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Facilitating Long-Term Mentoring To Effectively Implement Active Learning Instruction: Formation of the Promoting Active Learning and Mentoring (PALM) Network†

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A large body of data suggests that implementing active learning practices in a STEM classroom contributes to increased success in both achievement of student learning outcomes and retention of students. Despite these findings, significant barriers exist for instructors implementing active learning strategies in their undergraduate classrooms. These barriers can be effectively addressed by providing sustained support to instructors and postdoctoral trainees interested in implementing active learning strategies in their teaching practice. The Promoting Active Learning and Mentoring (PALM) network attains this objective by connecting instructors interested in learning more about active learning (Fellows) with individuals who have extensive expertise related to this practice (mentors). These facilitated connections occur in the form of active mentorship for a year or more, virtual journal clubs, and biannual gatherings of PALM Fellows and mentors. Here, we describe the foundation on which PALM was built and explain how a successful mentorship program can pave the way for educators to adapt and implement evidence-based practices like active learning in a college classroom.

INTRODUCTION

Across all STEM disciplines, evidence strongly suggests that active learning (AL) instruction promotes better attainment of student learning objectives, improves student retention, and reduces the achievement gap for underrepresented populations (1–4). As a result of this, current and future instructors may be inclined to consider implementing AL practices into their courses. The *Vision and Change* report (5) recommends that instructors focus on student-centered learning and AL practices in their teaching, and implementing this focus has caused a paradigm shift in the way many instructors think about effective instruction.

For instructors to successfully experience the benefits of AL instruction in their classrooms, they must have training and support in the design and implementation of pedagogically sound curricula (6–8). Many institutions have centers for teaching and learning that offer professional development programs in AL to faculty, postdoctoral trainees, and graduate teaching assistants. However, these opportunities are often limited to seminars or one-time workshops that do not offer the coaching and feedback about evolving teaching practices that are vital for instructors to understand and effectively implement classroom strategies (9, 10). Funding from federal agencies has led to more extensive opportunities to assimilate AL-based instruction methods. These opportunities include the Center for the Integration of Research, Teaching and Learning (CIRTL, https://www.cirtl.net/), the National Center for Case Study Teaching

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in Science (NCCSTS, https://sciencecases.lib.buffalo.edu/about/), the Partnership for Undergraduate Life Sciences Education (PULSE, https://pulse-community.org/), the National Academies/HHMI Summer Institutes (https://www.summerinstitutes.org/), and the Science Engagement for New Civic Engagements and Responsibilities (SENCER, (http://sencer.net/) Initiative, all of which focus on developing skills in teaching with empirically proven effective practices.

Developing instructors effective in AL through mentorship: Overcoming barriers, embracing supports

Peer mentoring has emerged as a potentially powerful way to successfully promote AL training and support instructor needs (11). However, this mentorship cannot be piecemeal in its approach. D'Avanzo (9) and Gormally et al. (12) emphasize the need for instructors to receive coaching and feedback about their teaching and note that attending one-time workshops or seminars is not enough for instructors to understand and implement effective teaching practices. The National Academies of Sciences, Engineering, and Medicine (NASEM) committee on the Science of Effective Mentorship in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) calls for an evidence-based approach for mentoring undergraduate and graduate students (13). We assert that instructor mentoring begs a similar approach, and that a one-on-one long-term relationship with an experienced mentor is instrumental to fostering effective AL practices. We also emphasize the importance of utilizing the experience of a variety of instructor mentors, from those who have demonstrated effective AL to those who are versed in educational assessment methodology and can help collect, analyze, and interpret evidence of the impact of AL approaches. This evidence can be helpful for evaluating the efficacy of new teaching approaches, supporting one's promotion, or convincing fellow instructors and university administration of the benefits of AL.

Several potential barriers hinder the establishment of successful mentorships. Instructors at smaller institutions may have no suitable mentor options with the expertise needed for one's specific course or approach and some may be in departments in which evidence-based instruction is not valued. Even in cases where all needs for mentoring, validation, and support are met, other internal and external barriers may exist that prevent instructors from utilizing available resources to transform their teaching. For instance, teaching strategies are deeply personal for many instructors, thereby causing any assessments of teaching to be taken as a personal judgment (14). A junior instructor may feel intimidated by mentorship from someone in the same department or institution who has a say in their career advancement, while a senior instructor may feel awkward being mentored by someone in their department who is more junior yet more experienced in evidence-based AL. These cases suggest a need to look externally for a mentor through a professional society or a program focused on AL instruction; however, without any guidance, this can be overwhelming. Fortunately, research shows that supports like an encouraging community tend to outweigh perceived impediments to implementation of AL (15, 16).

Small-scale efforts from life science professional societies, like the Mentoring in Active Learning and Teaching (MALT) Initiative and the Master Educator Program (MEP) from the American Society for Cell Biology and the American Society of Plant Biologists, respectively, have sought to aid in the formation of successful mentorships (10). These two programs (now ended) allowed participants to work with experts over an extended time to develop the skills and confidence necessary to succeed in classroom reform. Another model long-term instructor mentoring effort can be found in the social sciences and humanities operating through the Central European University (17). This is an international virtual network of mentee and mentor pairs that targets newly hired instructors.

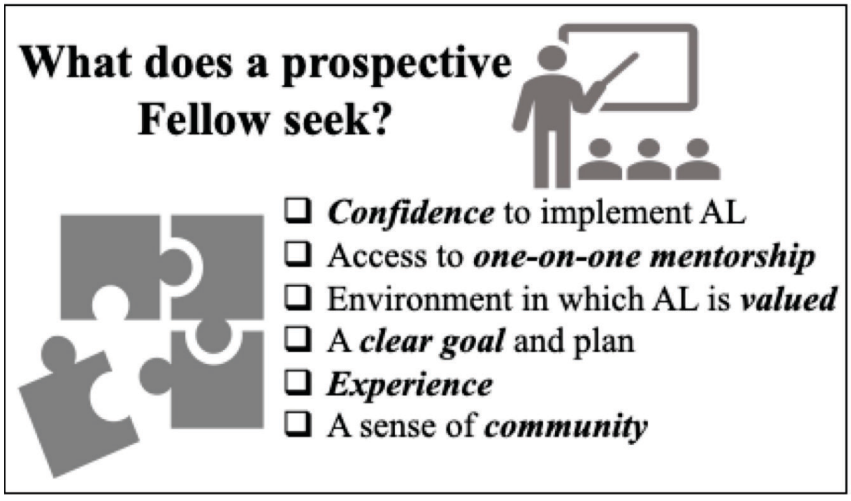

FIGURE 1. Prior to training, instructors typically seek one or more of the elements listed above that contribute to the successful practice of AL.

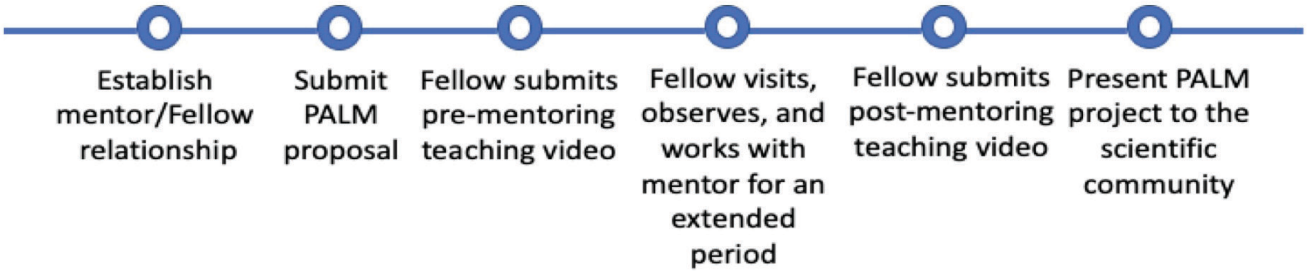

FIGURE 2. Timeline for a PALM mentorship. The mentor/Fellow relationship may be pre-existing or facilitated by PALM. The PALM program scores pre-mentoring and post-mentoring videos using the Classroom Observation Protocol for Undergraduate STEM (COPUS) (21) for instructor and student activity in the classroom. The mentorship proceeds according to the needs and the timeline of the mentor and Fellow.

In response to the need for a wider approach for providing effective mentorships in AL, the Promoting Active Learning and Mentoring (PALM, https://palm.ascb.org/) network was created in January 2016 as a National Science Foundation (NSF)-funded Research Coordination Network in Undergraduate Biology Education (RCN-UBE). PALM began as a joint venture of several life science professional societies (see Appendix 1) and has expanded its reach to instructors in other STEM fields who teach biology undergraduates, including general and organic chemistry. Here, we describe how the PALM network provides professional development support in the form of a mentor matching process, an extended mentoring relationship focused on AL development and implementation, and access to a collaborative and encouraging community of instructors with varied specific expertise within AL. Typically, prospective Fellows (the designation given to mentees in PALM) enter the program seeking support, sustained mentorship, and the opportunity to reflect on their teaching and expand their AL practice (Fig. 1). These mentorships have been important for the career development of postdoctoral trainees and instructors (18, 19) and display characteristics of mutually beneficial instructor mentoring programs (20).

HOW A PALM NETWORK MENTORSHIP WORKS

Interactions between individual Fellows and their mentors: The benefit of individualized attention

A PALM network mentorship begins by establishing a partnership between a current or future instructor who wishes to learn how to incorporate AL into their classroom and an instructor with extensive experience implementing AL who is willing to serve as a mentor (Fig. 2). While some prospective PALM Fellows recruit their own mentor, many rely on the PALM network to provide a few recommendations from a curated list of instructors who have volunteered to be PALM mentors. These volunteers have either been recruited directly by PALM leadership or responded to a broadly disseminated call for mentors. Since working with mentors they did not recruit themselves can be challenging for Fellows, prospective PALM Fellows reach out to mentors recommended by PALM leadership to explore whether there is potential to build a productive partnership before making their final mentor choice. Criteria typically considered when matching mentors and Fellows are: course topic, size, configuration of classroom, and any specific AL methods the Fellow would like to learn (Fig. 3). Geographic distance is not a primary consideration or challenge (Fig. 3) since much of the mentoring can occur virtually and PALM provides funds for Fellows to travel to observe their mentors.

Once a mentorship pair is established, the Fellow and mentor submit an application to the network describing their prospective plans, timeline, and budget (https://palm.ascb.org/process/). After Network Steering Committee members evaluate the application following the PALM rubric (see Appendix 2), the mentorship proceeds according to the specific needs and timeline of the Fellow/mentor pair (Fig. 2). Since each Fellow will have interests and needs specific to their classes, the PALM network does not designate any specific procedures or techniques to be used in the mentorship. This provides significant flexibility for the Fellow/mentor pair in their activities. For assessment purposes, Fellows submit pre- and post-mentorship videos of themselves teaching a class targeted for reform (Fig. 2). A trained and impartial PALM employee scores the videos for instructor and student activity according to the Classroom Observation Protocol for Undergraduate STEM (COPUS, 21). Additionally, some Fellows and mentors use the videos and the subsequent analysis of activities for reflection and planning for future iterations of AL exercises.

Interactions between individual Fellows and their mentors: Experiences of PALM pairs and dissemination of PALM projects

The PALM network offers a unique opportunity for Fellows to learn and develop AL strategies and implement them into their teaching. Because of the flexible nature of PALM, prospective Fellows can begin their AL journey at any level of expertise and work at their own pace (Fig. 3). PALM fellows enter the program with a range of expertise in AL instruction—at one end of the spectrum are those who have never tried AL and at the other end are those who conduct research in AL (Figs. 3 and 4). Some Fellows join the network

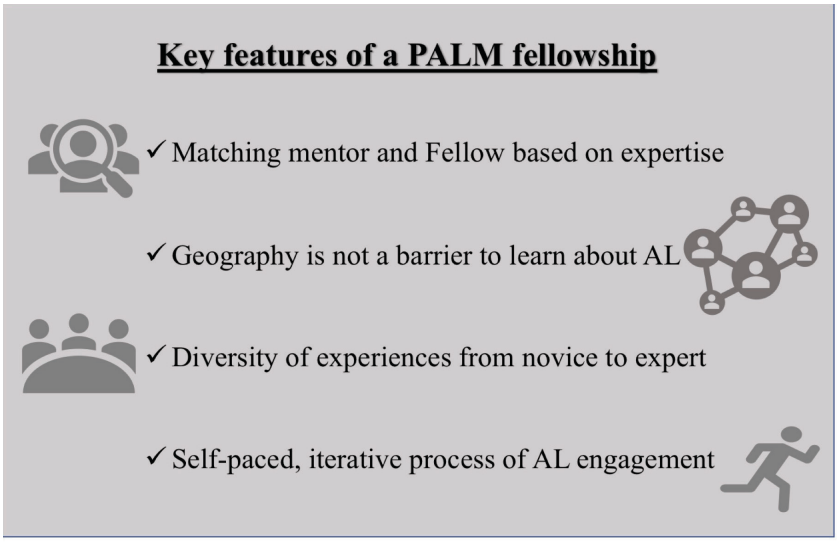

FIGURE 3. Key features of the PALM fellowship. The PALM network strives to provide a flexible and practical platform for instructors to begin and continue their AL journey.

seeking help to effectively implement a technology, such as classroom response devices or clickers, or an instructional strategy, like problem-based learning, into their classroom. Other Fellows seek help developing plans on specific topics or lessons. While visiting the mentor's institution, the Fellow may observe their mentor or their mentor's colleagues using a specific technique or technology in their class to get ideas on how they may implement it themselves.

The flexible PALM mentorship model provides Fellows the freedom to navigate their own journey through AL teaching. PALM AL projects have encompassed a myriad of new ideas in teaching, including using music as a way to make learning inclusive, gamification, student production of animations, molecular model construction, collaborating with engineering departments to teach physiology, and development of an AL assessment tool to increase student buy-in. Providing support for instructors to develop resources for their own courses creates an authentic professional development experience. Here we highlight the representative experiences of two PALM mentor/Fellow pairs.

Example 1. A junior faculty member at a large southeastern public research university was mentored by a senior faculty member at a smaller northeastern liberal arts college. The Fellow had considerable expertise in teaching bioinformatics and metagenomics to STEM majors. The mentor, a SENCER leadership fellow, teaches primarily nonscience majors about microbiomes and evolution using AL approaches that tie content to social and civic engagement. Besides tying learning to real-world issues, the mentor is also skilled in leveraging AL to assess student learning gains. The mentor and Fellow communicated through weekly emails and met virtually once a month. The mentor was able to assist the Fellow in exploring ways to infuse more discussion and collaborative work into their upper-level metagenomics course. During the visit to the mentor's class, the Fellow had an opportunity to witness how to use whiteboards to implement AL strategies among groups of students. The Fellow and mentor also discussed how to improve the Fellow's course to create student-produced notes to be used as an open educational resource. The mentor–Fellow pair has submitted the lesson plan for this assignment for publication. They plan to collaborate again on a project based on bringing social and civic engagement into microbiome courses at all levels.

Example 2. An adjunct faculty member [now tenured] at a midwestern community college was mentored by a senior faculty member at a mid-sized university in California who has extensive knowledge of AL and biological macromolecular modeling. The Fellow had explored using some AL approaches in their introductory biology classroom. The mentor, a PULSE Fellow, teaches a wide variety of biology courses, including introductory genetics, molecular biology, and advanced genetics. The Fellow was interested in creating both a case study focused on sickle-cell anemia and a protein model of hemoglobin with and without the sickle-cell mutation. The mentor and Fellow communicated through weekly virtual meetings and via e-mail. With funding provided by PALM, the Fellow attended the NCCSTS Summer workshop where they wrote a case study about ethics and a sickle-cell anemia patient. The mentor and Fellow then collaborated on an online model of hemoglobin in individuals with and without the sickle-cell mutation. The Fellow visited the mentor at their home institution to observe them teaching upper-level genetics courses in an AL classroom using online software to pose challenging genetics problems for students to collaboratively solve. The Fellow also presented their research to the campus community in a public seminar during this visit. After successfully using the case study in their classes, the Fellow has disseminated it to other interested instructors and has also presented a ten-week professional development workshop about AL strategies to STEM instructors at their institution. The Fellow published

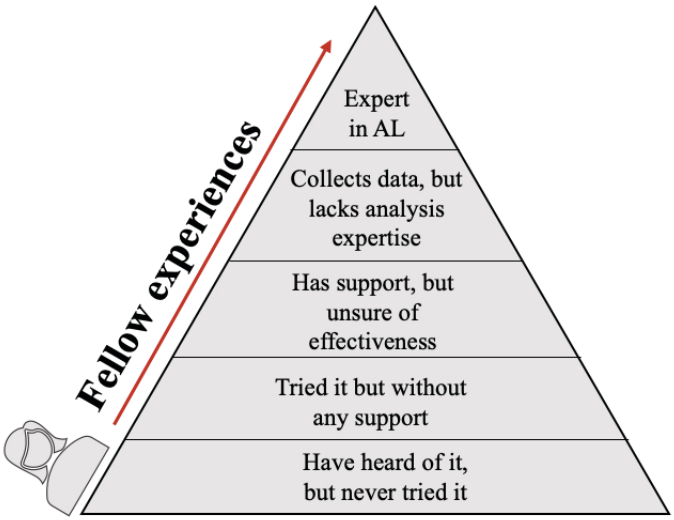

FIGURE 4. PALM Fellows can begin their fellowship at any experience level of AL as represented in the pyramid. The level of expertise achieved is determined by the Fellow's interests and career aspirations. PALM strives to create a continuum of combined expertise in the network instead of enforcing fixed individual milestones for AL. PALM also recognizes that these aspirations and interests are not static and may shift as Fellows engage with their mentor and the larger PALM network.

the hemoglobin model in a library of online macromolecular visualizations and is preparing the case study for publication.

Overall, PALM Fellows have reported that their mentorships have provided them with the support and confidence necessary to try new techniques in their classrooms. Both mentors and Fellows have reported learning from observing teaching in different kinds of institutions and learning new course organization and AL strategies. In addition, several PALM Fellows state that their mentorships have allowed them to become more reflective and make informed, data-driven teaching decisions. Positive interactions such as these will fuel innovation in AL and positively impact student learning in universities around the country.

Interactions between all mentors and Fellows: The benefit of mentorship within a network

The PALM network provides a foundation to support the growth of all participants as educators and teacher-scholars by helping them learn, implement, and sustain their use of AL (Fig. 5). This support is vital when facing common challenges like departmental resistance to AL, activities not going as planned, or problems with assessment. Having access to experts allows Fellows to get actionable feedback on their PALM projects, support when experiencing challenges to AL implementation, and ideas on how to assess project impacts (Fig. 5). All Fellows and mentors are encouraged to participate in monthly virtual journal clubs and discussion sessions to keep them up to date on current literature in AL. Discussions on seminal papers supporting the effectiveness of AL are used to promote awareness of evidence-based approaches and best practices critical for those new to AL. These meetings allow for the sharing of experiences and the exchange of ideas and also facilitate additional networking among PALM participants (Fig. 5). Biannual in-person and virtual network gatherings allow participants to gain perspective from multiple instructors on the types of lessons/activities they can use in their classrooms and can potentially spark new ideas and collaborations. A key feature of these gatherings is that all participants are valued equally for their input and recognized as equals no matter their level of expertise. Equally valuing all participants is an essential component of making a professional event more inclusive, beneficial, and successful (22). Additionally, at these gatherings, challenges are discussed and ideas shared as to how the network may be strengthened and improved.

An important element of PALM is the dissemination of what the Fellows have produced during their mentorships (Fig. 2). Since 2016, PALM network members have presented at their own institutions and at local and national conferences more than 40 posters and oral presentations reflecting the diversity of backgrounds and experiences of Fellows and mentors (https://palm.ascb.org/publications-and-presentations/). These presentations not only attract potential Fellows but also provide instructors with specific, practical ways to embed AL in their courses. PALM projects also have been published in a variety of venues targeting instruction (23–27), including in peer-reviewed journals like *CourseSource*, *The Journal of College Science Teaching*, and *Advances in Physiology Education*.

For some, these dissemination efforts count towards tenure and promotion requirements and enhance hiring decisions. Fellows have specifically credited their experience in PALM in helping them obtain faculty positions, move to

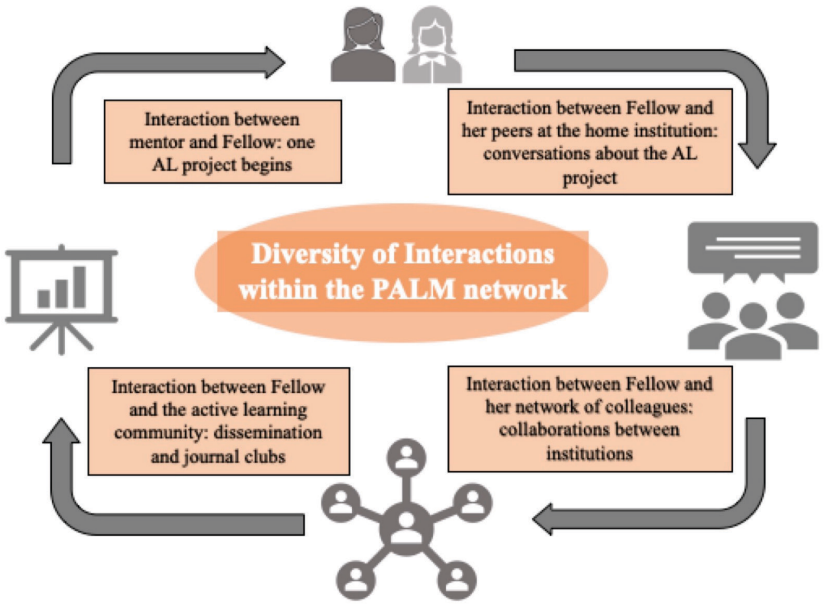

FIGURE 5. The PALM fellowship facilitates a variety of interactions that promote AL while expanding the network of instructors seeking feedback on AL practices. These interactions create a feedback loop to not only improve the AL practice but also expand the network of practitioners.

more secure faculty positions, and win over tenure committees. For example, one Fellow recounts:

> I just learned that I was granted tenure … The PALM fellowship totally transformed my career here.… Now I teach some of the best-reviewed courses on my campus, the kind of course I wish I could have taken as an undergraduate. Although my department was resistant … at first …, my students' enthusiastic response as well as my own validated assessments (which I learned to use because of PALM) won over the Rank and Tenure Committee.

THE PALM NETWORK: INSIGHTS AND FUTURE DIRECTIONS

Over the past four and a half years, the PALM network has evolved into a community of practice involving 41 Fellow–mentor pairs distributed across the country, with Fellows coming from 20 states (https://palm.ascb.org/fellow-mentor-pairs/). Several tactical approaches have helped the network grow over time. These approaches include improving visibility in the STEM education community via presentations, collaborations, and dissemination, recruitment of new applicants by word-of-mouth from mentors and Fellows in their professional networks, and the aforementioned virtual and in-person working sessions to discuss the work of PALM. Some of the most important indicators that the network has been developing successfully include growth of mentor and Fellow numbers, increased momentum and attendance at monthly journal clubs and pedagogical discussions, and novel professional interactions among network members independent of mentor–Fellow pairs, including invited lectures and workshops. These professional interactions highlight the diversity of directions available to Fellows to take their project after their mentorship (Fig. 6).

A number of future directions arise from the network's prior efforts. One proposal is to seek funding for an integrated STEM mentorship program, with instructors at participating institutions working across disciplines to coordinate evidence-based teaching. Some members have indicated an interest in investigating the mentorship experiences of PALM Fellows from diverse academic, ethnic and career backgrounds to examine their motivations to pursue the PALM fellowship and the outcomes of their respective projects.

The PALM network provides a working example of how mentorship, collaboration, and strategic support can convene communities of educators around a central goal or theme. Members of the PALM network are committed to cultivating thoughtful science educators who innovate and implement evidence-based educational practices in their classrooms to improve teaching and learning. We intend for this model to foster the efforts of others interested in developing similar communities.

SUPPLEMENTAL MATERIALS

Appendix 1: Professional societies that collaborated to submit the grant proposal to fund PALM
Appendix 2: PALM evaluation rubric

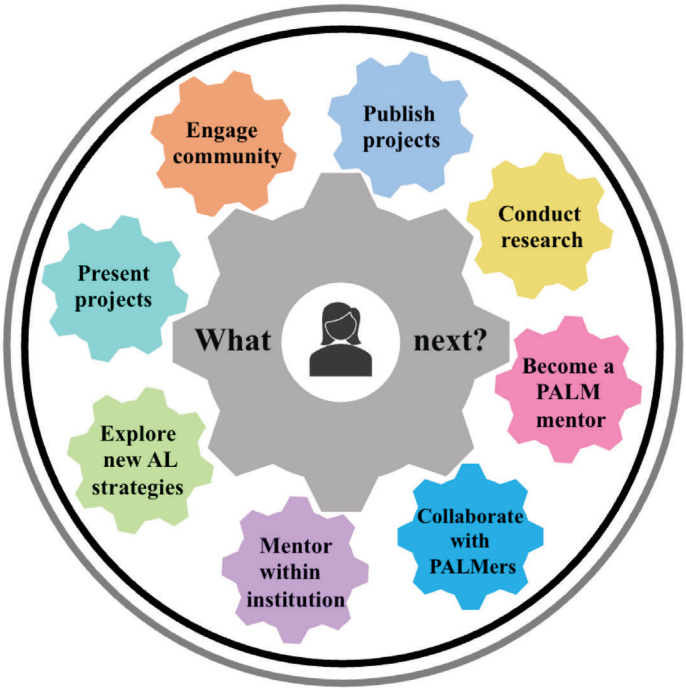

FIGURE 6. Potential opportunities for a PALM Fellow. At the end of the PALM fellowship, a PALM Fellow has several avenues to explore. As a member of the PALM Network, the Fellow can continue to pursue AL in many ways, as represented here.

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