,000) and as a percentage of raised capital (18% to 43%, mean 24%) [18]. To this end, he reports that survey participants rate the use of the lean startup with a "poor"overall satisfaction score of 2.8 (based on a 4-point Likert scale) [18]. This rating may reflect some of the teams' frustrations with testing, along with the MVP [18].

Other consultants reinforce these views. Shafer [56] identifies several pitfalls that involved bias and ill-designed experiments. He first cites facilitator and observer bias concerning hypothesis development and testing. Another point that this consultant raises considers the ambiguous results from open-ended experiments. Vlaskovits [57] adds that some environments are too complex and chaotic for meaningful hypotheses to be formed and tested. He explains that coming up with perfect experiments provides a great excuse for users not to take action because of the effort needed to run a proper evaluation that provides meaningful data [57]. Ng [32] observes that a significant problem with

experimentation is the testing of the wrong aspect. She notes that many come with the "I have an idea!" hypothesis [32]. This consultant explains that this mindset leads to a tunnel vision, in which the entrepreneur could not identify whether the guess was correct due to inherent bias [32]. Ng adds that forming a wrong hypothesis was due to the entrepreneurs misunderstanding the problem and overlooking the root cause [32].

A related issue involves that of engaging early adopters as part of the experimentation process. Heitmann describes this effort as looking through a "keyhole" and observing only early adopters, thus limiting the breadth of options [48]. Thus, he feels this focus would miss the "early majority" segment, essential to scaling a business. Finneran [53] also notes that working with "early adopters" and "early evangelists" might be unrealistic as none of these individuals would give feedback on unpolished software to be the first users.

Nirwan and Dhewanto [45] observe that Indonesian entrepreneurs experience challenges in creating and validating the problem and then the solution. The inability to obtain enough of a sample makes it difficult for the entrepreneur to capture customer feedback and confirm hypotheses. Schaefer [56] reinforces this point regarding experiments related to the lack of statistically significant effects due to small samples. Finneran [53] offers a similar concern in gaining an adequate number of customers to engage with the MVP early in the process.

Related to experimentation are concerns with innovation accounting. Ng [32] sees entrepreneurs' inability to define a baseline metric for accountability during experimentation. Burgstone [58] challenges the use of innovation accounting metrics (e.g., views, likes, engagement of customers, traffic) instead of standard accounting practices.

Iteration and pivoting

Scholars and consultants recognize potential limits with iteration and pivoting. Heitmann [48] observes that the entrepreneur's previous work was for naught without actual learning and change. Ng [32] supports this point and adds that a common mistake involves discarding an idea without learning from the dataand getting the whole team on the same page related to learnings and pivots. Vlaskovits [57] adds that it is hard to get entrepreneurs motivated to be resilient when, upon a pivot, one decides that one's initial direction was not enough.

Heitmann [48] observes that taking the stigma away from failure detracts from the focus upon persistence. He also notes that sometimes, the entrepreneur gets stuck in a pivoting cycle and fails to recognize the need to move on from this effort to activities to generate revenue and scale. Kressel and Winarsky [59] reinforce this point by commenting that constant pivoting is like having a compass without a bearing because it is continuous and without a specific purpose. Hence, the concern here is that the lean startup may be teaching entrepreneurs to think of success as merely the act of pivoting and iteration (i.e., the process) rather than focusing on delivering a final product and generating revenue (i.e., the outcome).

In practice, several other scholars offer additional insights related to challenges with pivoting. Gustafsson and Qvillberg [47] observe difficulty in pivoting due to customers' lack of big problems. The issue here is whether the startup here had failed to pivot due to inadequate learning through poorly executed customer discovery or experiments, or rather due to the lack of applying the learnings. Nirwan and Dhewanto [45] observe the same challenge in pivoting due to the lack of a significant problem to address in their business-to-business case study. These authors indicate that this action is a challenge because it leads to an incremental product as the solution that customers show limited interest in a fiercely competitive marketplace. They also notice a further barrier involves the speed of iteration due to regulatory and administrative considerations. Finally, from their survey of Croatian entrepreneurs, Lilac, and colleagues [60] report that these individuals do not change their business model despite their lean startup knowledge. Such observations reflect potentially a disconnect between knowledge and practice, or that the entrepreneurs remained fixed in pursuing their ideas despite their use of the lean startup.

Frederiksen and Brem [12] note a significant issue with pivoting. They explain that effectuation, an adaptative process, restricts the breadth of solutions [12]. Such limits influence the entrepreneur to chart a direction within specific boundaries that determine the pivot direction [12]. Felin et al. [40] add that lean startup experiments might lead to a narrow view of opportunities (i.e., looking for one's keys with a flashlight). Ladd [61] explains that the methodology might produce "false negatives," translating to the entrepreneur rejecting good ideas because the lean startup did not provide clear rules for defining go/no go, success (P/MF), stopping testing, and scaling.

Furthermore, their observations related to not additional advantages with more hypothesis testing points to the issue around a marginal, if any, the benefit of further experimentation, pivoting, and iterating [61]. To this point, Kressel and Winarsky [59] draw the analogy of the continued pivoting akin to a top without any specific direction. Hence, the need for a clear vision, processes, and decision points for entrepreneurs uses the methodology.

Boundary considerations

One question explores whether all types of firms can use the lean startup methodology. Considering its Silicon Valley roots, it fits with software-driven ventures that address a business-to-consumer market, especially when considering market uncertainty [29,62]. Bortolini and colleagues [34] add that the lean startup's popularity paralleled the "boom" period in the growth of mobile apps that began in the late 2000s. Investors Kressel and Winarsky [59] argue that the lean startup makes sense for software- or web-related companies with modest startup operating expenses. Frederiksen and Brem [12] explain that specific practices (e.g., experimentation, MVP, and iteration/pivoting) are most applicable to software development. Croll and Yoskovich [33] describe six digital models (e-commerce, the two-sided marketplace, software as a service, free mobile app, media, user-generated content) that use lean startup practices, particularly that of innovation accounting.

Interestingly, several established corporations employ the lean startup. Ries highlights over thirty firms (startups and established) in his book [29]. Notable firms include General Electric (GE), Hewlett Packard, Intuit, PayPal, Proctor and Gamble, Telefonica, Toyota, and Zappos [11.12,29,63-67].

Nevertheless, it is crucial to consider what type of business might benefit (or not) from an adaptive strategy such as the lean startup. For example, Andries and Debackere [68] reflect this consideration in their survival analysis of 117 firms from independent and large-firm new ventures in the biotech, automation, and environmental sectors. These Belgian scholars explain that some firms have barriers to shifting their business models due to significant investment needs for research and development and other organizational and inventory requirements [68]. They observe that not all industry sectors enjoy survival benefits with adaptation. Thus, users need to consider the impact (and context of) sector maturity, technology advancement, dynamics or industry pace (rapid vs. slow), capital intensity, financial support, and even economic cycle (e.g., recessionary) on the survival benefit with a business model adaptation strategy [68].

However, in some settings, such as the material technologies space (e.g., chemical, advanced materials, semiconductor, silicon chips), the lean startup may not apply well because such verticals must address technological uncertainty, along with legal/regulatory, financial, and operational risks [62]. Harms et al. [62] underscore this point by explaining that materials and science-based ventures (1) operate under a high degree of technological uncertainty to resolve so they can develop the actual products in a specific period, and (2) often serve business markets. Such characteristics may pose barriers to the optimal use of the methodology [62]. These scholars also observe that the close link of product and process innovation in such ventures makes the lean startup less suitable for resolving market uncertainty and creating challenges for an MVP [62]. Furthermore, they note that process changes can impact the product (and vice versa) [62].

Furthermore, feedback loops in such firms may take too long and be too expensive [62]. The processes of iteration or pivoting on a product might also require the resubmission of IP protection due to the changes in both products and manufacturing processes that a patent, for example, would cover [62]. Any change would lead to firms returning to the starting point, costing significant firm time and capital in its development and commercialization processes [62].

However, with that said, these authors do observe that such firms do use a modified version of the methodology [62] and the NSF I-CORPS™ program [5,6,7] emphasizes the solidifying of a sustainable business model as one of its endpoints for success with science and technology ventures.

Interestingly, in a case evaluation involving 69 semi-structured interviews and journal observations by employees in an early-phase firm with new manufacturing technology (e.g., heating process), Gustafsson and Qvillberg [47] reinforce some of the above considerations. They pose that the complexity of the manufacturing technology and process for the drying of sheet metal and the customers' differing needs significantly challenged the ability to prototype quickly and provide a quality MVP. They identified multiple barriers to the lean startup, including the customers' emphasis on end-product reliability, the need for physical distribution channels, and the lack of significant "customer problems" to address in the application segments they chose to explore.

The biotech and pharmaceutical industries further exemplify such challenges. These verticals involve a complicated business with many challenges that require a long time to market (approximately ten years) and significant investment ($2.5 billion) [69-71]. The lean startup's use during the drug discovery and development process may be problematic since firms cannot alter such products without a restart and may require new IP. Such efforts require time and capital. Patients in a clinical trial represent the only customers able to receive the product before regulatory approval. Finally, various pieces (e.g., manufacturing, packaging, labeling, and supply chain) are subject to regulatory approval. As the firm advances a material product, it needs to consider other value chain partners (e.g., regulators, licensing partners, large purchasing organizations, and insurers). These players can influence product development and peel away financial value from the asset and the innovator firm. Thus, the lean startup poses significant challenges for commercialization in these sectors and in any others where the firm needs to address multiple stakeholders and risks vis-a-vis iterative regulatory approval or sales cycle processes.

Interestingly, Eisenmann et al. [11] reinforce the above observation relative to the lean startup's poor fit in industries with long lead times and high demand. They explain that complicated businesses, which requires engineering and scientific breakthroughs or regulatory milestones to reach, are difficult, if not impossible, to launch a timely first-generation product and subsequent improvement for the lean startup to offer value. These authors add in industries in which individuals must limit mistakes [11]. These comments counter the "learn from mistakes" mentality with the lean startup. They highlight situations where a mistake would be intolerable, such as failure scenarios that a firm cannot fix post-launch, impacts a customer's mission-critical activities, or society has low tolerance [11]. Industries such as health care, pharmaceuticals and aerospace exemplify such areas. Another area they cite is an area where unmet demand is low, such as alternative energy sources [11].

What are the Outcomes Associated with Using the Lean Startup Approach?

The second question explores outcomes associated with the lean startup. Of interest relates to the influence of using this methodology on some type of performance-related outcome, or the extent to which a new venture meets its goals concerning market share, profit margin, return on assets, revenues, or other specific metrics [72,73].

Anecdotal experience

Most of the documented experiences involve anecdotal experiences (e.g., reports, examples in books, cases) [12]. The most notable examples involve the experiences of General Electric, the Startup Genome, and the I-Corps™ program [5,6,7,74,75].

A *Harvard Business Review* case description involving the multinational conglomerate, General Electric, offers insight into the successful use of lean startup at the corporate level [74]. The article discusses the FastWorks program. It provides notable examples by highlighting how two divisions experienced significant success using the methodology [9,74]. The first involves the gas turbine group, which achieves a product development cycle that is two-years faster and 40% less expensive, along with $2 billion in revenues) [74]. The second describes how the appliance group improves its efficiency by halving the cost and doubling the product development rate while doubling its sales growth rate [9,74].

The Startup Genome project offers further unpublished insights [75]. In analyzing survey responses from 650+ web startups, this group found greater success with startups that pivot once or twice (raise two and a half times more funds, three and a half times more substantial user growth, and 52% less likely to scale prematurely) [75]. However, they find that other factors, such as founder experience and team mix, influence outcomes [75].

The I-CORPS™'s program, which utilizes the lean startup as its base process, represents another significant experience. Nnakwe et al. [6] highlight results as of March 2017 within a review paper on the I-CORPS™: 973 teams from 222 universities and leading to 320 startups (30% of teams) and $83 million ($259 thousand/team) in follow on funding. VentureWell [5] provides updated numbers: 1450 teams from 230 universities and resulted in 600 startups (41% of teams) and $210 million ($350 thousand/team) in follow on funding. Unfortunately, neither group offers a rigorous analysis in the empiric literature.

These experiences offer valuable insight into the influence of the lean startup methodology. Each offers examples of outcomes associated with methodology, either using customer discovery or experimentation. However, these examples, among others, appear in non-peer review sources. More significant, they lack an appropriate methodologic rigor to clearly define the effect of the lean startup, dissect its influence versus other internal and external confounders, and, finally, to account for any potential author biases in documenting these experiences.

Empiric experience

Several studies are beginning to shed some light on the impact of the lean startup or lean startup-like practices (e.g., adaptation) on new venture performance (Figure 2). They represent a diversity of experiences. Such studies (published as of early 2020) represent variability in outcomes may represent differences in study populations, design, endpoints, and business sector.

Camuffo et al. [76] provide some of the most rigorous data from a randomized control trial involving 116 Italian startups (59 treatment, 57 control) and 16 data points over a year. These scholars highlight that the treatment group progresses through more intensive training on predicting performance frameworks and conducting rigorous hypothesis tests [76]. They observe that these efforts translate into more pivots ($P<0.05$, linear regression) and dropouts ($P<0.05$, linear regression), along with a shorter time to revenue ($P<0.05$, Cox

Figure 2. The breadth of empirical evidence concerning the impact of LS on new venture outcomes and performance.

regression), versus the control group [76]. These findings emphasize the importance of structured training and follow up with the methodology.

Ghezzi and colleagues [1,18] offer additional insights. The first involves a conference paper that describes a comparative case assessment of the lean startup (two teams) versus business plans (two teams) with startups in the mobile space [1]. They find that teams using the lean startup (versus those using a business plan) realize respectively, (1) shorter times for product development (3 and 4 mo. versus 8 and 15 mo.), shorter venture organization (3.5 mo. versus nine mo. and 1.5 yr.), and first customer acquired (1 and 2 wk. vs. two mo. and none); and (2) equity funding (2 lean startup, 1 business plan) [1]. Their second study involves a comprehensive survey of 227 startups in the mobile space. In it, entrepreneurs cite several advantages with the lean startup: (1) decreasing time and cost for startup testing (74%); (2) aligning customer and business idea (68%); (3) verifying and pivoting business model (52%); and (4) gaining financing (39%) [18].

Ladd et al. [20] share a mixed experience involving 271 clean-tech teams (185 lean startup, 86 non-lean startup) using a bimodal endpoint (award/no award) to assess pitch competition performance at the end of an accelerator program. The lean startup users represent 13%, and non-lean startup users are 7% of successes within the whole group, whereas only 19% of the lean startup users and 22% of the lean startup users within each group are successful [20]. However, teams validating their hypotheses fare three times better in the competition (P<.01), and customer discovery is significant in enhancing success (P<0.05) [20]. Unfortunately, the number of validated hypotheses and subsequent success and concurrent use of hypothesis testing does not correlate linearly, and customer discovery does not improve outcomes [20]. However, by focusing on validating the customer segment, value proposition, and channel areas of the business model, the lean startup group out performs those who did not use the methodology by two-fold (P<.001) [20].

Eesley and Wu [35] provide another relevant study showing mixed observations. They compare the short-term and two-year performance of students randomized to adaptive or planning-based approaches (with and without diverse mentoring) in an entrepreneurship class taught as a Massive Open Online Course [35]. In the short-term, teams (n=942) using the business planning approach perform better in course grading by 0.552 points (P<0.05) than the students in the adaptive-only group [35]. However, the diverse adaptive group can narrow the gap with an additional 0.538 points, which mitigated the planning group's advantage [35]. The two-year follow-on survey (n= 554) finds that those who used adaptive approaches fare better concerning revenue (P<0.5) and funding (P<0.05) [35].

Andries and Debackere [68] report the results of an investigation of the adaptation-performance hypothesis in 117 entities (65 independent new ventures and 52 business units of established firms). Drawing data from the annual CorpTech directory and defining adaptation as at least one significant change in one's business model, they provide results from survival and multiple variate analyses (Cox) [68]. In their study, these Belgian scholars report that firms adapting their initial business model (i.e., pivoting or an adaptive strategy) experience higher survival versus non-adapting firms (P=0.0892, Log-Rank test; P=0.0636, Wilcoxon test) over the 15 mo. analysis period [68]. However, they report that this benefit does not apply to all firms [68]. Further analysis reveals that survival benefits vary with types of business [68]. Adaptation benefits less mature, capital-intensive, and high-velocity industries versus more mature, stable industries [68]. Also, it benefits business units of established firms more favorably than in independent firms [68].

Nilsen and Ramm [77] report negative findings from a survey of 47 Norwegian high-tech startups in their thesis. Their survey includes information around the knowledge and use of the lean startup and the company [77]. The firm-specific data calculates a success score based on several questions clustered to define this variable [77]. They report that the respondents are knowledgeable about the methodology [77]. However, these authors do not see the translation from knowledge to practice to success [77]. First, the analysis finds no significant correlation (Pierson's r) between knowledge and use of LS (r=0.093, p=0.535) [77]. More significantly, the analysis fails to identify a correlation between the use of lean and the success score (r=0.091, p=0.542) [77].

In examining these studies, several issues do appear. First, these reflect a limited sample of the experience. Second, this mix reflects various methodologies, endpoints, industries, firm types, and results, depending on the researcher's lens. Third, five (Camuffo [76] Ghezzi [1,18], Ladd et al. [20], and Nilsen and Ramm [77]) directly evaluate the lean startup methodology, whereas two Andries and Debackere [68] Eesley and Wu [35] examine adaptation, which emulates the lean startup-practices of iteration and pivoting. Fourth, four studies make a comparison, with three (Camuffo et al. [76], Ghezzi et al. [68], and Ladd et al. [20]) using the lean startup as one of the evaluation groups. Fifth, two (Camuffoet al. [76] and Ladd et al. [20]) utilize a sample of over one hundred groups. Finally, only Camuffo et al. [76] utilize rigorous methods.

Interestingly, it is the work of Camuffo et al. [76] that stands outs. It highlights the importance of rigorous use of the "scientific approach." Further, the study indicates that those startups that use the methodology rigorously can discard poor ideas early (dropouts), pivot to new ideas (pivots), and reach a successful outcome (revenue) earlier. Other academics, such as Felin et al. [40], laud this study as a positive example of using the lean startup. However, while this study provides valuable peer-review evidence concerning the influence of the method on outcomes, its limits include the business sectors studied (e.g., Internet, furniture, retail), outcomes identified (dropout, pivot, time to revenue), and timeframe (one year). Accordingly, it set the path for further research to examine a broader spectrum of startups, outcomes (e.g., sustained revenues, growth, market share, venture investment, viability).

What Learnings Should Practitioners Consider when Utilizing this Approach?

This final question delves into the relevance of the observations and considerations that prior sections in this paper raise. Most importantly, it highlights the need to translate such learnings to practice for entrepreneurs (along with their mentors and teachers) to consider using lean startup methods.

Education and implementation

The first learning relates to education and implementation. First, entrepreneurs need to build a strong foundation. This base includes a thorough understanding of the lean startup principles, the associated canvases, and the skills involving customer discovery, interviewing, experimentation, and inventory accounting. Such a foundation is necessary for proper implementation. However, understanding the concepts might not be enough. Work with Norwegian tech startups indicates that knowledge of the lean startup concepts and methods does not correlate with its actual use (r=0.093, p=0.535, Pierson's r), creating a need to bridge this gap [77].

Camuffo et al. [76] underscore the need for this rigorous training to build a strong foundation. This group also emphasizes the need for rigorous implementation using the scientific approach [76]. However, it is not just the scientific approach but the consistent use of all the essential lean startup practices, not just individual pieces on an ad hoc basis period [76]. The entrepreneur needs to complete one's assumptions and updates in the business model canvas (and value proposition canvas) correctly during customer discovery and other business model development experiments. For example, a common misconception that entrepreneurs misinterpret is using channels not as distribution channels but rather as media channels. Another involves including partners when one thinking about distribution channels.

Also, individuals need to understand how to define hypothesis statements, design appropriate experiments (including large enough samples), utilize proper metrics, and interpret (and apply) results. The observations by Ladd et al. [20] reinforces this point, both related to the positive outcomes (proper hypothesis testing translates to success) and negative findings (no difference in pitch results, which may be due to non-rigorous use of the lean startup in the experimental group).

Further, one needs to engage in customer discovery properly and conduct experiments to address set hypotheses, with unaided feedback, rather than

framing customer or market responses by sharing the completed product, rather than an MVP or no product at all. Such efforts will support an objective assessment of the customer need, response, and market to reduce uncertainty effectively.

Control for influences

The second learning considers accounting for both internal and external factors. Such might confound outcomes or influence the understanding and implementation of lean startup concepts. Considering internal factors, the entrepreneur needs to control cognitive biases in conducting customer discovery and experiments [41,42]. Also, one needs to be aware of both entrepreneur and customer interpretations of questions and responses from interviews, the design and results of experiments, and controlling for the various influences on the methodology'suse and implementation [33,41].

For external factors, one needs to account for cultural considerations with MVPs use and customer interviews [45,46,54]. Entrepreneurs need to ensure they select a business in a dynamic market with a defined technology, not necessarily an application-or service-based business versus those with a base technology or product with substantial IP, regulatory, or capital requirements [62,68]. This consideration is essential since entrepreneurs in these business sectors have multiple risks beyond the resolution of customer and market considerations, translating as P/MF.

Use in an appropriate business sector or use other mitigations strategies in conjunction with the lean startup

The third learning involves ensuring that the entrepreneur is using the lean startup in the correct business space. It makes sense to engage the market quickly by running a rapid experiment to achieve P/MF, as in software and applications-based businesses to reduce market uncertainties.

Harms et al. [62] underscore this need in their paper examining lean startup and materials ventures. The primary focus of the methodology's actions is to reduce market uncertainty. However, if a firm is venturing into a more complex business sector (e.g., biotechnology, chemicals, materials ventures, pharmaceutical), it needs to address other risks. Such uncertainties to mitigate include technological, legal/regulatory, financial, implementation/operational, and time to market risks. Recognizing the need to manage these other uncertainties in such sectors is essential, even if the entrepreneur uses the lean startup to mitigate market risks. Hence, one must recognize the need to address these risks and utilize appropriate strategies to mitigate them.

Furthermore, one needs to consider the appropriate strategy for moving forward the entrepreneurial venture based on the business sector, business model, competition (and competitive advantage), and relationship to a sector's value chain. One helpful strategy tool is the entrepreneurial strategy compass, which consists of several strategies for startups [78]. One needs to consider whether the firm is (1) engaging a market rapidly, (2) fit in within a value chain, (3) develop a new value chain, and (4) employing an IP approach [78]. Another helpful strategy includes a stage-gate system for evaluating the ability to achieve technological or regulatory milestones in sectors involving significant technological, regulatory, financial investment, or time-based risks [62]. Furthermore, there is value in using a business plan in sectors (or points in development) where there are limited market (or technological) uncertainties or that the entrepreneur has them resolved [62].

Focus on what investors seek

The fourth considers the focus on what the investors seek. While the lean startup centers on addressing customer needs, testing products, and validating a repeatable business model, it does miss a few vital elements that investors may seek. Kressel and Winarski [59] emphasize several critical success parameters that the lean startup might not adequately address. The first involves a substantial market opportunity with swift growth potential. Another is an outstanding team that can implement. The next considers a differentiated technologic or business solution (i.e., competitive advantage) that exceeds what is offered by competitors. The final piece points to a value proposition that delineates a new venture's value, strategy, and implementation/operational efforts.

Remember to focus on meaningful outcomes

The final area relates to being oriented to economic performance and critical commercial milestones. The lean startup tends to focus on interim metrics that tie in with the experimentation process [29,33]. While this practice is valuable, entrepreneurs need to consider the actual commercial outcomes tied with new venture performance rather than interim metrics as leading indicators. That means the entrepreneurs need to set milestones that include customer acquisition, customer trial and acquisition, customer acquisition versus total customer potential, confirmation of the business model, revenue, time to the first customer, revenue, profitability, growth, and survival. Such metrics extend beyond (and are more meaningful) than such interim metrics, including winning pitch competitions and gaining investor resources. Work by Camuffo [76] and Ghezzi et al. [1] provide useful examples of meaningful endpoints that the entrepreneur should incorporate into one's dashboard.

Conclusion

This paper examines three relevant questions concerning the lean startup methodology. These focus on considerations around (1) what limitations exit with the methodology and/or its use; (2) what is the methodology's impact on performance outcomes; and (3) what learnings can practitioners and educators employ as part of the startup efforts. To this end, there are several conclusions to draw.

First, this analysis finds that limitations do exist. Observations from case studies, consultants, practice pieces, and scholars raise concerns with several essential components. These issues relate to elements within the framework (e.g., customer discovery, experimentation, and MVP) and their proper use in practice. Furthermore, some of the considerations related to proper implementation might be related to cultural considerations. To this end, entrepreneurs and educators should critically examine the lean methodology, consider the business space in which it adds the most value, and take vigilance to ensure that entrepreneurs are rigorously employing this approach.

Second, concerning outcomes associated with the use of the lean startup, the literature is not equivocal. This finding is due to the diverse methods, populations, endpoints, and business sectors. These also reflect a mix of anecdotal and a limited number of peer-review studies. However, work by Camuffo et al. offers a glimpse of the potential of the lean startup and its use. It emphasizes that (1) rigorous educational and coaching efforts by academics and mentors and (2) strict implementation by entrepreneurs can lead to significant differences in discarding poor ideas, the number of pivots, and the realization of revenue (and earlier). Still, more work is needed to see whether such observations apply to business sectors beyond that studied (furniture, Internet, and retail) and to longer-term, more sustainable endpoints.

Third, this discussion, based on the evaluation of evidence from the first two questions, offers several practical learnings for entrepreneurs (and their mentors and teachers) to consider when deciding to utilize this entrepreneurial approach. These points for practice relate to (1) education and implementation, (2) consideration of internal and external influences, (3) application and use within appropriate business sectors, (4) focus on what investors seek, and (5) focus on meaningful outcomes. Practitioners should consider some of the recommendations offered when utilizing this methodology to optimize their experience and outcomes. To this end, entrepreneurs, educators, and mentors should consider the recommendations to ensure this methodology's optimal use in practice and educational programs.

In closing, there is a significant need for further research. Quantitative work, which employs rigorous controls, may address the outcomes' question to offer greater clarity and dissect the methodology's impact versus its implementation (along with associated influences). Qualitative work can help dissect the underlying factors that influence the methodology use and contextual factors within and outside the startup. Such work will help to define the real impact of the lean startup on startup success more clearly. More importantly, these

findings will help educators and mentors help entrepreneurs understand and implement the lean startup and other appropriate strategies to enhance their abilities to achieve positive long-term, sustainable outcomes.

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