Learning and Identity in Virtual Learning Environments

Iterative Design and Implementation of *Philadelphia Land Science*

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Abstract: In this study, we developed, implemented, and refined *Philadelphia Land Science (PLS)*, a virtual learning environment (VLE) intended to support high school students' exploration of career roles in environmental science and urban planning as a future possible self. *PLS* was developed using *projective reflection (PR;* Foster, 2014) which frames learning as identity exploration over time to inform the design of games and game-based learning curricula to facilitate intentional change in learners' (a) knowledge, (b) interest and valuing, (c) self-organization and self-control, and (d) self-perceptions and self-definitions in academic domains/careers. *PLS* was built by modifying the Epistemic game *Land Science (LS)*. This paper explicates design iterations of *PLS* that were implemented in a science museum in Philadelphia. This work contributes to the burgeoning area of education research that seeks to unleash the potentials of immersive, interactive, and interdisciplinary media forms such as VLEs to promote learning as an ongoing process of identity exploration and change.

Introduction

Scholarly contributions from multiple traditions have examined how participation in the ever-expanding media landscapes through formal (e.g., school), informal (e.g., museum) and nonformal (e.g., community) settings has fueled inquiries into the relationship between learning and identity. For instance, Mizuko Ito's (2009) ethnographic study of American youth engaging in participatory activities afforded by various new media settings revealed how participation in communities of practice can support interest development and changes in one's perceptions and competence in a domain. Other researchers have examined how participation in social media applications can serve as a gateway to help young adolescents' identity development in STEM in their everyday lives (e.g., Kitchen Science, Science Kit, Sci-dentity) and to support their aspirations to pursue a pathway in a STEM field (Ahn et al., 2016). These studies on youth, media, and technology are important as they allow fields to cross over and influence how we theorize, investigate, and distill how young people engage in pedagogical relationships with technologies that may have educational significance (Sefton-Green, 2006).

Recent educational research on identity in virtual learning environments (VLEs) such as games is burgeoning given the media's mass appeal and the pedagogical characteristics of games that can stimulate academic engagement and situate learners in personally relevant experiences (Foster, 2008; National Research Council, 2011). For instance, Fraser and colleagues (2014) explored the associations of 1,502 teenagers (14–18 years old) from across the United States among their science identity (i.e., competence with science content, social performance when engaging in science-related activities, and perception of oneself and validation from others as a science person), science understanding, and gaming preferences. There is growing evidence to support the claim that games can support identity exploration

(e.g., Khan, 2012), and that the resulting identity changes shape academic learning, motivation, and interest (e.g., Cadely, Pittman, Kerpelman, & Adler-Baeder, 2011). However, this area of research is still in its infancy and lacks empirically tested theories that illuminate (a) characteristics for designing identity-exploration opportunities in games and game-based curricula, (b) different trajectories of identity exploration and change that players may enact, and (c) the role of educators and contexts in supporting such processes (Shah, Foster, & Barany, 2017).

In this paper, we introduce a theoretical framework that conceptualizes identity exploration and change—*projective reflection (PR).* We then discuss the framework's use in the iterative redesign of the urban-planning virtual environment *Land Science (LS)* into a new experience, *Philadelphia Land Science*, that more closely aligns with PR constructs to promote intentional student identity exploration and change. Our research question asks: How can projective reflection inform the iterative design of the virtual environment *Philadelphia Land Science* to support student identity exploration and change around urban planning and environmental-science careers?

Projective Reflection

Projective reflection offers one conceptual tool for understanding the way learners engage in self-transformation, or identity change in immersive interactive environments such as games and virtual worlds (see Figure 1). This model integrates a focus on content and on the self through a view of learning as inextricably tied to the self and defines learning and identity in VLEs as the process by which a person engaging in digital gameplay or virtual environment enacts an activity-based identity with the potential to modify the person's learning and identity in this and other domains (Foster, 2014). Projective reflection informs the process of identity exploration as it is measured at repeated points over the course of student learning experiences, thereby tracking learning as identity change across the four constructs of knowledge (Kereluik, Mishra, Fahnoe, & Terry, 2013), interest and valuing (Wigfield & Eccles, 2000), self-organization and self-control (Hadwin & Oshige, 2011), and self-perception and self-definition (Kaplan, Sinai, & Flum 2014), and mapped along six questions: (a) what the learner knows—current knowledge; (b) what the learner cares about—self and interest/valuing; (c) what/who the learner expects to be throughout the virtual experience and his or her long term-future self; (d) what the learner wants to be—possible self; (e) how the learner thinks—self and interest; and (f) how the learner sees himself or herself—self-perception and self-definition (Shah, Foster, & Barany, 2017). These questions are used during measurements of a learner's initial current self, the exploration of possible selves (measured repeatedly over time), and a learner's new self (at a specific end point; Foster, 2014).

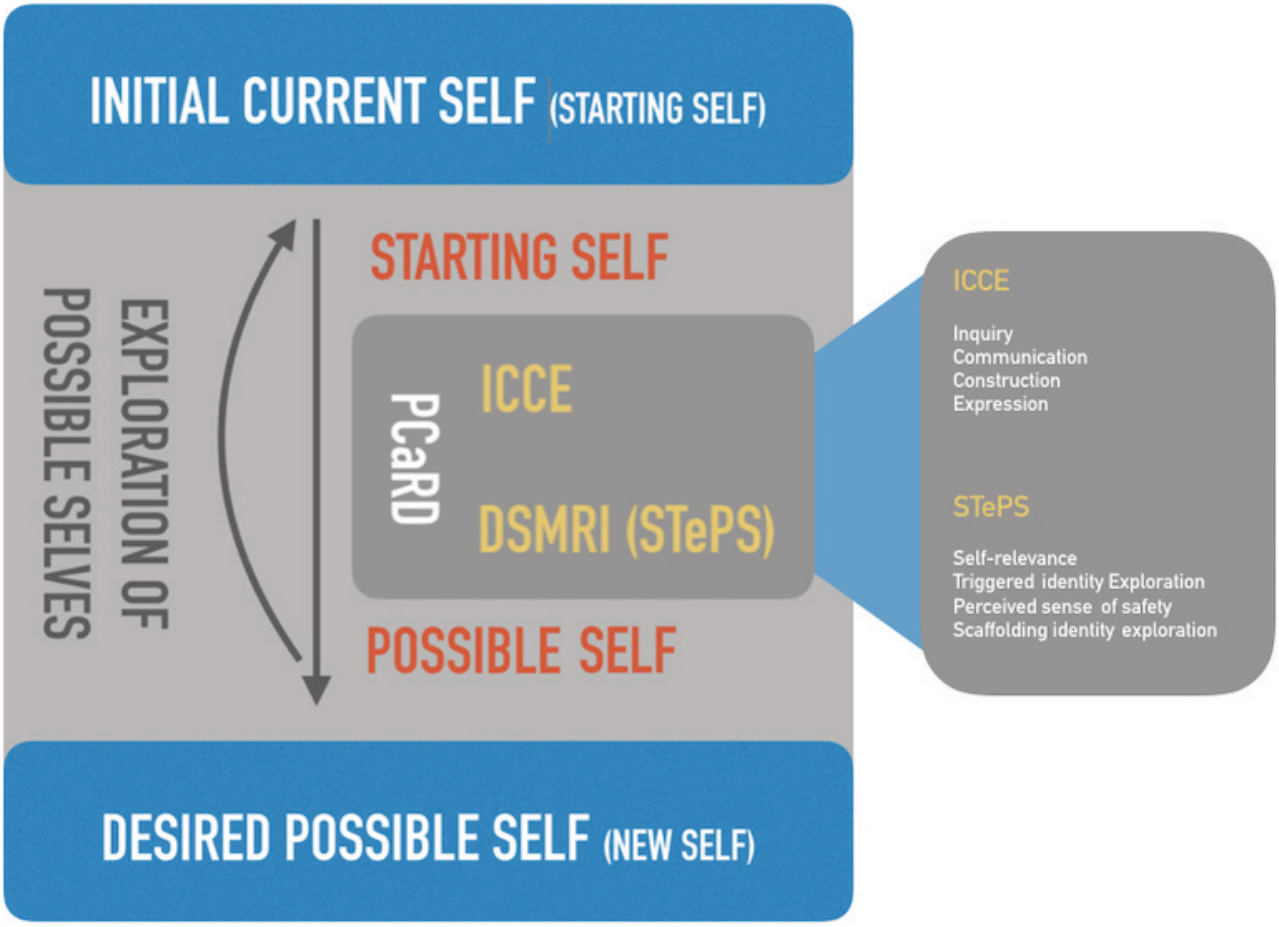

Figure 1. Projective reflection.

The Play, Curricular activity, Reflection, Discussion (PCaRD) pedagogical model for game-based learning offers one way of enacting PR (Foster & Shah, 2015b). Since games are conducive for situated learning experiences, learners engage in identity exploration in a game by role-playing a possible self (i.e., urban planner), an identity they may or may not want to strive for in the future (Markus & Nurius, 1986). During play, students' exploration of the role is guided by the design of the game (e.g., content areas covered) and pedagogical supports within and outside of the game (e.g., mentors). Based on elements of players' starting selves and the extent to which a given game allows for individualized role exploration, curricular activities, reflections, and discussions are designed to draw upon students' funds of academic, personal, and in-game knowledge and experiences to make the identity exploration personally relevant to each student (Silseth, 2018). Designed opportunities for inquiry, communication, construction, and expression (ICCE) underlie students' experiences during play-curricular activity-reflection-discussion. Students are engaged, thus making the process of identity exploration a transformative learning experience in a Deweyan sense (Dewey, 1902; Foster & Shah, 2015a). Finally, in order to best support each student in his or her process of identity exploration, game-play and supportive experiences are designed to be dynamic so as to seamlessly but intentionally promote self-relevance and a perceived sense of safety, while triggering or scaffolding exploration in the academic domain (Kaplan et al., 2014).

Projective reflection can serve as an analytical lens to design games and game-based learning curricula

or retroactively examine identity exploration in completed play experiences. In the past, the extent to which a game-based curriculum using existing commercial and educational games and facilitated by PCaRD supports for projective reflection has been examined with high school students for science, social studies, and mathematics (Foster & Shah, 2016a). Additionally, *Keys to the Collection (KttC)*, a mobile augmented-reality game, was guided by the framework with the objective of stimulating the interest of 9–13-year-olds in the arts through designed experiences for PCaRD in a museum setting (Foster et al., 2017).

Methods

Philadelphia Land Science (*PSL*) was designed, developed, and implemented from 2014 to 2017 as part of an ongoing five-year NSF CAREER project undertaken to advance theory and research on promoting identity exploration and change in science through interactive and immersive environments such as games (Foster, 2014). Early phases of the project involved characterizing the processes of identity change in known exemplary science games/virtual learning environments (*EcoMUVE*—Metcalf, Kamarainen, Tutwiler, Grotzer, & Dede, 2011; *Land Science*—Bagley & Shaffer, 2015; and *River City*—Ketelhut, 2007) that aim to develop science-related user identities. These environments were selected because of the strong line of research and theoretical grounding that influenced their development, testing, and refinement over several years. From 2014 to 2016, the process involved (a) conducting an analysis of the design of the environments for affording identity exploration and change, and (b) examining existing data from complete studies of participants in the environments to learn science and explore science identities. The analysis was guided by constructs that defined the projective reflection framework: knowledge, interest and valuing, self-organization and self-control, and self-perception and self-definition. The procedure for analysis and the designed affordances and constraints for Land Science were identified as a result (Foster & Shah, 2016b).

From 2016 to 2017, the principal investigator (PI) and his team of researchers collaborated with the Epistemic Games Group (EGG) to design an iteration of *Land Science* using the virtual internship authoring (VIA) tool. This iteration of *Land Science*, named *Philadelphia Land Science*, capitalized on the game's existing technological, pedagogical, and content characteristics to support greater alignment with projective reflection constructs. Furthermore, *Philadelphia Land Science* was customized to reflect Philadelphia, the context of implementation. Over 18 months, the collaboration involved visits to the EGG and weekly meetings to receive training in the use of VIA, creating land parcels for Philadelphia, and playtesting the frameboard. The EGG also hosted *Philadelphia Land Science* on its server and online platform (WorkPro Banner), which logged player data. Additionally, some EGG personnel offered real-time technical support during the implementation of *Philadelphia Land Science* at a science museum from October 2016 to March 2017.

Research Design

Philadelphia Land Science was developed, implemented, and refined using a design-based research (DBR) methodology (Cobb, Confrey, DiSessa, Lehrer, & Schauble, 2003). DBR supported cycles of design, enactment, analysis, and redesign as the authors implemented the game in a classroom where the game's technological, pedagogical, and content characteristics were adjusted by subsequent interventions. Each time we used *Philadelphia Land Science*, we examined classroom artifacts (e.g., student survey responses and written reflections) and reviewed researcher observation notes to inform

game and classroom modifications that could enhance learner identity exploration and change related to environmental science. While modifying the game during interventions was not possible, external aspects of facilitating identity exploration were improved based on insights from the application. That is, the Play, Curricular activities, Reflection, and Discussion (PCaRD; Foster & Shah, 2015b) opportunities were modified as needed in response to participants' experience with the game to better support the process of identity exploration. Thus, game improvement occurred in successive cycles of application.

Settings and Participants

Two eight-week courses titled Virtual City Planning were offered at a popular science museum in Philadelphia in 2016–2017 to ninth-grade students from a local magnet school emphasizing science learning. The museum partnered with the school to offer four–eight-week-long enrichment courses during an academic semester. Courses were held for 90 minutes on Wednesday afternoons. Thirty-five ninth-grade students participated across the two interventions. Student groups consisted of 19 girls, 14 boys, and 2 nonidentifying students; 34% identified as African American, while other students identified as Caucasian American, Latino/a, or other. Students played the game in a museum classroom using laptops provided by their school. Class structure typically consisted of an overview of activities, followed by engagement with *Philadelphia Land Science* or other curricular activities until a scheduled 15-minute break, at which point mentors would provide in-game feedback. Students then completed related curricular activities for the second part of class, or continued longer projects.

Roles and Procedure

The team of researchers included the PI, a postdoctoral scholar, three doctoral students, and nine undergraduate students. The PI and the postdoctoral scholar guided all aspects of the project; students modified *Land Science* game content and context to reflect the Philadelphia context, pedagogical structures to further align with PR, and assessments to track identity exploration over time. The overall projective reflection experience was guided by (a) *internal aspects*: in-game experiences within PLS, and (b) *external aspects:* activities that occur in designed spaces outside of PLS, but as a result of gameplay. The PCaRD model informed the design of both internal and external aspects to facilitate the intentional process of identity exploration. Thus, it was essential to design both the internal and external aspects of the study concurrently, ensuring they were in sync. Below we describe design iterations of *Philadelphia Land Science* as a tool for facilitating learning as identity exploration and change in environmental science. *Land Science* is described to familiarize readers with the original game structure, and then characteristics of *PLS* are discussed for iterations 1 (in detail) and 2 (briefly, as it is beyond the scope of this paper).

Land Science

Land Science was conceptualized by the epistemic frames theory, which introduces learners to basic skills, habits, and understanding related to urban science (Chesler et al., 2015), such as scientific modeling and real-world problem solving. *LS* was designed to serve as a virtual internship for students exploring urban planning and related environmental, economic, and engineering concepts. *Land Science* features include: (a) a notebook entry tool where players summarize and justify actions through professional emails to a virtual supervisor, (b) a resources page that offers content knowledge about the city, stakeholders, and environmental and economic issues, (c) an interactive city map connecting player

rezoning choices to environmental and economic effects, (d) a chat log that hosts cooperative mentor-peer meetings, and (e) intake and exit surveys that gather intern feedback. The design of *Land Science* is typical of immersive virtual environments developed around pedagogical praxis or epistemic frames theory (e.g., *Nephrotex, EcoMUVE*) that emphasize the thinking (cognitive), being (civic), and doing (practical) that is essential to all complex learning (Shaffer, 2006).

Philadelphia Land Science—Iteration 1

The design goals of iteration 1 of *Philadelphia Land Science* (*PLS1)* were the intentional facilitation of identity exploration through designing opportunities for changes in what the players know and think, what they care about, how they see themselves, and what they want and expect to be in relation to urban science and environmental science careers. *PLS1* included changes that personalized the game experience for students and optimized affordances of the museum implementation context.

Internal Aspects of Content Changes

Given the demonstrated success of *Land Science* in promoting changes in students' content knowledge, much of the existing game content was either retained in *Philadelphia Land Science* or mirrored to reflect a Philadelphia context. For example, *PLS1* maintained the general expression of city zoning codes and scientific/economic output variables but made changes to represent context. Land-use codes described as single-family, two-family, and multifamily residential were renamed as low-, medium-, and high-density housing to offer more flexible definitions of downtown Philadelphia housing density, as almost all residential areas in Center City qualify as "multifamily." New housing-density descriptions aligned more closely with students' lived experiences in an urban center and illustrated the housing-density nuances more precisely.

Scientific/economic output variables on the interactive map were aligned with the Philadelphia context and starting levels (i.e., gallons of water runoff) shifted to reflect current Philadelphia measurements. Environmental variables related to animal populations in Massachusetts were changed to address Philadelphia native species (i.e., Eastern mud turtles). New content descriptions emphasized the local relevance of these species and illustrated how map changes might affect them.

Land Science included brochures for four fictional stakeholder groups in Massachusetts that detailed their respective values and provided biographies for individual stakeholders so that students could understand and address their needs. *PLS1* designers developed brochures and biographies for Philadelphia groups that emphasized analogous combinations of economic and environmental values:

- The Bridgeway Community Action Association supported low-income families and emphasized housing and environmental issues.
- The Environmental Council of Greater Philadelphia advised on environmental conservation issues such as wildlife protection and pollution control.
- The Philadelphia Economic Affairs Coalition supported economic growth and valued increased zoning for houses and businesses.
- The Philadelphia Institute for Neighborhood Preservation sought to improve citizen quality of life by balancing environmental and economic change.

While *Land Science* included representative nonplayer characters based on gender, race, and ethnic background, *PLS1* capitalized on opportunities to demonstrate diverse employees and leaders in urban planning. Portraying urban planners with whom players can identify is key to the development of possible selves in the domain, as it encourages players to see themselves in a given role and develop domain-specific knowledge (Foster, 2008). In-game diversity also addressed the museum context, as the majority of players were likely to be members of groups currently underrepresented in STEM fields (women, non-White employees).

Internal Aspects of Pedagogical Changes

Land Science was designed with a cyclical pedagogical structure that scaffolded students' progression from one "room" to the next, guiding students through the process of developing urban-planning proposals that gradually allowed students to explore the motivational, cognitive aspects of being an urban planner. In each of the 12 rooms, students reviewed an email that explained upcoming activities, provided context, and outlined deliverables for players to complete and write about in notebook entries. Students reviewed content resources, participated in meetings, made zoning changes on the interactive map, and reviewed stakeholder feedback on map designs. Each room culminated with notebook entries in which students summarized their activities, which were reviewed remotely by instructors, who accepted or returned student work for resubmission.

PLS1 maintained much of this pedagogical structure, particularly as its design authentically progressed players through urban-planning processes. Seven new deliverables were added across the 12 rooms (as informed by PR) that prompted students to consider developing (a) interests and values (i.e., submit "a formal summary of the changes you would make to meet your own needs as a citizen of Philadelphia"), and (b) self-perceptions and self-definitions (i.e., "reflect on your role in this internship and your expectations about this role going forward").

Questions on intake and exit surveys in *PLS1* were designed to assess all four PR constructs; items consisted of short-answer, multiple-choice, and Likert-style questions that took about 30 minutes to complete. Intake and exit surveys bookended identity exploration in the game, allowing researchers to assess players' starting selves and new selves at the end of the intervention; game and classroom data tracked changes between these start and end points.

External Aspects of Pedagogical Changes

Supplemental curricular activities, reflection, and discussion were also designed and implemented in the classroom environment to support a more integrated classroom experience, as supported by PCaRD (Foster & Shah, 2015b). For example, using paper maps and markers, students drew how they would want the city to be redesigned, and then they explained and justified these changes in a whole-group discussion. This activity was designed to foster engagement in the experience and offer an opportunity to construct a rezoned Philadelphia based on individual interests and values. Students also created blog posts to describe the interests and values of one community stakeholder they were working to please. Posts offered advice for peers on how best to meet stakeholders' needs.

Researchers chose to leverage pedagogical opportunities afforded by the classroom space, student proximity, and existing peer relationships. Thus, instead of virtually facilitated meetings structured around a virtual mentor's questions, *PLS1* meetings had in-person facilitators role-playing as urban-

planning professionals, who guided meeting topics and discussions around important points and encouraged socially shared regulation among peers.

Opportunities for student reflection were also facilitated in the classroom experience. The most notable example of this occurred when a role-playing urban planner shared a midintervention class synthesis of students' demonstrated changes in what they know, care about, want/expect to be, and how they think and see themselves; students reflected on how they have changed in these areas. Online blog posts (separate from the game) provided further opportunities for self-reflection.

Internal Aspects of Technological Change

The *Land Science* interface was designed to virtually simulate the experience of working as an urban planner, and most technological features were retained in *PLS1*. Progression of game activities was moderated by remotely situated real-world mentors who initiated emails from a virtual supervisor, answered questions, reviewed students' work, and provided in-game feedback. *LS* also included a chat feature where players held meetings and communicated with peers and mentors. Though these online meetings were translated to in-person role-plays in *PLS1*, researchers retained the chat feature so that players could connect to online moderators if needed. For example, when a student submitted a notebook entry too early, online mentors coached him or her through its retrieval through chat.

LS included example notebook entries that students could reference as they developed skill in professional writing and speaking. Such resources are well suited for the goals of the original game, as they model ways of thinking and acting around urban planning. Review of the *LS* gameplay data showed that students recognized these examples as optimal responses, but some would copy sections of sample text to construct their notebook responses. Given the emphasis on personal reflection and regulated learning practices in *PLS1*, redesign shifted supportive texts from *how* a notebook is written toward *what* players should write in their entries. *PLS1* instead included statements reiterating the deliverables needed for each entry (i.e., "please include a short summary of your experience completing the Entrance Interview").

Philadelphia Land Science—Iteration 2

Gameplay and classroom data from *PLS1* were collected and analyzed to inform the iterative design of the internal and external aspects and further align with the goals of the museum context. *PSL1* built upon existing gameplay structures to add increased opportunities for in-game and in-classroom self-reflection and discussion around possible selves; however, the game with these additions proved to be too long and cumbersome to offer a complete and engaging experience to students in eight class periods. Thus, modifications were designed into iteration 2 of *Philadelphia Land Science (PLS2)* that simplified and streamlined gameplay narratives and processes, while upholding original *LS* goals and developing more targeted intentional shifts in learners across PR constructs. The following list offers an overview of the changes made in *PLS2*:

- *PLS2* included readability changes to in-game text but retained existing content.
- *PLS1* gameplay consisted of 12 "rooms" that iterated student activity through more than 50 distinct "deliverables." *PLS2* streamlined game processes to include 31 deliverables across eight rooms while maintaining intentional alignment with projective reflection constructs.

- Further in-class curricular activities emphasizing reflection and discussion were created with the goal of supplementing game affordances to enhance personal connections, develop contextualized content knowledge, and provide opportunities for student self-reflection. Curricular activities from *PLS1* were also redesigned with this goal in mind.
- To accommodate Internet connectivity issues in the museum, paper versions of all in-game resources, surveys, and activities were developed and included in personalized student work binders.
- Weekly PowerPoints outlined class structure, detailed class activities, and shared technological information.
- Online blog use was discontinued because of time and connectivity constraints.

Conclusion

Projective reflection is an emerging framework that can serve as a lens to examine existing games and inform the iterative design of games for identity exploration and change. The framework stresses the importance of intentionality and focus on the self as inextricably tied to examining identity exploration and formation, and it can demonstrate to educators, researchers, and designers how games can be conducive to examine this relationship. *Philadelphia Land Science* was designed to build upon the strengths of existing virtual internships, most notably *Land Science*, to facilitate projective reflection, that is, an intentional process of learning as identity change that emphasizes knowledge construction, interest and valuing, regulated actions, and self-perception and self-definitions (Foster & Shah, 2016a; Shah, Foster & Barany, 2017). Explication of the design iterations that structured game development offers insights into how projective reflection can inform the creation of virtual environments to support student identity exploration and change around specific role identities or possible selves (e.g., urban planning career). Future research will elaborate on the impact of *PLS* and supportive curricular interventions for promoting student learning, conceptualized as identity change using projective reflection. Further design iterations may also involve (a) the incorporation of a map of Philadelphia that updates to reflect real-time zoning changes, (b) map and game development around specific city sections and/or of the entire city, and (c) the inclusion of more land-use codes and variables to develop value-driven, personalized learning as identity change.

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