Exploring the Potential of Computational Self-Representations for Enabling Learning: Examining At-risk Youths' Development of Mathematical/Computational Agency

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ABSTRACT
This paper reports on a study conducted within an alternative high school for students evicted from the mainstream and that utilized the virtual world (Teen Second Life or TSL). The use of self-representations in virtual worlds to enable and facilitate Science, Technology, Engineering, and Mathematics (STEM) learning is a promising endeavor. At the same time, it is not clear how the ability to construct imaginative self-representations can impact students' abilities to view themselves as STEM learners and doers. Furthermore, questions over whether students should view avatars instrumentally to accomplish virtual tasks, as virtual selves for playful identity construction and performance, or to what degree the avatars should accommodate representing aspects of students' real selves vs. extraordinary fantastic characters. This paper provides pilot evidence, elicited using grounded theory techniques on data collected in a three-year design-based research study into fostering at-risk students STEM learning [1]. We propose a three-axis model of students' stances in relationship to their avatars. Using insights from the cognitive science theory of conceptual blending in order to characterize students' perspectives of their avatars as imaginative integrations of their real and virtual selves, we present a set of case studies illustrating students' stances in terms of our three axes. The upshot is that students in the study tended to fall into three one of three categories: (1) viewing their avatars as necessarily reflections of their real world identities, (2) viewing their avatars as mere proxies for building artifacts in the world, and (3) viewing avatars as characters external to themselves for engaging in a play of identity performance and presentation. Group (1) found the affordances of TSL to be inadequate, hence serving the needs of this group may require alternative design solutions in light of real world behavior.

Keywords
STEM learning, mathematical/computational agency, conceptual blending, avatars, virtual worlds, self-representation, identity play

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1. INTRODUCTION
Women and ethnic minority groups are underrepresented in Science, Technology, Engineering, and Mathematics (STEM) professions in the United States of America. Current efforts to address this problem have focused on the school or the district levels (e.g., the government's No Child Left Behind Act). Solving this problem requires all stakeholders' involvement (educators, researchers, policy makers, parents, administrators, and others) advocating a variety of approaches. One effective approach developed by the first author [1] in a project called *Fractal Village* has proposed is to empower students as agents in their own learning. She conducted a three-year design-based research study into fostering at-risk students STEM learning. The study was conducted within an alternative high school for students evicted from the mainstream. A class of thirteen students worked over eighteen 110-minute class sessions in the virtual world (*Teen Second Life* or *TSL*). They began by choosing and editing avatar representations. Using these representations they collaboratively built/programmed a virtual community.

Learners should be able to see themselves as learners and doers of mathematics and creators of computational artifacts *while enacting their own performed genders, ethnicities, histories, etc. should they desire to do so*. Simultaneously, they may benefit from constructing imaginative self-representations largely divorced from their real-life socially stigmatized categories. The second author has developed theory and technology, with bases in cognitive science and digital media arts, for doing so under the rubric of the Advanced Identity Representation (AIR) Project [2, 3].

The predominantly African American class demonstrated a wide range of reactions to the avatars and editing capabilities. Empirically assessing results in *Fractal Village* using elaborated insights from the AIR Project, we seek to learn which strategies for self-representations are most efficacious for facilitating STEM learning, whether the affordances provided by *TSL* support the construction of these self-representations, and, if not, provide insights into assessing which self-representation construction affordances would be better.

2. THEORETICAL BACKGROUND
In this paper, we use the AIR Project's cognitively grounded theoretical model of computational identity construction as the basis for an empirical study examining the students' enactment of

their identities [2]. Cognitive categorization is a basic mental operation necessary for understanding the world, and is based in human embodied and cultural experience and imagination [4, 5]. The model we use considers how identity phenomena such as stereotypes, paragons, group representatives, and other arise from what are called "prototype effects" [4]. Such effects are evaluated in light of the how the computational identity systems are built and the affordances they enable. A more detailed account of the elements of this theoretical framework follows.

2.1 Shared Technical Underpinnings of Computational Identity

The approach to computational identity articulated here is relevant across multiple forms of digital media. Various computational identity applications such as social networking sites, avatar creation systems for virtual worlds, and games are implemented using a limited and often overlapping set of techniques. **Fig. A** (below) describes, at a high level, the components that comprise the majority of widely used computational identity technologies [6]. Fundamental to implementing computational identity applications, the six components in **Fig. A** that commonly form the basis for avatar/character/profile construction can enable dynamic and contingent models of social identity in digital environments as described in [7].

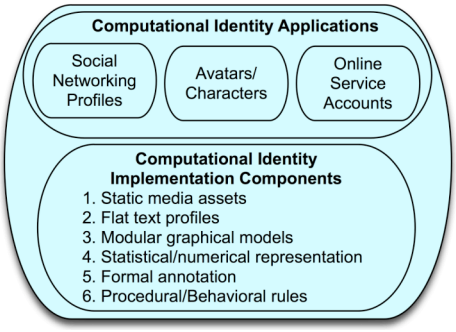

Fig. A: Shared Technical Underpinnings of Computational Identity Applications [2, 3]

Understanding the applications and limitations of the technical means by which users stage their identities across digital media forms can enable customizability and cross-community communication facility in social identity systems.

2.2 The AIR Model of Cognitively Grounded Computational Identity

Our approach begins with the basic cognitive building blocks of identity (discussed in a subsection below) upon which social identity categories are built. Cognitive scientists have proposed that human conceptual categories form "idealized cognitive models" (ICMs) upon which categories of objects in the world are built [4]. These models can explain how users project their identities into their avatars. [7]

The AIR model is useful for identifying where schisms exist between a technical structure and a real world idealized cognitive model as encoded in a classification data-structure. This entails closely examining the blend of computationally afforded identities and real world identities that James Gee calls the "projected identity" as shown in the cognitively grounded AIR model (e.g., a player taking on the role of a priest in a computer role-playing game and trying to be helpful and supportive to her or his friends). [7]

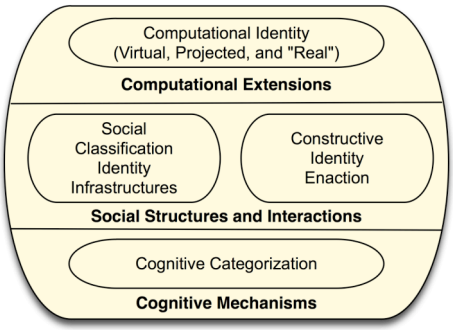

Fig. B: The AIR Model of Cognitively Grounded Computational Identity [2, 3]

The key here is that our understanding of both computational structures and the ways that users interpret them is based in imaginative cognitive processes such as categorization. The focus on categorization and classification arises because these phenomena are often reified in infrastructure and are thus amenable to computational modeling.

2.3 Conceptual Blending Theory

A brief account, drawn from [8], of conceptual blending theory follows. In cognitive linguistics, metaphor theory proposes that the understanding of many basic abstract concepts relies upon metaphorical thinking and analogy, and that metaphorical thinking arises from a basis in embodied human experience of the world [9, 10]. George Lakoff, Mark Johnson, Mark Turner, and others have studied metaphor as mappings from one conceptual space to another [10, 11] . Conceptual blending theory builds upon Gilles Fauconnier's mental spaces theory [12] and elaborates insights from metaphor theory [13]. Gilles Fauconnier and Mark Turner's conceptual blending theory describes the means by which concepts are integrated [14], guided by "uniform structural and dynamic principles" both unconsciously in everyday thought and in more complex abstract thought such as in literary arts or rhetoric. Conceptual integration networks are composed of conceptual spaces and conceptual mappings used in blending the component spaces for situations that are more complex than a single metaphor. The basic elements of a conceptual integration network are [15]:

(1) Input Spaces (the conceptual spaces to be combined)
(2) Cross-space mappings (links between analogous elements in different input spaces)
(3) The Generic Space (a conceptual space mapped to both of the input spaces that describes shared structure between the input spaces)
(4) The Blended Space (the space in which elements from the input spaces are integrated)

Fauconnier and Turner assert that the process of blending is structured by sets of "constitutive" and "governing" principles that exert pressure to produce optimal blends. The constitutive principles describe the structure of conceptual integration networks and the process of blending, while the governing principles optimize emergent structure in the blends all "other things being equal" [14].

2.4 Cognitive Categorization

The approach to identity here is influenced by the prototype theory of the psychologist Eleanor Rosch, and especially work in categorization by the cognitive scientist George Lakoff. [4] George Lakoff's work in this area over two decades ago is well known and influential, yet it is a thread that has been underdeveloped with respect to issues of social identity construction (an exciting exception being the work of the linguist Otto Santa Ana on conceptual metaphor-based bias in [5]). Furthermore, this theory has not been significantly applied to cases of identity representation in digital media.

Important for the purposes here, Lakoff describes a metaphor- and metonymy-based account of how imaginative extensions of "prototype effects" result in several phenomena of social identity categorization that have proven useful for the AIR Project [4]:

- Representatives (prototypes): "best example" members of categories,
- Stereotypes: normal, but often misleading, category expectations: (e.g., gender stereotypical categories define normative expectations for language use)
- Ideals: culturally valued categories even if not typically encountered (e.g., note the difference between an ideal and stereotype – Ideal husband: good provider, faithful, strong, respected, attractive, Stereotypical husband: bumbling, dull, beer-bellied),
- Paragons: defining categories in terms of individual members who represent either an ideal or its opposite (e.g., "he is no Turing when it comes to computing," "it's the Taj Mahal of apartments!"), and
- Salient Examples: memorable examples used to understand/create categories (e.g., after experiencing an earthquake in California someone may never wish to travel there, even from a place with a higher incidence of natural disaster).

Our work here closely examines idealized cognitive models (such as Lakoff's) as computational data-structures, hence identity prototype effects are seen as expressed by algorithmic means in platforms such as *TSL*. In looking at transcript data from *Fractal Village,* such phenomena that define normative expectations and stigma (stereotypes, ideals, salient examples, etc.) within *TSL* become apparent and provide a basis for suggested identity models that enable users to move beyond disempowering expectations.

3. METHODS

3.1 Participants

The 13 student participants in this study were all members of an urban California alternative high school classroom. The students were 15 – 19 years old, the ethnic make-up was predominantly African-American, and there was a near-equal gender distribution. All students at this school qualified for federal free lunch programs, and over half of the students in the study classroom had Individual Education Plans (IEP), because they are categorized as Special Education students.

3.2 Procedure

The intervention began with students creating logins and avatars. In choosing login-names, each participant was asked to compose a first name, yet *TSL* required them select a last name from a pre-compiled list. In choosing a visual representation for themselves, users were limited to a dozen basic images (see Figure C), which they could subsequently modify through dedicated interface features for altering skin color, adding tattoos, changing their facial features and hair, "putting on" makeup and accessories, etc.

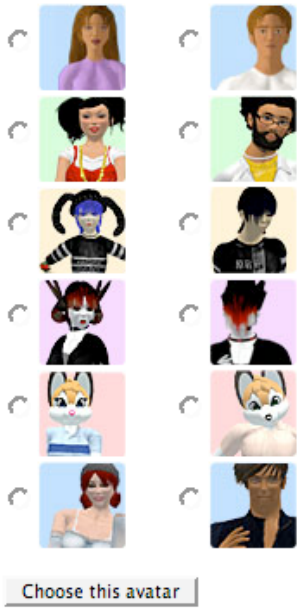

Figure C. The generic set of avatars that participants could choose among and later modify.

3.3 Data Collected

Our raw data consists of: digital movies of students' collaborative work; screen-capture movies that archive every keystroke and mouse click made by each student over the entire intervention; personal journal logs each student kept throughout the study; movies of day-by-day individual semi-clinical interviews with a subset of focal students selected on the basis of real-time events that occurred in the classroom; rich field notes we amassed and co-edited on our laboratory wiki; videotaped design-team debrief/plan sessions; and participant-generated mixed-media artifacts, i.e., worksheets, modeling constructions, and computer screenshots (see Figure D, below).

Figure D. Student-constructed avatars and a sample of constructed objects (i.e., a tunnel).

3.4 Data Analysis

Analysis was comprised of a series of steps using situated discourse analysis [16], techniques from grounded theory [17], microgenetic analysis [18], and drew on conceptual blending theory [14]. This process is elaborated below as a series of steps.

Step 1. Selection of data: We selected data segments relevant to virtual identity construction. For example, one data segment was a video clip of a group discussion at the end of the first day of the project that included rich exchange between the principal, teachers, researchers, and students regarding students' initial experiences of constructing virtual identities as externalized through avatars. An example of segment not included is a video of a student debugging code they wrote to generate a jukebox since this would not be considered pertinent to virtual identity construction utilizing an avatar (though not the focus here, certainly the role of artifact construction and use will play a role in our study of identity creation at a later date). Additionally, still images complemented the video data.

Step 2. Transcription: Raw video data was transcribed.

Step 3. Chunking raw data: Using situated discourse analysis, we segmented this transcription into utterances as determined by turn taking. Thus, the words an individual verbalized continuously without interruption or change of speaker would be considered an utterance.

Step 4. Finding patterns and meanings among utterances: We then adapted techniques from grounded theory and looked at the utterances for codes, or patterns, occurring between the utterances. Grounded theory techniques are useful here because they reveal qualitative patterns within data without a-priori hypothesizing about outcomes. Grounded theory analysis consists of four steps as described below [19][20][20]: Grounded theory involves four steps: (1) identifying codes that act as anchors to all key data points to be gathered; (2) grouping the codes into concepts; (3) grouping concepts into similar family theories; (4) theory development based on previous steps, that is a collection of explanations that describe the subject of the research. For purposes of our analysis here, we focused on steps 1 and 2. Using two coders, through discussion and two iterations of coding we achieved 100% inter-rater reliability.

Step 5. After identifying the codes and concepts we used microgenetic analysis, drawing on cognitive linguistics as a tool, to analyze the utterances deemed meaningful.

For our coding scheme, we found indices of students' views of their own, and others', avatars in relation to real world users. First, we noted every reference to avatars (normative or idiomatic vocabulary notwithstanding) and highlighted them in the transcript. We then noted if the utterance indicated a blend of the user's real self and the avatar as a virtual self (e.g., when referring to an avatar "look at my hair" and the contrasting "look at my dude's hair" are each indicative of different types of blends—the first an integrated projected identity and the latter an external character).

We anticipated finding blending phenomenon such as the above, yet we did not presuppose this in our coding scheme. The analysis of utterances to reveal students stances toward their avatars occurred by grouping like utterances and characterizing as input spaces to the blend. Given this, we assessed if the utterance referred to a conceptual blend and identified prospective input spaces, generic space, and frames from which the input spaces seem to have been drawn from. Though a subjective process, each such attribution was inferred directly from data, i.e., we only speculated based on student utterances-in-context, not from our own opinions about students' unarticulated thoughts.

In especially illustrative examples, we took particular care to notice vital relations (cross space mappings revealing analogous structures in the input space), compression (reduction of abstract concepts to human scale in the blended space), and types of conceptual integration networks in order to assist in explicating the phenomenon at hand. For example, the "identity" vital relation indicates that the student and the avatar are integrated in the blend space. Cases where a category of person (e.g., "black" or "Mexican") is rendered human scale through a particular avatar appearance comprise a type of compression of category to a paragon (a metonymic ICM). Finally, cases where both the real and virtual selves are being integrated in the blend seem to be drawn from the same frame (frames are broad, commonly understood knowledge of a particular domain, e.g., the notion of a community) comprise "single-scope" blends, whereas cases where they seem to be drawn from quite different frames (e.g., the real self is drawn from the community frame and the virtual self is drawn from the computational tool frame) comprise "double-scope" blends.

The advantage of utilizing conceptual blending theory to perform this analysis is that it provides a careful terminology and structure to account for the ways that specific elements of the real and virtual selves are integrated in a projected self. It also provides a uniform means to account for cases where the "projected self" consists of an avatar used as a tool to accomplish tasks rather than as self-representation. Regardless of the status of conceptual blends as cognitive phenomenon directly resulting from particular neural structures (an open and controversial question), the relative precision of the conceptual blending construct for characterizing different types of integration and the elements thereof has proven useful. Specific insights gained using this framework are discussed in the next section, most importantly, including a three-axis model of stances that students take toward their avatars.

4. RESULTS

Through analysis as described above, we found there to be three distinct dimensions of students' stances toward the construction and use of avatar-based identities. The three dimensions are named below (and depicted in Figure E below):

(1) Everyday vs. Extraordinary graphical appearance: Avatar appearance can range from the everyday to the extraordinary or fantastic. Students tend toward preferring one or the other extreme, though a preference for anthropomorphic avatars was observed (likely due to the platform). This dimension is context-sensitive since one student's perception of what everyday appears to be can be quite different from another students. In fact, "engineer," was more extraordinary to some of the students than "gangster."

(2) Mirror (1st Person) vs. Character (3rd person) ontological status: Student perception of avatars ranged from virtual representations of their real selves to perceiving them as characters external to themselves operating, or to be operated, within the virtual world.

(3) Instrumental/Playful use: Students' uses of avatars ranged from their instrumental deployment as tools to accomplish tasks and proxies for them to act in the virtual environment to accomplish tasks construed as

computational to deployment gamelike personae as a means for engaging in imaginative identity play.

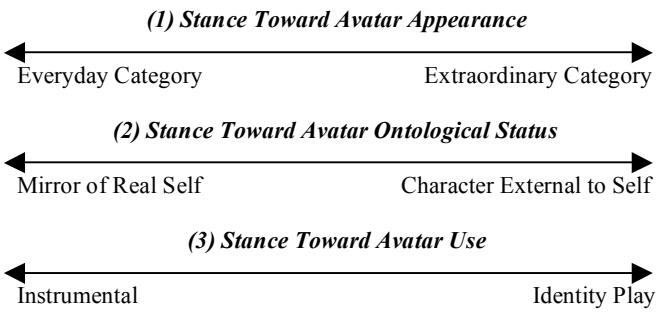

Figure E. Three dimensions related to user perception and use of virtual identity.

Recall from the Methods Section that the project goals were framed for students as open-ended. Following a Freirian critical pedagogy perspective in which students' own generative themes were elicited [21], students were shown various avatars and activities and invited to propose their own ideas to investigate within the virtual world. Thus, while we are aware that the project's framing including the researchers' and educator's own ways of referring to avatars, the activities completed, peer register, and the project's goals of enabling student to see themselves as learners and doers of STEM material, could have primed the students' stances toward their avatars to fall at particular locations along the above axes, we believe any possible priming was minimized. While one of the main goals of the initial study was to help foster within students a sense of themselves as STEM learners and practitioners, we did not explicate this to students, thus this motivation did not impact students' view of their virtual identities.

Below, we interrogate three students' views of avatars as a means of exploring the three dimensions and to ground later discussion of the schism that exists between computational identity platform affordances and students' desires for avatar construction. The first two provide less detailed accounts, but are used to describe the means by which we discovered the three dimensions of stances that students take toward avatars. The cases are also used to characterize particular stances encountered in multiple students' based on the combination of their positions along each of these axes. The upshot is that a subset of students that we call *Mirror Players* seemed to see avatars as primarily performative, avatars for them are reflections of the students real selves used for identity play and intended to be faithful to the students' real world categories. Unfortunately, these students seemed the most likely to eject themselves from the study because of dissatisfaction with the affordances of *TSL* to enable the type of customization that they desired. Alternatively, such students put in extra effort in order to realize avatars that they only construed as "adequate" (e.g., Figure F, image on right side, below).

For a second set of students that we call *Character Users,* the avatars are characters that exist only as proxies to instrumentally accomplish objectives in the virtual world. For these students, avatar appearance was incidental and fit everyday categories only because of less deviation from default avatars, though at times some of these avatars were also quite extraordinary due to students' limited masteries of avatar customization. For example, the bright pink skin toned, blue haired avatar in Figure D, above. The third case study is more in-depth and is used to help explicate the difficulty of *Mirror Player* in constructing robust self-representations for identity play.

4.1 Case Studies

4.1.1 Case One: Mirror Player DS

DS is an example of a student who: (1) wanted his avatar to have an everyday appearance and (2) tended toward preferring his avatar to mirror his real self. At the end of class discussion on the first day of the project DS proclaimed that the project was "stupid." It was only when his classmates revealed that DS's avatar had "female features" with "long eyelashes" that DS acknowledged his real source of displeasure arose from his inability to construct his avatar as he would have liked. Excerpts below are transcription of portions of this conversation, exemplifying DS as a mirror player. The numbers in the analysis indicate which of the three axes the statement is pertinent to.

Transcription	Analysis
[PI asks students for their initial reactions] **DS**: It's stupid.	
[Other students chime in explaining they had fun, made outfits, etc., then the PI inquires why DS thought it was stupid]	*(3) In this entire excerpt all discussion revolves around identity play, it is never instrumental.*
DS: It's stupid.	
Res_KB: Yeah, I think we were really struggling to try to get the hair looking like a mortal.	*(1) The term "mortal" indicates an everyday category.*
PI: Ok, tell me more.	
KJ: His dude was, had female features.	*(1) KJ and DS's descriptions collude to communally define norms for appropriate everyday categories, or ideals.* *(2) The avatar is referred to as "his dude," seemingly indicating an external character.*
DS: Yeah!	*(2) Yet, DS seems to be emotionally invested in the issue, perhaps suggesting a mirror stance.*
SK: Is that why you mad? [Several students laugh]	*(2) If DS is indeed angry, this suggests a mirror stance due to the female features being viewed as integrated with his real self.*
SK: [inaudible] A little feminine? There's nothing wrong with bein' feminine [still chuckling].	*(2) SK, a female student, refers to the state of being female. Speculatively, her mocking tone and use of the term "being" suggests that feminine qualities of the avatar input space is being integrated/identified with user's real self input space, indicating a mirror stance.*
KJ: It had eyelashes, like	*(2) KJ utilizes a character*

long.	*stance, perhaps distancing DS's real self from the avatar.*
OJ: You can't change it or nothin'?	*(3) OJ reinforces the idea of avatar customization as identity play by inquiring about the ways in which DS can alter his avatar.*
KJ: Naw, blood. We were tryin' to put some hair and their hair was, you know how old like, [pause] old white women wear their hair? Like a little…	*(1) KJ's unfamiliarity with the hairstyle suggests that it is extraordinary to their experience, though they were trying to achieve an everyday hairstyle.*
Unknown voice: coif?	
KJ: Coif.	
OJ: Some of them have dreads. [inaudible]	*(1) OJ's suggestion implies that the dreadlock hairstyle is a more desirable alternative as a more everyday style.*
Principal_Vincente: Why else was it frustrating?	
DS: Cause we could be doing something else man and we got to do this.	
…	

Table A. A transcript excerpt pertinent to DS.

Below in Figure F, we see on the left the avatar that he constructed by the end of the first day when the discussion took place. On the right we see his avatar after he was able to get it to an acceptable, but not ideal look (although this view allows us to only see his character from the back, note the broad shouldered physique, bald head, and attempt at what the student described as flames flaring from the torso). The identity play resulted in a largely everyday avatar, but with some fantastic features suiting DS's masculine ideal

Figure F. DS's avatar representation at end of first day of project (left) and at the midpoint (right). He ejected himself from the study at this midpoint, therefore there is no avatar of himself at the end of the study.

4.1.2 Case Two: Character User SQ

SQ is an example of a student who (1) exhibited a moderate preference for his avatar to fall within an everyday category, (2) exhibited a strong perception of the avatar as unrelated to his real self, and (3) viewed his avatar as a tool to accomplish his goal of building a skyscraper in the virtual world.

Figure G. SQ's initial avatar, his skyscraper, and his avatar at the end of the project (left, middle, right respectively).

In an interview conducted with SQ, he was asked why some people care about their avatar appearance and others do not. Below is a transcription of portions of that interview that exemplify SQ's categorization as a Character User.

Transcription	Analysis
PI: [first 30 minutes of this interview were spent talking about SQ's family and school history followed by an inquiry into his experience with the project]….So do you care what your avatar looks like?	
SQ: No I don't really care, I don't really care.	*(3) This is a clear and direct message that SQ has an instrumental view of avatar identity, or at least is not invested in identity play.*
PI: Why?	
SQ: Cause it's just like an animated dude. Ahh man that's what we got to pick out of but I was like man I ain't going to be tripping. So I picked the dude and	*(2) SQ clearly does not see the avatar as a direct reflection of himself, rather he views it as a character separate from himself.* *(3) Merely "picking" the character indicates a minimal degree of constructive play.*
PI: you didn't want to be a woman?	*(1) Based on the rapport the PI had built with SQ, she asked laughingly if he had wanted to pick a woman avatar, knowing that for him this was not in his image that constituted his "everyday."*
SQ: huh?	
PI: You didn't want to pick a woman?	
SQ: I was going to put then I was like I'm not going to pick her. No I ain't feelin her. Yeah	*(1) Jokingly, SQ admits he wanted his character to be "manly," thus more closely*

I saw the dude I was like yeah, Manly stuff.	*aligned with his male identity. (3) SQ is engaged in identity play to the degree that he does not want an avatar complete divorced from his real masculine identity preference.*
PI: Some people care a lot about what their character looks like.	
SQ: Yeah. Yeah.	
PI: So why do you think some people care so much and some people are like whatever like it's just some "animated dude?"	
….	
SQ: I just wanna, I wanna build something nice. I wanna build something I really don't care what he look like. You should look at my avatar, he wearing a frock. Cause I was tryin' to dress him, I was tryin' to dress him and I messed up on him and then I just left him like that. He's wearing a dress. And I was working with him you know?	*(2) SQ affirms his external view of his avatar. (3) SQ affirms his instrumental view of his avatar. He clearly states he does not care what his avatar looks like and that he only wants to use it to accomplish construction tasks.*

Table B. A transcript excerpt pertinent to SQ.

4.1.3 Case Three: Character Player CGT

CGT is an example of a student who (1) exhibited a slight preference for her avatar to fall within an everyday category, but also made an extraordinary avatar (a purple skin-toned human superhero), (2) viewed her character as representing her real self and thus puts in many hours of care into crafting her avatar characters, and (3) viewed her character as a means for identity play. She did, however, also engage in instrumental uses. For example, she wanted to plant a garden and led a beautification project on the island and used her avatar as a means to explore potential for constructive play with flowers, plants, and trees.

Figure H. Three sample images from a series of avatar changes made by student CGT who represents a student with a view of avatar construction as an opportunity for identity play (importantly, these are screenshots chosen by the student for being postcards to send people, not randomly taken from the video as they were en route to constructing the characters).

4.1.4 Case Four: Mirror Player Detail, The Meaning of Being Solid

After helping his classmate DS describe concerns of an overly feminine avatar, KJ and the class continued discussing their experience with the project. The transcript below provides remaining relevant portions of conversation so as to prepare the reader for an analysis of a comment KS makes about wanting his character to be "solid."

Transcription	Analysis
KJ: I'm thinking it could be cool if you just had some body set up like a male, you feel me a Mexican **PI**: Without long eyelashes. **KJ**: A Mexican male and a black male. Set up.	(1), (2), (3) KJ states what his everyday categories are, that he sees these avatar constructions as a reflection of his real world self He indicates no inclination toward an instrumental view of the avatar.
Teacher_Inuyasha: Hello, are we missing out on someone here?	
KJ: just, just, just, just like you feel me, a little sample then you could mess with it, like you could make a default body. ….	
Teacher_Inuyasha: But wouldn't you want to create, what if you're a black male but your character, you want to be a Mexican…girl?	
KJ: I don't want to be a girl.	(1,2) KJ reveals what his everyday category does not include, the female gender. KJ is seeing the projected identity as a mirror reflection of his own characteristics.
Teacher_Inuyasha: But I'm saying wouldn't you guys want to have variety?	
SK: You wanna be around a bunch of boys?	
OJ: I'm not sayin' that you shouldn't…I'm just sayin' **SK**: Yeah. It's not real. **OJ**: I'm not saying that you shouldn't **SQ:** It's true though. …. **SK**: yeah cause hers [referring to Res KB] was an alien, tattoo, Mohawk and green skin.	(2) Here we see KJ being challenged by his classmates to consider the possibility of his avatar construction not reflecting his real world identity.
Res_KB: So like some of the options that we had, the	(1) A member of the research staff, Researcher KB, makes

original, some of the original default skins, all the skins are tintable to some degree but some don't really tint enough to look like an African-American skin.	an assumption regarding what she perceives are KJ's everyday categories. In this statement we see that she makes an assumption that when KJ says "a black male" that in part he is talking about a skin tone that is dark enough to represent an African American person.
KJ: No, not even that. I'm just saying, just something I could just start with….one that looks um, uh, hmmm….you know solid, male or female.	(1) However, we see KJ correct Researcher KB, proclaiming that his everyday category is not necessarily about skin tone per se, but rather a different set of characteristics that he describes only as "solid." The below analysis picks up on this notion of "solid".

Table C. A transcript excerpt pertinent to DS.

When KJ describes the state of being "solid," clearly he does not mean something so simplistic as being provided with an avatar of appropriate skin tone. He could mean that in addition to physical appearance, the avatar should be able to present the body language, gestures, facial expressions, fashions, discourse styles, and other attributes that would allow it to become a paragon for the values encapsulated by the term. It means African American or Mexican, but more importantly, an epistemic form [22] that allows of the ways of being the supersede ethnic labels (indeed they are shared across ethnic) categories, grounded in marginalized urban, youth, northern Californian, self-identified person of color experiences.

There are two major aspects of how this "solidity" could be enabled. First, the system would need to provide a set of affordances that could construct an avatar that fits within the appropriate category that comprises an ideal. Recalling the discussion of Lakoff's metonymic categories above, we could say that *ideal* category is highly situated within his own context. Hence, the *Second Life's* updated dark skin-toned male default avatar (as in Res_KB suggestion) was insufficient as a *paragon* – its tight suit with a high waist double-breasted jacket and striped yellow necktie or hand-on-hip posturing brow skin-toned avatar in Figure I may be far from KJ's urban notion of "solid."

Figure I. Full length image of two current generic avatars available.

Secondly, he means that users should be able to perform as this paragon of "solidity." Essentialist perspectives (those based on "the belief that an object has a certain quality by virtue of which it is what it is" [23]) would consider someone to be of a certain race because he or she possesses certain physical characteristics, or to be of a certain gender because of possessing certain innate qualities of behavior. There are two major challenges to essentialism, however. The first recognizes the limitations of "understanding of the subject that characterizes a single axis of identity as discrete and taking priority in representing the self—as if being Asian-American, for example, were entirely separable from being a woman." [24] The second recognizes the problem that some members of a group may end up to "impose their vision of the group's identity onto all its members." In contrast, that identities are a social constructs, can be performed, are created by social institutions, etc., we can see that the KJ requires the system to allow for construction of social identities independent of objective qualities. For example, KJ requires a performative constructivist models that emphasizes enaction of social identities in the virtual world, e.g. allowing him to "perform" masculinity, and engage in the ongoing act of performing, e.g. "walking solidly." There are many ways that this can occur. Some aspects should be built into the infrastructure, whereas others must be enacted by users. At times the infrastructure should have preconstructed affordances (e.g., emotes), while at other times the facility should exist for users to build the appropriate appearance or behavior.

It is instructive at this point to revisit the shared computational underpinnings of computational identity mentioned in the theoretical framework above. Altering a graphical skin is relatively easy. Indeed, there is already a tradition of using infrastructure allowing this to perform identity. In [25], it was noted that many feminist theorists agree that, in order to demonstrate agency, a person must resist the hegemonic patriarchal status quo [26]. This form of oppositional agency has gradually been adopted by some users/artists/hackers of digital worlds. In 1999, Sonya Roberts released her *Female Skin Pack Excerpts*, a series of female texture maps for the original *Quake* avatars, because the game designers neglected to provide a female protagonist. The eerie composition of a female skin on a muscular male figure embodied a form of resistance to power. 3D graphical models are harder to change without robust tools for doing so that often end up constraint the set of possible results (e.g., the contrasting inverse relationships between the ease of use and relative degree of customization in *Sims 3* and *Second Life*). Scripting character behaviors is more challenging for novices still requiring both animation and even perhaps artificial intelligence (AI) programming skills.

All of this suggests that performing a "solid" way of being is not a simple technical problem, it is a problem that requires understanding the cognitive and social issues at hand, and assessing them in light of what can be implemented computationally (whether by users or system implementers). To truly enable KJ to take the stance he desires regarding his projected self, a balance must be struck between his highly situated desires, the project goals, and the possibilities given the limitations of *Second Life*. Furthermore, if these aspects cannot be reconciled, it may be the case that new theory and technology is necessary [2, 3].

5. CONCLUDING REMARKS AND FUTURE WORK

Through our analysis we discovered three dimensions to students view of their virtual identities, and characterized two observed stances that students took relative to their avatars. These axes and stances can help us understand how virtual identities impact their real world development of STEM identities. Since this study, makers of *Second Life* have updated their generic avatar set (see Figure J, below).

Figure J. *Second Life's* updated default avatars.

In viewing these new generic avatars, we can expand our questions of virtual identity construction to include performativity, facial gestures, body movement and language, posture, etc. Thus, student view of virtual identities goes beyond the top level view of avatar appearance to characteristics associated with performance and discourse style. Thus, we intend to continue by conducting further work with youth that can expand our understanding of projected identities and the impact of virtual identities on students real world STEM identities. Ultimately, we shall use this understanding to design effective computational learning environments for fostering at-risk underrepresented students STEM agency.

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