ACCESS

An Integrated Service Platform for Preparing Future Workforce

WHITE PAPER
Version 1.1

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Executive Summary

With the advance of new technologies, such as robotics and artificial intelligence (AI), the demand for skilled workers is changing dramatically in the global economy. It is an important mission to nurture the workforce by enhancing their skills, and workforce reskilling will have profound implications for government, business, and economy. Therefore, strategic investment in continuously retraining and upskilling American workers is an urgent business priority for corporations and the U.S. government. Tackling this challenge requires coordinated efforts from employees, employers and policy-makers. To date, however, workers lack an integrated service platform that enables individuals to search for new jobs, plan for advanced careers, collect resources and feedback from the job market, and pursue continuous education via virtual or distance learning.

The proposed white paper concept, ACCESS (*Advanced Career Compass for Enhancing Skills to Successes*), integrates multiple services to prepare the future American workforce. The new system leverages advanced technologies and aims at providing a *personalized* career compass that provides data-driven job market recommendations and continuous learning strategies. ACCESS not only prepares future American workers for job searching, career planning and continuous learning, but also prepares employers for workforce reskilling and strategic planning.

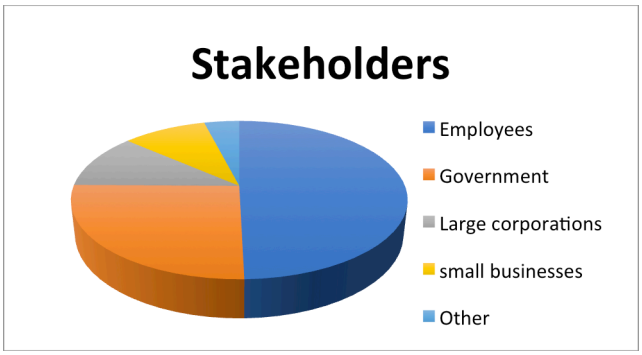
ACCESS provides several key features: personalized resume building, customized job searching and alerts, a data-driven recommendation system empowered by machine learning, career planning, and continuous learning. The system also allows individuals to (i) build professional networks and create learning groups; (ii) build customized curricula for continuous learning; (iii) recommend another user's skill for a specific job; and (iv) integrate with the existing government-supported workforce reskilling and redeploying services (e.g., the Government Effectiveness Advanced Research or GEAR Center). Moreover, within the ACCESS platform, employers can efficiently manage human resources (HR) within multiple government agencies or business branches and design effective job training programs for employees. This may potentially change the functionality of traditional HR department.

ACCESS is a decentralized and secure service that is operated via websites and mobile apps. It can support a large workforce network, or can be managed within a small or restricted network (e.g., the National Science Foundation) through security control. ACCESS also provides opportunities to integrate the platform with other distance learning or professional career networks (e.g., LinkedIn).

We envision that ACCESS will offer a unified platform for stakeholders from both the public and private sectors to modernize the future workforce. Continuous learning and reskilling will prepare the American workforce for career advancement and future challenges in the era of technology revolution.

1. Introduction

In the era of automation, digitalization and AI, the workforce is being confronted by technologies that are changing the landscape of their professions. As the proliferation and capacity of automation and robotics increases, the workforce finds itself with greater and greater competition, and the skills of workforce are required to rise to new heights. The recent McKinsey Global Institute report predicted that by 2030, 14% of the global workforce may need to switch job categories, as the advances in AI, robotics and automation have redefined the world of work [1]. The World Economic Forum (WEF) also predicted that 1.4 million American jobs will be disrupted by technology and other factors by 2026 [2, 3]. Therefore, investing in workforce education and enhancing reskilling and learning programs has become increasingly urgent. However, translating public awareness of this trend into action still requires strategic planning and joint effort from multiple stakeholders, including employees, employers and policy-makers.



For individual employees, lifelong learning and continuous reskilling are not only the key to securing stable employment, but also to building satisfactory careers and seizing rewarding job opportunities. For employers, strategic investment in workforce training is necessary for keeping up with the pace of technology revolution in order to adapt to workforce market trends and maintain a competitive edge. For policy-makers, fostering continuous reskilling and learning across the economy will be critical in order to maintain a labor force with the tools needed to sustain economic growth [3]. To fulfill the common goal of continuous reskilling, through coordinated efforts from both the public and private sectors, a joint force must be formed that would ensure that workers succeed and contribute their full potential to the economy and society.

Although the goal of modernizing the American workforce is a long-term challenge for many stakeholders, the most critical effort starts with individual worker, especially people for whom employment is at risk. However, adult reskilling faces several common challenges (e.g., mental preparation, time constraint, family and employer support). The chance of success in adult reskilling or upskilling highly depends on the individual's prior education, willingness to adapt, access to resources, learning cost, and opportunities for lifelong learning inside and outside the workplace. To help individuals in overcoming these barriers, we propose an innovative and scalable solution that works for individuals of all economic or educational background levels ("universality"), and at any time or location ("mobility"). The new solution is driven by technologies such as big data analytics and AI-powered recommendation systems, which will go beyond the traditional "career path" thinking and "workforce planning" methodology; the new solution will also incorporate agile and experiential development, provide personalized career planning and continuous learning strategies, and account for the user's willingness, experience and skill.

2. Adult Learning and Reskilling

Learning new skills requires changes, and changes cause "cognitive dissonance" in the brain; this is more challenging for adults in their mid-careers. Depending on their age, gender or experiences, adults often use completely different strategies to learn new skills than do children or college students. Above all, time and location are two primary constraints that create barriers to effective education or reskilling; this is particularly difficult for those that must "work" and "learn" simultaneously, or those who need to constantly provide family (parental/financial) support.

According to the late American adult educator Malcolm Knowles, 'andragogy' refers to the specialized pursuit of effective curricular design and instruction delivery for adults [4]. Unlike children, who are primarily passive receivers of others' expertise, each adult learner is unique based on their past background and prior experience, as well as their current work and social status. Adult learners may have multiple advantages over children or young teenagers. For instance, adult learners are more self-directed and goal-oriented in that they are strongly driven by practical needs or rewards instead of pure knowledge curiosity; adults have better focused attention and respond better to familiar tasks; and adults can learn faster by leveraging their domain knowledge or working experiences. On the other hand, adult learners in the workforce also share many disadvantages. For instance, they are slower in acquiring new skills; they may be less unwilling to welcome new concepts or technologies; and daily jobs or family responsibilities create a constant distraction from learning. These advantageous and disadvantageous factors in adult cognition should together be taken into account when preparing the American workforce for learning.

Reskilling represents a mindset shift for individual adults. To create a willingness for change, individuals need to find ways to motivate themselves and realize their own potential. Human psychology and neuroscience will play a guiding role in the construction of effective reskilling methodologies. First, brain circuitry is highly plastic and dynamic, which allows adults to continuously gain new knowledge and acquire new memories. Second, the brain circuitry of the reward system evolves and supports goal-driven behaviors. Third, the brain's prediction circuits constantly develop, which fosters new changes, creativity and exploration. Finally, individuals need to prioritize compassion over compliance. Prior studies suggest that coaching for compliance (e.g., externally set goals) often increases stress level, reduces work efficiency, and triggers stress and cognitive dissonance. In contrast, coaching with compassion (e.g., internally set goals) activates the region of an individual's brain that promotes motivation and gains perspective on a big picture.

To motivate the adult learner, career advancement and self improvement should be a common goal for all workers. Each individual should establish a long-term goal and short-term expectations. Lifelong goals may involve multiple and incremental steps of accomplishment like receiving a promotion, earning advanced degrees, passing professional exams, or getting certificates or licenses. Individuals would have to overcome their own barriers (e.g., lack of time, money, interest, or confidence) and acquire support from their social circles (family or friends) and employer. Learners should also seek positive reinforcement to improve their learning speed and efficiency.

Retention is critical to adult learners. The amount of retention is directly affected by the degree of understanding of the newly acquired information and by application of the information. Since most adult learners have acquired various levels of experience in their specialized jobs, learning can be accelerated by the principle of "transference" or "transfer learning". In other words, individuals can benefit greatly from knowledge association, similarity, and abstraction.

The ACCESS platform aims to incorporate the principles of adult learning and cognition during the course of continuous learning.

3. Categorization and Quantification of Jobs

Jobs are highly diverse and specialized across every field and industry. For the same job title, the job description and requisite qualifications can differ substantially according to the nature and need of the position and organization (e.g., National Science Foundation vs. National Institutes of Health). Take the National Science Foundation (NSF) as a working example; job titles can be categorized by their nature or responsibility in relation to the NSF mission (**Table 1**). For instance, administration positions have the primary responsibility for administrative support of the NSF core mission; executive/managerial positions have the primary responsibility for management of the NSF workforce; science/engineering/education positions are responsible for the delivery of the NSF core mission; and business operation positions share the responsibility for providing operational support to the persons who deliver the NSF core mission.

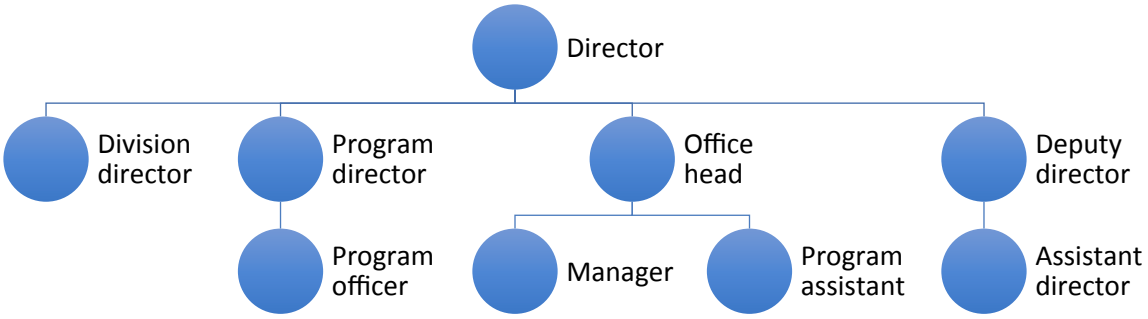
Table 1. Representative job categories and titles at the NSF.

Category	Job titles
Administration	Administrative Manager, Operations Specialist, Program Assistant, Science Assistant, Secretary, etc
Executive/Managerial	Assistant Director, Office Head, Division Director, Deputy Director, etc
Science/Engineering/Education	Program Director, Engineer, Scientist, Educator, Mathematician, Statistician, etc
Business Operations	IT Specialist, Budget Analyst, HR Specialist, Auditor, Attorney, Grants and Agreement Specialist, Program Support Manager, etc

Table 2. Representative job categories and titles at the NIH.

Category	Job titles
Administrative	Administrative Officer, Auditor, Budget Analyst, Contract Specialist, Economist, Human Resource Specialist, Program Analyst, Editor, Purchasing Agent, etc.
Executive	Director, Scientific Director, Deputy Director, etc
Scientific	Data Scientist, Staff Scientist, Physician, Investigator, etc

Jobs are usually defined by their verbal description. However, mathematical descriptions and quantification of jobs are pivotal for several reasons. First, it allows us to represent a job uniquely via both alphabetical and numerical values. For instance, an alphabetical letter could indicate the nature of the job, while a numerical value could represent the job level within each category--with a higher value representing a higher-level job requiring more experiences or skills. Second, it would allow us to construct a hierarchy of jobs based on their "similarities". Data analytics and machine learning tools can be employed in this task. Third, it would allow workers to search for a job efficiently. Finally, it can be useful for visualizing high-dimensional data. Therefore, it would be useful to extract information from the text in job descriptions and represent it in mathematical space (so-called "embedding").



Consider a scenario of switching jobs in the career ladder within the NSF. There may be a transition within each job category (e.g., assistant director→deputy director→director), or a transition between different categories (e.g., program director→division director). The closer the similarity between two jobs in the hierarchy, the less difficult the transition becomes. In addition, it is possible to change jobs between the NSF and other federal government agencies, such as the National Institutes of Health (NIH), including its individual institutes and centers of different biomedical disciplines. Many jobs at each government agency share similar responsibilities (such as the administrative category in **Tables 1 and 2**); whereas some other jobs may fall into different categories. By using advanced machine learning tools, jobs can be further clustered based on their online job descriptions [5]. Ultimately, all jobs are embedded, quantified and linked in a hierarchy based on their similarities, forming an "*Internet of Jobs* (IoJ)".

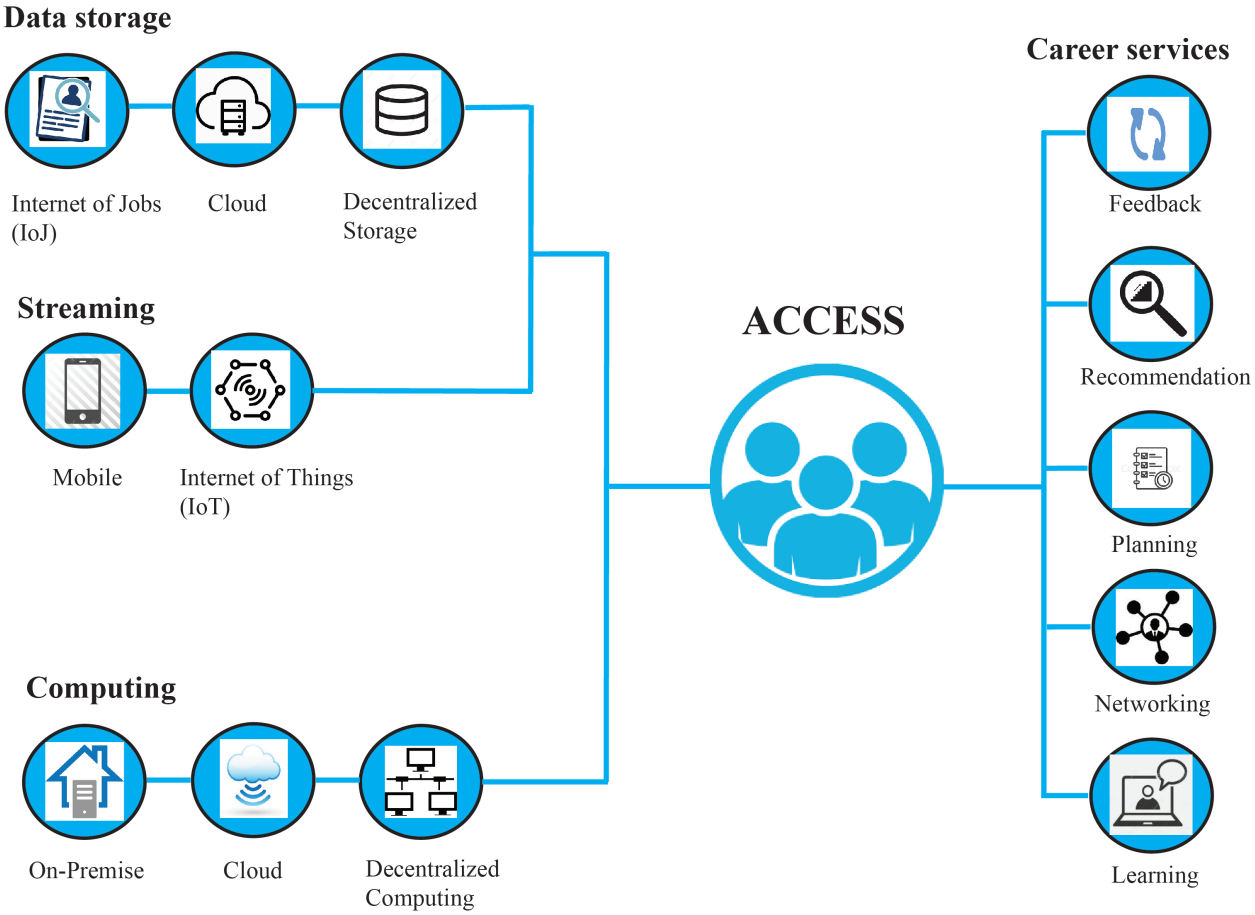
In addition, a skill set property is assigned to each job. The skill set will be also quantified based on the experience or qualification (such as the certified exam).

4. ACCESS: What does It Offer?

As a white paper concept, ACCESS can be viewed as a personal career assistant or a smart app that knows each user's skills, strengths and preferences, incorporates the principles of adult learning, and provides continuous planning and learning.

What is unique in ACCESS, and what are the competitive advantages of ACCESS compared to other professional career networks or learning platforms?

Conceptually, ACCESS provides a novel and unique integrative service platform. First, it focuses on personalized services in terms of job and career development. Second, it focuses on the user's long-term career growth and continuous learning instead of intermediate job application. Third, it exploits big data from the internet (e.g., job postings/descriptions) and provides data-driven job-skill-oriented feedback. Finally, it integrates multimodal and multi-form adult learning strategies supported by advanced technologies.



Technically, ACCESS is innovative in many aspects:

1) ACCESS helps the user construct a job-specific and skill-oriented resume. Depending on the nature of the job, the system will optimize the portfolio presentation based on the provided information.
2) ACCESS allows an efficient job search. Unlike traditional job search engines, ACCESS collects job description information from the government or public websites and matches it with the custom search criteria. The mathematical quantification of jobs also allows efficient matching, ranking, clustering and visualization of the "Internet of Jobs".
3) ACCESS analyzes the discrepancies between a desired job's description and the user's resume and further provides search feedback or recommendations.
4) ACCESS offers career-planning strategies and incorporates key adult learning principles.
5) ACCESS provides multiple strategies for continuous learning/reskilling and points to online resources.
6) ACCESS builds an "Internet of Jobs" and accommodates professional networking.
7) ACCESS provides efficient means for Just-in-Time references or recommendations for specific job skills.
8) ACCESS allows the two user ends (employees vs. employers) to interact in multiple ways, such as job inquiry and assessment of reskilling credit and learning.
9) ACCESS is a web-based service, and uses digital cryptography to protect the user's privacy and secure communications.
10) ACCESS utilizes big data analytics and state-of-the-art machine learning techniques.

5. ACCESS: Architectures and Functions

ACCESS consists of the following functional modules, which together provide an integrated service platform:

1) User registration and login
2) Resume building
3) Networking
4) Job searching
5) Career planning
6) Learning
7) Workforce training

User registration and login

The user can choose the registration role of either employee or employer. The registration or login information will require a unique pre-assigned code

(e.g., government employee ID or government agency code) and follow-up official ID verification through email or phone. In the case of employees, the registered user will provide their personal information (e.g., date of birth, gender, contact information and addresses, with complete current and past employment history). The system will be password protected, in combination with security question protection.

Resume building

The system will help the registered user construct a personalized resume. The basic resume information includes

- Personal contact information
- Education (diploma/degree/certificate)
- Professional membership
- Experience (projects/related publications)
- Skill sets (technical/management/social)

Depending on the job category, users can provide detailed descriptions of specific skill sets. For instance, examples of technical skills may include programming languages, software, hardware, design, engineering, finance, accounting and etc.

Examples of management skills may include team leadership, entrepreneurship, directorship, strategic planning, negotiating and etc.

Examples of social skills may include public relations, communication coordinator, mentoring, organizing and volunteering activities, etc.

User will also be able to add details including but not limited to

- Personal accomplishment (scholarships, awards, honorable mentions, public recognition)
- Public records (publications, patents, copyrighted materials)
- Disability or veteran status if applicable

Networking

Similarly to the functionality of other social networks, the user can invite their colleagues to join ACCESS and establish work connections with them. The user can be an individual, a government agency, or a representative from a corporation or small business. In establishing the network, the user may reveal their work-related history or affiliations with other users; this may include the details of users collaborating on a project as teammates, or their overlapping time within a school/program/corporation/government branch. Registered users can also send messages to the members in their network and make a solicited or unsolicited recommendation of another user's specific skill. Other persons who are outside the individual user's ACCESS network may also respond to messages, such as soliciting a reference, and will be kept on record.

Importantly, for security reasons, each user will have the option in their privacy settings to disable such out-of-network communications.

Job searching

The employee user can search jobs with advanced inquiry options, such as

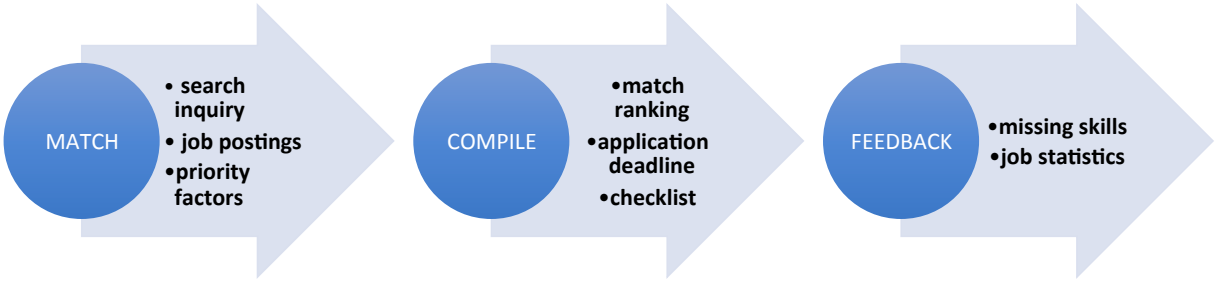
- Job title
- Job location (continent, country, city)
- Job time shift (full-time vs. part-time)
- Job start date
- Job preferences on salary, benefits (healthcare/dental/vision, vacation, parental leave, etc.), compensation (moving/housing etc.)
- Other criteria (work permit, citizenship or immigration status)

The employee user can use AND/OR criteria to fine-tune the search parameters and weigh them according to importance factors. The search engine will automatically search for designated job databases throughout government websites (e.g., www.usajob.gov and www.usa.gov/government-jobs) or other networks (e.g., www.indeed.com, www.monster.com, www.linkedin.com).

In addition, the employer user can search for potential employees with advanced search options:

- Job title
- Job location
- Job time shift
- Job start date
- Job skill qualification and relevant experiences
- Other job requirements (e.g., language, citizenship or immigration status, security clearance)

ACCESS responds to search inquiries in three steps.

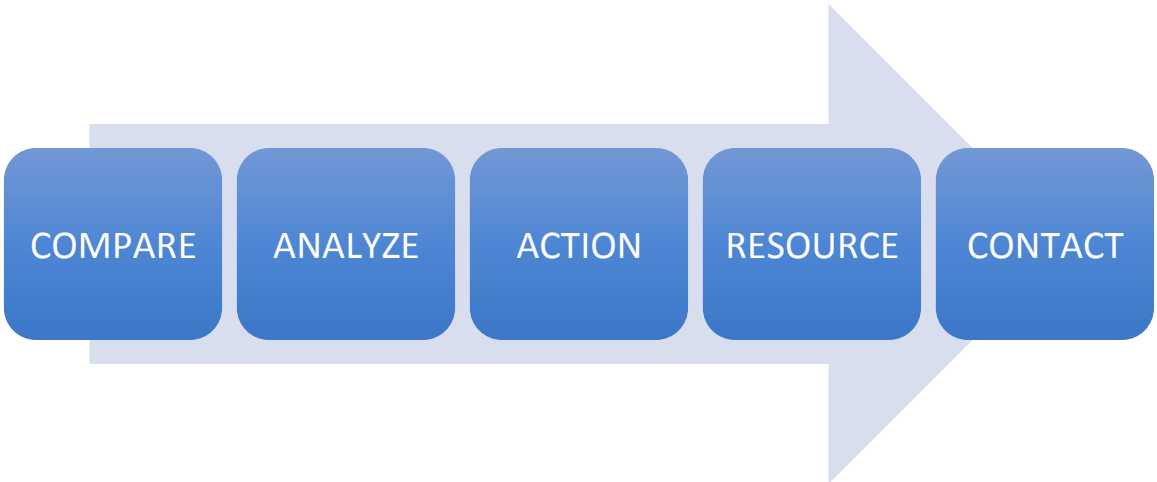


1) MATCH: Once sufficient information is collected, the system will automatically recommend its preferred candidates to the user, ranked by relevance or qualifications. The employer user will be able to check the recommendation list in detail and select candidates for further consideration. If there is no matching job available, the employer user can set up an automatic search frequency (e.g., daily/weekly); the system will send out an email alert when any new job match becomes available.
2) COMPILE: The system will compile the selected list and generate a job-reminder calendar regarding the job application deadlines or checklists. When contact information is available at the employer/employee profile, the employer or employee can also contact the other side.
3) FEEDBACK: Based on the desired job openings and qualification requirements in specific job types, the system will infer the key missing skills for the user (e.g., insufficient experience, lack of specific technical skills) and produce relevant job statistics (e.g., how many minimum years of experience are required for a specific job title in all job listings).

Each of these three steps will be technically supported by data analytics and statistical machine learning algorithms. The user will also have the option to investigate the historical public data on job postings to track trends in job requirements.

Career planning

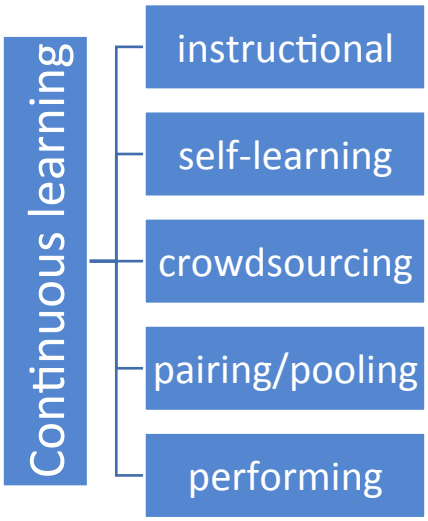
One of the key features of ACCESS is to allow users to construct a career plan based on the feedback from a specific job search. For instance, imagine the following situation. A person wants to become a system engineer, and his feedback collected from the available job listings indicates that he has insufficient work experience or is lacking a specific skill. ACCESS would recommend a career path towards his goal within a certain time frame (short term: <6 months; mid-term: 6-18 months; long term: >18 months). Specifically, ACCESS will construct the career plan in the following steps:



1) COMPARE: The system will generate a blueprint that lists the user's strengths and weaknesses compared to the other (anonymous) job seekers who have searched for similar types of jobs through ACCESS in the past.
2) ANALYZE: The system will analyze the job statistics and point out any gap between the user's skill proficiency and the common requirement in similar job listings.
3) ACTION: The system will recommend actions to establish a career path towards the goal. Examples of actions may include acquiring a new skill or improving skill proficiency, attending online courses, getting certificates, attending networking events, etc.
4) RESOURCE: Depending on the specific need, the system will point to available resources that may help support the actions (e.g., online lectures or course materials, free career consultation, networking event opportunities in professional conferences).
5) CONTACT: Depending on the privacy setting, the system may allow the user to contact users with senior job positions in order to seek career development advice.

Learning

Another important component of ACCESS is its continuous learning program. In the future, many jobs (e.g., accountant, receptionist, library technician, legal assistant) may be replaced by AI-powered robots or automated machines. Therefore, to meet such ever-growing challenges, it is important to enable the workforce to continuously learn and develop new skills using digital or distance learning technologies. ACCESS designs multiple paths for individual goal-directed learning.



1) **Instructional learning**: Because of time, space and resource constraints, traditional classroom learning has been replaced by instructional learning programs supported by online videos and courses through universities (e.g., MIT OpenCourseWare) or public domains (e.g., YouTube, Open University, Khan Academy, Coursera, Udemy, etc). ACCESS will suggest relevant recommendations and online resources.
2) **Self-learning**: Self-education is pivotal for personal growth. Driven by career plans, individuals can set up goals, design learning schedules, and seek feedback and evaluation at different learning stages. Depending on the customized self-learning program,

ACCESS will suggest an educational curriculum, recommend study tasks on a daily or weekly basis (e.g., exercises, computerized quizzes) and monitor learning progress (by sending reminder alerts). The quiz material will be automatically extracted from the learning material in ACCESS. Based upon the learning progress or evaluated outcome, ACCESS will adapt the learning difficulty in follow-up sessions. For positive reinforcement, ACCESS will produce virtual rewards when an intermediate goal is reached at a specific learning stage.

3) **Learning by crowdsourcing**: The individual can learn a great deal from crowdsourcing by asking questions through an online platform. Many existing online platforms (e.g., Reddit.com) and interactive forums (e.g., Codecademy.com for computer programming) have provided effective means to communicate with domain experts, peers or virtual teachers. ACCESS will suggest relevant pointers and online resources.
4) **Learning by pairing/pooling**: Learning can be more motivating with peers who share a similar background or career goal. Individual can form small study groups with common study interests and share their learning experiences. Such examples include online chat, person-to-person meetings, case studies, think-pair-share, peer teaching, and Just-in-Time teaching. ACCESS will suggest learning partners based on their preferred criteria (e.g., location, age, time availability).
5) **Learning by performing**: Learners often learn well by performing tasks. Users can develop multi-level understanding of their learning experiences via classroom teaching, debates and group projects. ACCESS will suggest opportunities for those activities through school education programs or other professional development forms.

Depending on the topic or skill, ACCESS will offer a wide range of learning styles to users. Multimedia instructional resources and instructional feedback will be beneficial to learners, especially at the early stage. At different learning stages, ACCESS will produce quantitative evaluation to ensure that learners reach key milestones.

Prior studies suggest that learning becomes more efficient through positive reinforcement and reward. Learning is hard work, but can also be fun. Sharing learning progress and successes with peers can be positive reinforcement. To increase incentives for continuous learning, credits will be rewarded when a specific goal is fulfilled. In the case of an employer, credits can be used for assessing a job candidate's preparedness or for rewarding the educational effort of employees.

Workforce training

From the employer perspective, ACCESS provides a platform to manage the workforce. Let's use the NSF as an example. The NSF's human resource (HR) department may be able to access the skill sets of all employees within certain NSF divisions. Based on new job requirements, the HR department can design custom training programs for individual groups or employees. Through ACCESS, the employer may also receive Just-in-Time learning feedback that supports further improvement upon the training curriculum.

6. The NSF Model

Let's assume the NSF as a working example model for the ACCESS platform. Imagine that every employee at the NSF has registered and created a profile in ACCESS. All users are directly or indirectly connected at work. As the individual end user, if an NSF employee considers career planning, there are four possible career paths:

1) Linear career path in the same field within the NSF. This type of transition or promotion is mostly determined by experience, skill and performance.
2) Lateral career transition into different fields within the NSF. This type of transition may be driven by duty, need, pay and career potential.
3) Career transition into similar or different fields within other federal government agencies. This type of transition may be driven by opportunities, environment, pay and career potential.
4) Career transition into new fields outside of NSF and other federal government agencies. This type of transition is strongly driven by career development, environment, pay, long-term goals and the big picture.

No matter which career path is selected, the NSF employee would use one of the ACCESS functions (MATCH→COMPARE→FEEDBACK) to better understand the job statistics in the category to be applied to as well as his/her own strengths and weaknesses for the job. The feedback would give a clear picture of whether the NSF employee is qualified and a good fit for the job.

If the NSF employee is qualified for the job, he/she can solicit a reference or recommendation from his/her colleague or supervisor, especially for a specific job skill. ACCESS can process the request and deliver the reference instantly to the hiring division within the NSF or other federal government agency.

If the NSF employee is lacking some skills for the job, he/she can use another ACCESS function (COMPARE→ANALYZE→ACTION→RESOURCE→CONTACT) for career planning. Once the gap or missing skill is identified, ACCESS will recommend a blueprint for multiple actions. The NSF employee can utilize the resources within or outside the NSF, or contact people with better qualifications or skills for career advice. The NSF employee should also take advantage of federal government employee training programs (e.g., on federal leadership development, www.opm.gov), as well as other courses/training/development opportunities offered in private sectors to federal employees. Once the career goal is established, the NSF employee can use the learning module in ACCESS to start the training or reskilling program according to his/her need.

7. Technical Solutions

ACCESS uses web-based, decentralized services for storage, streaming, and computing. Users may access the mobile service through a smartphone or the Internet of Things (IoT). The ACCESS platform will be built upon several core technologies, listed below.

Statistical Machine Learning

- Dimensionality reduction, embedding, similarity quantification
- Predictive data analytics, missing data statistics (e.g., data imputation)
- Document analysis, topic analysis, hierarchical clustering
- Collaborative filtering
- Recommendation system
- Goal-directed reinforcement learning
- Active learning

Software Development

- Mobile app: a Java-based platform for developers
- Web-based cloud computing
- Cryptography for user privacy and secure communication
- Human-machine interface
- Virtual reality (VR) learning
- Distance learning

In summary, the current white paper serves as a basic concept for the solution (Part 1). The second stage (Part 2) will involve recruiting a multidisciplinary team consisting of software engineers, computer scientists and data scientists to develop a prototype of the ACCESS platform.

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