

Promoting and Tracing High School Students' Identity Change in an Augmented Virtual Learning Environment

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Abstract: This paper illustrates the application of Projective Reflection (PR) as a theoretical framework in an ongoing NSF-CAREER study to trace learning as identity change among 20 high school students. A 9-week augmented virtual learning environment (AVLE) course, *Virtual City Planning*, was created and implemented in a science museum classroom. In-game and in-class student data and mentor observations were collected and analyzed using Quantitative Ethnography (QE) techniques to identify patterns of identity exploration enacted over time. This paper offers group findings to illustrate general trends of identity exploration during the AVLE, and one illustrative case study to provide an in-depth look at an integrated identity exploration trajectory. This work concludes with a discussion of the need for promoting identity exploration as an educational goal, and a means to support learners to adapt to the changing workforce of tomorrow. The affordances of AVLEs are discussed to advance research in this nascent area.

Introduction

Educational research has increasingly emphasized ways to develop learner skills in *identity exploration*, or the intentional repeated examination of who a learner is and who he/she wants to become (Kaplan & Flum, 2012), which can lead to identity change in targeted directions over time (i.e. change towards a future in a STEM career) (Foster, 2014). Virtual learning environments (VLEs) such as games have been increasingly identified and researched for their potential to support change in both cognitive (i.e. knowledge) and affective (i.e. motivation) elements of self (e.g. Kamarainen, Metcalf, Grotzer, & Dede, 2015). To rigorously leverage these affordances, however, research points to the need for robust conceptual and design frameworks for developing game environments (DeVane, 2010), and the purposeful inclusion of real-world pedagogy that can supplement game content as part of an integrated learning experience (Clark, Tanner-Smith, & Killingsworth, 2015). We refer to this merging of a primarily virtual environment with real-world augmentations as an augmented virtual learning environment (AVLE) (Milgram, Takemura, Utsumi & Kishino, 1994), which integrates the benefits of both worlds to comprehensively provide identity exploration opportunities. Rowsell & Abrams' (2011) I/identity framework offers a useful starting point with its "multidisciplinary approach to mediating I/identity in the 21st century," with consideration for both individual (i)identity change, or "an embedded sense of self that inherently fuels and/or shapes one's behavior" (p. 4), and collaborative aspects of (I)identity change that are "rooted in practices and overt forms of meaning-making" (p. 4) offered by AVLEs.

Thus, in this paper, we illustrate one way of conceptualizing learning as a process of exploring possible role selves through experiences in AVLEs to gain the knowledge and skills to reconstruct oneself through a theory called as Projective Reflection (Foster, 2014). The paper describes the application of Projective Reflection in an ongoing NSF-CAREER study that informed the design and implementation of *Philadelphia Land Science (PLS)*, a text and web-based VLE for exploring environmental science and urban planning roles. The in-game experiences mediated by PLS were augmented by an external in-class curriculum to further scaffold students' exploration of the two roles. Thus, the combination of PLS + the external curriculum was referred to as the Virtual City Planning AVLE, which was offered to 20 high school students over a 9-week period in a science museum in a northeastern US city. Data corpus included in-game logged data, research memos, pre-post interview questions, written and visual artifacts created in-game and during external individual and group curricular, reflection and discussion activities. These data sources were used to examine the following research question: "To what extent did participants engage in an integrated identity exploration in Virtual City Planning as a result of exploring the roles of an environmental scientist and urban planning?" Implications are discussed to advance educational research on framing, facilitating and tracking learning and identity in AVLEs through the use of emerging frameworks such as Projective Reflection.

Theoretical framework

Projective Reflection (PR) is a theoretical framework that conceptualizes learning as identity exploration that facilitates learners' engagement in self-transformation or identity change in AVLEs and explicates the process of

learning as identity exploration over time (See Figure 1) (Foster, 2014). Four theoretical constructs in PR support identity exploration, and structure assessments of learners' cognitive and affective change over time: (1) knowledge, (2) interests and valuing, (3) self-organization and self-control, and (4) self-perception and self-definition (Foster, Shah, & Barany, 2017). Six questions are used to synthesize these changes into a comprehensive characterizations of a learner's initial current self, their exploration of possible selves (measured repeatedly across the experience), and the new self at the end of the intervention (Foster, 2014): 1) what the learner knows – current knowledge, 2) what the learner cares about – self and interest/valuing, 3) what/who the learner expects to be throughout the virtual experience and their long term-future self, 4) what the learner wants to be – possible self, 5) how the learner thinks – self and interest, and 6) how the learner sees him/herself – self-perception and self-definition (see Table 1).

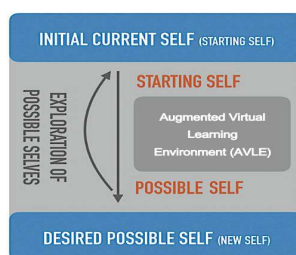


Figure 1. The Projective Reflection framework for conceptualizing learning as a process of identity change over time.

Over the duration of an intervention, a learner is encouraged to engage in targeted and intentional reflection on aspects of self along the four PR constructs, including (a) her/his starting self at the beginning of a learning experience, (b) repeatedly throughout the exploration of possible selves as supported by the AVLE, and (c) her/his new self at the end of the intervention. Furthermore, AVLEs are designed to have opportunities for participants to play, engage in curricular activities, reflect and discuss in relation to the roles explored both in the game and outside (Foster & Shah, 2016). For each student, the process of tracing change is carried out chronologically, guided by the six questions which allow us to explicate the extent to which the learner explored a possible role by developing intentional changes in their knowledge, interest and valuing, self-perception and self-definition, and self-organization and control skills- indicating the extent to which the identity exploration was comprehensive or integrated. In this paper, we report the case of a female student as an elucidation of one integrated identity exploration trajectory over the 9-weeks from the start of her participation in Virtual City Planning (weeks 1-2), during the course (weeks 3-7), and the end of the course (weeks 8-9). Group patterns of identity exploration are also identified to not only better understand the case study, but also to highlight the overall changes in the four constructs informing identity exploration as a result of engaging in the AVLE over the 9 weeks.

Methodology

This research was conducted as part of an ongoing 5-year NSF CAREER project awarded to advance theory and research on promoting identity exploration and change in science using virtual learning environments using Projective Reflection (Foster, 2014). Building on this broader agenda, researchers designed and implemented an AVLE that featured the weekly use of the VLE *Philadelphia Land Science (PLS)* and supportive real-world augmentation in the classroom (for more information see Shah et al., 2018). The resulting AVLE, titled Virtual City Planning was offered to a total of 54 Philadelphia high school students who participated in weekly STEM career programming at their local science museum. *Virtual City Planning* was offered to facilitate learning as identity change by engaging participating students in real-world activities on environmental science and urban planning. *Philadelphia Land Science (PLS)* allowed players to explore roles related to urban planning and environmental science careers as they connect to the Philadelphia context and redesigned/rezoned the map of the city with different stakeholders. In *PLS*, groups of students were synchronously guided by online and in-person mentors to collaborate with their peers in redesigning the map of the city. Building on the strengths of *PLS*, the research team designed real-world features (i.e. non-digital design and reflection activities) that leveraged affordances of classroom context to further support identity exploration.

Three versions of Virtual City Planning were offered from September, 2016 to May, 2017, each successively refined from the previous offering (9-weeks in Fall with 20 students, 8-weeks in Winter with 19 students, and 4-weeks in Spring with 19 students) to strengthen the extent to which the activities in the AVLE could support students' process of projective reflection (Cobb, Confrey, DiSessa, Lehrer, & Schauble, 2003). This paper focuses on the first iteration of Virtual City Planning, which was enacted over nine weekly 90-minute

sessions with 20 students in the science museum. 60% of them were females ($n = 12$), 30% were males ($n = 6$) and the other 10% preferred not to reveal their sex ($n = 2$). They attended a local magnet school which focused on STEM preparation and had several programs for teachers' professional development and students' STEM enrichment integrated with/within the museum.

Procedures and data collection

Data sources included logged in-game data, classroom artifacts, and researcher observations. Once collected, data was organized chronologically by student to track PR changes from the beginning, at repeated points during, and at the end of the AVLE.

Over the 9-weeks, Virtual City Planning allowed participants to learn about the process of proposing a rezoning proposal for the city of Philadelphia that addresses the competing and complementary needs of four stakeholders in a well-balanced manner. Activities in Philadelphia Land Science and outside of it were designed to facilitate intentional shifts in what learners know, how they think, what they care about, how they see themselves, what they want to be and expect to be in relation to environmental planning and urban science. For the first half of the course, learners were assigned to one of the four stakeholder groups to explore specific environmental and/or economic needs of the city. The four stakeholders were Philadelphia Institute for Environment Preservation, Philadelphia Economic Affairs Coalition, Environmental Council for Greater Philadelphia, and Bridgeway Community Action Group. In the second half of the course, students were jigsawed in a manner that every new group had a representative from each of the four stakeholder groups; thus, simulating the real-world scenario of multiple interests and expertise coming together to address real-world issues. The two parts of the course prepared students towards the goal of proposing a rezoning plan.

In Session 1, we engaged players in learning about their teams and understanding the expected workflow of PLS. In this session, we also gathered data to establish students' starting self by way of an intake interview in PLS, background survey, and a focus group discussion. Sessions 2 and 3 required participants to research the stakeholders' concerns from various factions of the city (commercial, residential, environmental, civic, social) and understand what is expected of the urban scientists in the 'request for a re-zoning proposal.' Sessions 4 and 5 engaged players in creating models to create and test the extent to which their re-zoning proposal balanced the needs of the stakeholders on an interactive map of Philadelphia using a mapping tool called iPlan. They received feedback from the stakeholders and their mentors which lead to iterative refinements in sessions 6-8. Data were obtained from sessions by way of in-game logged data (chats, notebook entries, iplan maps, researcher memos) to understand what each participant was focusing on more or less along the four constructs as he/she was exploring the role assigned and those that emerged naturally, and how the participant was engaged in the identity exploration process individually, in participation with PLS, and within the classroom setting (interaction with peers, mentors). Finally, in session 9, players worked towards finalizing a written document explaining the rezoning plan and representing the plan on a map. Data was collected to establish participants new self by way of an in-game exit interview, and a focus group discussion.

Data analysis

Data was coded both inductively and deductively to answer the question of "To what extent did participants engage in an integrated identity exploration in Virtual City Planning as a result of exploring the roles of an environmental scientist and urban planning?" Overall, Quantitative Ethnography (Shaffer, 2017) was adopted to guide the data analyses procedures. First, researchers engaged in a deductive coding process for each case (Krippendorff, 2004) using the qualitative analysis software MAXQDA. Lines of student data were coded as illustrating self-reflection on demonstration of the four PR constructs, with the agreement reached by two graduate-level coders. Thereafter, qualitatively coded chronological data was quantified using a binary approach. Each line was coded for the occurrence ($=1$) or non-occurrence ($=0$) of four constructs in order to prepare the data for Epistemic Network Analysis. Epistemic Network Analysis (ENA) (Shaffer, 2017), a tool that can be used with Quantitative Ethnography, was employed for modeling the structure of connections in the data to look for discernable patterns between the identity of participating students demonstrated at the start, during, and at the end of their participation in Virtual City Planning. This association structure between the changes in their knowledge, interest and valuing, self-organization and self-control and self-perception and self-definition, was modeled mathematically by creating an adjacency matrix based on their co-occurrence in the course over time, by the three data points. As such, ENA offered a unique way to recognize the patterns of identity exploration at both the group (Big I) and individual levels (Little i) for engaging in projective reflection as a result of Virtual City Planning. We referred back to the interactions and activities coded in the data to close the interpretive loop and thus fully understand the phenomenon mirrored in the model for each student and the group at large.

Findings

Group findings are presented in this section as the themes across four constructs of PR: knowledge, interest and valuing, self-organization and self-control, and self-perception and self-definition. Then, individual findings for one case “Andrea” will be illustrated by Epistemic Network Analysis (ENA) and explained.

Group findings

Change across knowledge

Based on the results of the inductive-deductive qualitative coding of student data, three thematic patterns related to student knowledge changes were identified: (1) demonstrations of core content knowledge and problem-solving and critical thinking, (2) shifts from general to specific knowledge demonstrations over time, and (3) connecting new information to existing awareness of situated context.

Demonstrations of core content knowledge and problem-solving and critical thinking. The majority of codes applied to student data identified instances in which students demonstrated core content knowledge gains, such as an understanding of what urban planning is and how it is conducted. These trends exist largely due to the design of the AVLE. For example, the intake survey prompted James to describe what urban planners do, to which he responded: “They collect data about the places around us and get important people to change it.” Similarly, as a result of the design of the AVLE, a large proportion of codes identified instances in which learners engaged in problem-solving and critical thinking by generating solutions to in-game problems, or by offering justifications for their design choices. For example, Alice explained her choice to add more industrial zoning to downtown Philadelphia, saying “people need more places to work and find jobs to work” which supports the affordances of AVLEs for developing meta-knowledge skills.

Shifts from general to specific knowledge demonstrations over time. A review of shifts in knowledge demonstrations over time within individuals reveals a general shift from broad understandings of urban planning and environmental science towards more specific recognition of the complex relationships between domain variables over time. For example, changes in Kimberly’s responses to the question “What factors might an urban planner need to consider when planning/designing a city?” reveal increased specificity and a deeper understanding of urban planning processes from engagement in the AVLE. In week 1, she wrote that urban planners “need to factor in the needs of other people” while in week 9 she was able to explain how “[urban] planners must think and fit the needs of stakeholder. Stakeholders focus on things they like to see or not like to see for specific cases.”

Connecting new information to existing awareness of situated context. As students demonstrated increases in urban planning and environmental science over time, they also regularly connected the urban planning problems, processes, and AVLE context (Philadelphia) to the knowledge of similar issues as they experience them in their own communities. For example, as Ali encountered the economic and environmental issues emphasized in the AVLE, he was able to reflect on the issues he had noticed in his own neighborhood (pedestrian safety). He later applied his new knowledge of how to identify problems and design solutions to his own context: “if I would want to change things, I would put more safety signs on streets to make people feel safe. my changes may help because driving lately has been more of a problem because people are frightened of others on either the highway or just a simple street.” These connections demonstrate the potential of the augmented AVLE for promoting deeper learning integrated into learners’ understandings of their own interest and values, patterns of self-organization and self-control, and self-perception and self-definition.

Change across interest and valuing

After the analyses of qualitative data for interest and valuing, two themes emerged: (1) change from personal interest to less personal goals and interests, (2) overlapping changes in interest and knowledge.

Change from personal interest to less personal goals and interest. The students’ interest and valuing changes showed a significant difference from the beginning to the end of the AVLE. Yet, the direction of the change from more personal goals and interests in the beginning weeks to less personal interest was an evident trend in all students. Deductively, many of the students’ reflections and responses to survey questions were coded personal interest in initial weeks, while similar questions toward the end of the AVLE led to more “global relevance codes” which demonstrates a shift to less personal goals when the player recognizes how tools and content related to a community or society and satisfies the needs of the group members. For example, when Andrea was prompted with the question of “How the design of Philadelphia has affected you?” in post-survey she responded: “... [environmental issues] can impact us by changing the city it can make a better environment. If we change the ecosystem to be better, it can make Philly look good and it will be healthier for us” which shows a well-suited response for “global relevance” as well as “personal relevance”. This was just one example of many responses demonstrating students’ less personal interests toward the end of the AVLE.

Overlapping changes in interest and knowledge. Another evident theme in students' responses regarding interest and valuing was that change in this construct happened in concert with a change in knowledge, they demonstrated their interest using new words and expressions which were inductively coded as knowledge, too. For example, when Ellen was asked to report her team's recommended value of bluebirds which are among endangered species in the Northeast, she answered "The recommended value of bluebirds is 2270 bluebirds. The stakeholders believe this is the perfect amount because if there were more there would be too much environmental space and not as much housing. However, if there were less than the city would not have the environmental space that it needs." A justification which shows Ellen both has the knowledge of keeping endangered species in her surrounding environment and values people's needs in having environmental space they need to.

Change across self-organization and self-control

The emerged themes came out of the researchers' memos from the students' demonstration of self-organization and self-control: (1) Asking help from the more knowledgeable peers/stakeholder, (2) Working toward a common goal and demonstrating metaknowledge.

Asking help from more knowledgeable peers/stakeholders. Asking help from the knowledgeable peers/stakeholders came mainly from the researchers' memos recording instances when students were asking for help when discussing their final map changes with their peers and stakeholders which was coded co-regulated learning. In co-regulated learning examples, the students were asking for help from more knowledgeable peers, stakeholder, and sometimes instructors.

Working toward a common goal and demonstrating metaknowledge. When the students were working in groups toward a common goal in addressing the stakeholders' concerns, they were not only demonstrating socially-shared regulated learning but also problem solving, critical thinking, communication and collaboration skills which were meta-knowledge components under knowledge construct. For example, when they were asked to justify the rezoning of their map "...[zoning for business] is important because there is not a lot of space for business so we are thinking to make more space for it." First, they indicated that they are looking for a way to solve the issue (problem-solving and critical thinking), second, they were indicating that they are working toward a common goal by bringing a plural pronoun (we). This example with many other examples of this sort informed us that the students worked toward the common goal with their stakeholder, and brainstormed ideas with the members of the group to resolve the issues and rezone the maps.

Change across self-perception and self-definition

The change in this construct was traced by coding self-efficacy, self-concept, and possible self-explored as the three main sub-constructs under it which led to one overarching theme: (1) No eloquent change in students' self-perception and self-definition.

No eloquent change in students' self-perception and self-definition. The analysis of students' qualitative data did not show drastic changes in students' self-perceptions and self-definition. Nearly all the students responded the same to the prompt of "what do you want to be in the future? what do you NOT want to be in the future?" before and after the AVLE. For instance, Ali said "basketball player" Ciara said "wealthy, happy, educated" Elijah said "business owner" and many other similar responses which were not changed in the post-survey. This indicates that the students' perceptions of themselves, their interest and their future desires barely change.

Case findings

The illustrative case example Andrea demonstrated intentional reflection and integrated change in all four areas: knowledge, interests and values, patterns of self-organization and self-control, and perceptions and definitions of self over time in three levels of starting self, possible selves explored, and new self which is summarized Table 1. Figures 3-6 illustrate the strength of PR connections in these levels and the strength is calculated from the number of coded segments using ENA. Overall, Andrea demonstrated many instances of foundational knowledge in relation to self-perception and self-definition with the hope of working in the science field and "contribut[ing] to some type of urban planning" in initial weeks of using AVLE (Figure 3). Later in the course, Andrea's identity exploration focused more on the interest and valuing aspects as a result of engaging in the AVLE; this was integrated her emergent and detailed knowledge of urban planning (see Figure 4). Finally, a good balance between her knowledge, interest and valuing, and self-perceptions and self-definitions were revealed which is also shown in Figure 4.



Figure 3. Andrea's Starting Self. The connection between knowledge and self-perception and self-definition is the

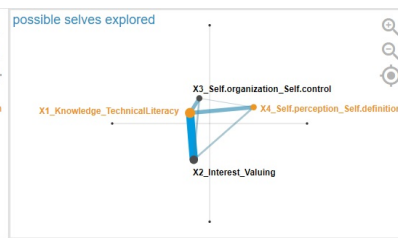


Figure 4. Andrea's Exploring Possible self. The connection between knowledge and interest

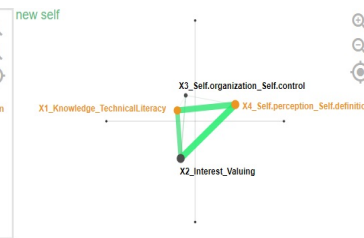


Figure 5. Andrea's new self, shows a good balance between her knowledge, interest and valuing, and self-perception and self-definition.

Andrea's starting self

The adjacency matrix of knowledge, interest and valuing, and self-perception and self-definition in Andrea's starting self (Figure 3) during the first two weeks of the course reveal that the connection between knowledge and self-perception and self-definition constructs are stronger than others. This strength comes from her "Agree" responses to Likert-scale questions which were assessing both knowledge and self-perception and self-definitions constructs such as: "I would be able to express my view in form of a group of people" or "I would be able to create a plan that addresses the issue". Also, the connection of these constructs with interest and valuing construct is not as week as their connection to self-organization and self-control. Andrea demonstrated interest and valuing by describing her interest in the environment "I want to help make the environment we live in clean" understanding the relevance of designing the city to her personal life "the design [of the city] affects me because of too many buildings and it gets so crowded". She also proposed suggestions for rezoning the city by telling "we should get rid of some buildings or separate them into different areas of Philadelphia, so we can have enough room and make it feel less crowded" which demonstrated her problem-solving abilities in relation to relevance during the first two weeks of the course.

Andrea's exploring possible self

Figure 4 shows the adjacency matrix for Andrea's exploring possible self which illustrates her change from week 3-7. Comparing to her starting self, Andrea demonstrated more knowledge and interest and valuing construct, and her adjacency matrix showed weaker connection to other constructs. Totally, knowledge and interest and valuing constructs together in all activities were coded (n=205) times which obviously have a bigger portion in Figure 4. For knowledge, she demonstrated increasingly detailed knowledge of urban planning by suggesting her detailed recommended land parcel changes "We changed the industrial areas to open wetlands so that the wetlands couldn't be polluted. WE decided that the open wetlands should be just on the wet side of the map, near the water so that the lands or the people around the area didn't pollute it and poison any of the animals or the creatures on that part of the map/area." She capitalized "WE" which means that she is emphasizing her collaboration with other team members and socially shared learning. She also demonstrated many instances of relevance which made her adjacency matrix thicker in this construct, too: "Me as a citizen has to show how people should respect how to treat the environment. I think that our changes will affect the area in a good way and in a bad way because people will need to find more industrial areas and it will be good because the environment will be safe." However, the link between knowledge and self-perception and self-definition is weaker as well as self-perception and self-definition and interest and valuing comparing to Figure 3 (her starting self). One explanation may be that she had a better understanding of each of these tasks because the AVLE had simulated real-life activities and allowed her to self-reflect during the program, thus, picked a less direct assertive response to the questions that were assessing those constructs.

Andrea's new self

Figure 5 illustrates Andrea's adjacency matrix for her new self in final weeks of 8-9 which shows a good balance between her knowledge, interest and valuing, and self-perception and self-definition. This figure is well supported by qualitative themes as we discussed earlier "overlapping changes in interest and knowledge". For the majority of students, many instances of knowledge co-occurred to the interest and valuing utterances and in some cases, they were both presents in a single utterance. For example, when Andrea was asked "Whose needs and opinions should a city plan reflect?" she responded, "it should reflect of the citizens of United States of America" compared to some other peers who had answered "people" or "citizens of the city". This is a detailed utterance which both demonstrates a good understanding of the city planning goals and the needs of the people who live in a country asserting the fact that any decision in rezoning the city will impact the whole population of America indirectly.

This utterance was coded both for core content foundational knowledge and global relevance which was a sub-category of interest and valuing.

Analyzing Andrea's adjacency matrices from starting self to new self, and the similarity of starting self to new self, uncovered the fact that Andrea's responses to many questions of knowledge and self-perception and self-definition were unrealistic at the beginning of the program. Using AVLE, she could explore her identity and challenged some of her notions about her capabilities (see Figure 4). However, by using AVLE she could develop many aspects of the Projective Reflection constructs in a way that made it similar to her starting point. This time her responses were more realistic in the sense that she gave less affirmative but more detailed responses to the prompts which were asked initially.

Table 1: Summary of findings from the iteration 1 group and from an illustrative student case

| PR Construct | Starting self (initial reflections; Weeks 1-2) | Possible selves explored (during AVLE; week 3-7) | New self (concluding reflections; week 8-9) |
|-------------------------------------|--|---|--|
| Knowledge | Described experiences with digital tools, provided general, factually correct responses to knowledge questions | Demonstrated increasingly detailed knowledge of urban planning (i.e. understanding relationships between specific design variables), and strong literacy using <i>PLS</i> compared to peers | Shared clear, detailed knowledge of urban planning concepts and general design process |
| Interests and valuing | Shared that she valued "making the environment we live in clean" | Expressed enjoyment of AVLE experience, regularly identified relevance of urban planning to desired future career in science | Described expanded interests in not only environmental conservation but also "the man-made items that surround it." |
| Self-organization and self-control | Shared enjoyment of group work and confidence in her ability to complete learning tasks | Participated as a group leader - volunteered design strategies in group meetings, offered technical assistance to peers, described feedback she received and her strategies for improvement | Affirmed how her participation "helped me see what it was like being an urban planner" |
| Self-perception and self-definition | Hoped to work "in the science field" as an engineer or scientist; recognized that this future career means she would "have to [have] contributed to some type of urban planning" | Shifting towards a future career in medicine, stating "urban planning would affect me in a way because of jobs and how there would be enough places to go and study medicine." | Hoped to be "a doctor, scientist, astronomer;" strongly agreed when asked if she could see herself as an urban planner in future |

Discussion

Case findings and group themes are summarized in Table 1. Synthesis of Andrea's changes over time revealed *integrated* identity exploration through engagement with the urban planning process: the development of increasingly-specific content knowledge and AVLE literacy, repeated and diverse connections to personal interest and values and an enjoyment of the experience, active peer-to-peer leadership and the enactment of self-regulation strategies, and connections to her current and desired future roles as they emerged. As a result, Andrea was consistently able to find personal value and enjoyment in relation to her perceived self and active knowledge gaining over time. These connections demonstrate the potential of the augmented AVLE for promoting deeper learning integrated into learners' understandings of their own interest and values, patterns of self-organization and self-control, and self-perception and self-definition. As such, the AVLE, which leveraged the affordances of both virtual environments and real-world augmentations (i.e. roleplay and discussion) has the capacity to promote a comprehensive identity exploration trajectory as defined by the four PR constructs.

Group findings suggest that the AVLE experience encouraged at least some aspects of identity exploration around urban planning careers for all students – each player concluded the experience able to justify whether or not they wished to become an urban planner based on aspects of their AVLE participation. However, a review of group findings revealed that not all students enacted every aspect of PR and that many students approached identity exploration in different ways (i.e. increasing confidence versus frustration over time). These results illustrate the need for further inquiry into patterns of identity exploration so that additional supports may be designed in AVLEs to better support PR across learners with different starting self-characteristics (i.e. interests, knowledge, etc.).

Theoretical and educational significance

Projective Reflection (PR) serves as a theoretical lens for supporting student learning as a process of identity exploration that leads to change over time. The ability of adaptive collaboration to engage in (a) the intentional reflection on the self, (b) the process of exploring possible future selves related to new careers and roles in collaboration with stakeholders and other group members, and (c) the enactment targeted and intentional steps toward a desired new self, will serve as a particularly valuable skill for learners preparing for an evolving 21st century workforce. The development and enactment of *Virtual City Planning* offers useful insights for addressing how learning experiences may be optimally designed using a robust theoretical framework to support targeted identity exploration and change processes (DeVane, 2010), and how students' trajectories of identity exploration and change in the same learning experience may differ (Foster, 2014). As practical and theoretical understandings of identity exploration trajectories emerge through this research, the capacity of learning practitioners to design early targeted supports for learners based on their starting self characteristics increases.

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Acknowledgments

This material is based upon work supported by the National Science Foundation. The views expressed are those of the researchers.