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ABSTRACT

A qualitative case study approach was used to identify the psychosocial effects of the high-fidelity, virtual reality simulation provided in the college-level air traffic control (ATC) training program offered at the Minnesota Air Traffic Control Training Center and to evaluate the applicability of virtual reality to academic/training situations. Thirty-eight students currently enrolled in the ATC training program were interviewed individually, and the ideas of a total of 13 program graduates were elicited in 3 focus group discussions. Despite their widely different levels of previous education, prior experience with aviation, age, gender, ethnicity, and level of speech, all of the present and former students praised flight simulation as a way of helping them gain valuable ATC and teamwork skills, ATC experience, and confidence. The students stressed that the simulation taught them as much about working with people as about working with high-tech equipment. Various supervisors of program graduates also considered flight simulation an effective way of teaching students safety and airspace procedures/operations in a less threatening environment than on-the-job training environments. (Appended is the interview instrument. Contains 38 references.) (MN)

Sweaty Palms!

Virtual Reality Applied to Training

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Sweaty Palms: Virtual Reality Applied to Training

Introduction

For most of us the work of air traffic controllers is invisible. We board aircraft somewhat cognizant of the risks but also reliant on the fact that automobile accidents claim more lives than aircraft accidents. When we think about the training of those involved in the aviation industry, most of us can visualize the work and training of pilots and mechanics but the work and training of air traffic controllers dwells somewhere in the land of the esoteric and hidden. This presentation will explore the notion of virtual reality applied to the training of air traffic controllers.

We readily think of the importance of simulation in the training of pilots. Some of us may have even played the computer game, "Flight Simulator." Until 1991, however, little simulation was truly applied to the training of air traffic controllers. This presentation focuses on a federally-funded project in Minnesota that has succeeded in accomplishing a school-to-work transition for college graduates by developing an innovative approach to the training of air traffic controllers, a training approach that relies on the power of high-fidelity simulation, a simulation experience that is more akin to virtual reality or virtual experience. The presentation will draw its perspective from a research study conducted during the period of time from August, 1993-March, 1994.

Background

From the creation of the Civil Aeronautics Authority by a 1938 act of the United States Congress until 1991, persons who sought the career of air traffic controller learned the occupation in one of two ways: training in the armed forces or training under the direct surveillance of the Civil Aeronautics Authority, renamed the Federal Aviation Agency in 1957 and the Federal Aviation Administration in 1967 (Nolan, 1990). Both mechanisms for conducting the work of air traffic control involved careful selection and screening of applicants. Both types of training proceeded from a foundation of clear assumptions about candidates and training/screening methods that would result in a well trained controller workforce.

In the late 1980s, dissatisfied with the results of their training methods, the Federal Aviation Administration (FAA) began considering the possibility of contacting institutions of higher learning so that they would conduct pre-training of air traffic controllers. Criticized from within by controllers because of the nature of the training regimen and lambasted from without by Congress because of the high cost of training coupled with the low output rate from the training of "developmentals," the FAA's term for entry-level controllers, the FAA under administrator T. McArtor undertook research to learn the reasons some air traffic controllers decided to remain in the occupation while others experienced an adversarial relationship and left the organization. This research prompted a series of initiatives under FAA auspices.

One of these initiatives lead to a document entitled Flight Plan for Training which outlined a new model for FAA education and training. Administrator McArtor charged the air traffic division with developing a new curriculum based on "scientific examination of the thought and conceptual processes used by the best controllers" (FAA, 1989, p. 39) to "identify optimal ways to present information and sequence lessons" (FAA, 1989, p. 39). The administrator directed the second major initiative in the "flight plan" to forge "a new partnership with the academic and industrial communities" to meet training and human resource development needs (FAA, 1989, p. 27). The administrator envisioned ties with colleges and universities wherein college students could receive "pre-hire training" and upon graduation, enter the FAA training system (FAA, 1989, p. 28).

In response to these initiatives, a team from the Minnesota Department of Transportation Office of Aeronautics approached the FAA administrator and the head of the newly created Office of Higher Education and Training to propose changes in air traffic control training. After hearing the Minnesota team's proposal, the director of the Office of Higher Education and Training challenged the group to expand their vision and to return within a day with a revamped, collegiate-based proposal--complete with budget. The team did so and proposed a demonstration project that would:

> develop a training program that will provide qualified individuals with the knowledge, skills, and abilities required to become candidates for positions as Air Traffic Control (ATC) Specialists in Federal Aviation Administration (FAA) Air Route Traffic Control Centers....(MARC, [n.d., p.3).

The proposal received positive responses from key officials in the FAA and became a funded project to be "managed by the Mid-America Aviation Resource Consortium (MARC) and supported by a cooperative agreement with the FAA" (MARC, [n.d.], p.3). The Minnesota Technical College System was selected by the Mid-America Aviation Resource Consortium, a group formed in 1989 by Minnesota's public higher education community, to deliver the training and has continued to provide the training and leadership for this project. In 1992 four additional collegiate sites were chosen to complete a cluster of "collegiate training initiative" programs wherein a new approach to air traffic control training could be tested and delivered--as an alternative to the Federal Aviation Administration Aeronautical Center located in Oklahoma City, Oklahoma.

Since the research on air traffic control training has focused on non-collegiate-based programs, the Minnesota project offered an opportunity to study a collegiate model for air traffic control training, a model that developers saw as preparing the way for a paradigm shift for air traffic control training. The Minnesota program (hereafter referred to as MnATCTC) began as a research project. Consequently, the staff, faculty, and students have seen themselves as developing something that has never existed before. This posture has created an environment of experimentation with marked results noted in students' self-reported satisfaction with the program (results drawn from seven feedback sessions with members of the seven graduating classes to date conducted by the researcher as one of her employment tasks with the project) and in

FAA supervisors' satisfaction with graduates' on-the-job performance.

Nature of the Study

The study reported in this presentation reflects a research effort that sought to identify the social and psychological effects of simulation on collegiate air traffic control students in a research-project setting. Previous to the MnATCTC, air traffic control training was said to take a "high tech, low touch" approach. This researcher was particularly interested in the total immersion, virtual reality or virtual experience type of training the MnATCTC students received and the consequent constellation of effects the training environment would have on students' assessment of their ability to handle the complexity of work as an air traffic controller.

Several instructional "content goals" developed by MnATCTC faculty address the psychosocial dimensions of air traffic control and so served as guiding themes for this study. These content goals point to:

1. the essential teamwork aspect of air traffic control,
2. the necessity of recognizing personal stressors and
3. the critical importance of developing coping skills when faced with stress. If the simulation experience is as high-fidelity as the program designers fashioned it, one might look for students in the program to experience many of the same psychosocial effects that air traffic controllers do. The primary research question in the study was: What are the psychosocial effects of high-fidelity

simulation on air traffic control students. The question focused on noncognitive measures in students' self-reports of their experiences. The study sought to discover and describe the effects of the simulation experience as reported by students enrolled in the program as well as by program graduates.

A second question that grew out of the initial planning for this study was the applicability of the notion of "virtual reality" to an academic or training situation. Since the simulation laboratory so closely resembles an actual air route traffic control center (also called a "center" or an "en route center," the study affords an opportunity to look carefully at one application of virtual reality concepts in a practical training situation.

Simulation Theories

Several researchers over the last three decades offer theoretical frameworks on the subject of simulation. Van Ments (1990) believes,

> From a conceptual point of view, it is desirable for students to internalize and personalize learning experiences so that they become firmly embedded into skills and behaviour [sic]. It is a question of closing the gap between thought and experience. As the saying goes:
>
> I hear and I forget;
> I see and I remember;
> I do and I understand (p. 823).

Van Ments offers a useful, "widely accepted" definition for simulation. He writes,

> A simulation is a working representation of reality; it may be an abstracted, simplified or accelerated model of the process. It allows students to explore systems where the real thing cannot be used for teaching purposes because it involves other people or is too expensive, complex, dangerous, fast, or slow.

> Simulations may be tightly or loosely structured but will always be dynamic, as opposed to a model, which is static" (p. 824).

Van Ments indicates that the nature of simulation is such that it aid. in the "long-term retention of material" (p. 825)--a desired benefit for those learning the complex skills associated with controlling aircraft.

Van Ments addresses three other aspects of simulation--all of which this researcher has noticed while conducting observations during the training of students at the MnATCTC. Van Ments points to:

1. The "high level of motivation and enjoyment" simulation engenders in participants. He writes, "It is often difficult to stop the activity....This leads therefore to a high degree of retention of what has been learnt [sic]" (p. 825).

2. The fact that complexity and simulation work hand-in-hand. He states,

> Simulation techniques are particularly good at enabling the student to acquire an emotional, affective understanding which deepens the cognitive, intellectual grasp of the problem, an important element in the learning of social and communication skills" (p. 825).

3. The observation that use of simulations "alters the relationships between students and between students and teacher." (p. 825).

Virtual reality

While simulation provides a powerful tool for students' learning in the air traffic control training center, the notion of virtual reality, or more specifically, "virtual experience" serves

as a useful means to more clearly describe the nature of the reality observed at the MnATCTC.

The brand of reality visible in the MnATCTC simulation laboratory illustrates almost to the letter the description provided by Traub (1991) of a high-intensity learning environment. In fact, a visit to the training facility prompts comments such as the following:

- *"I feel like I'm at Chicago Center"* [the Air Route Traffic Control Training Center located outside Chicago] (a visiting full-performance controller).
- *"When working with students here, as I look at the simulators, for me it's real-time, real airplanes. I don't even notice who the students are"* (an MnATCTC instructor).
- *"This looks just like Farmington"* (an applicant who has just visited the Minneapolis Air Route Traffic Control Center). Many controllers who visit MnATCTC comment on the similarity between the simulation laboratory and an en route center. Most quip that the equipment is much newer and the room has windows unlike actual air route traffic control centers.

The physical setting amazes most visitors because of the complex equipment immediately visible upon entering the large (23' x 28') room. The simulation lab consists of two banks of eight side-by-side radar simulators, each flanked on the right by the flight progress strip bays and equipped with the buttons, knobs, back-lit keyboards, and computer read-out display units (commonly called "crud" by controllers) found in an actual FAA radar

facility.

One description offered by a virtual researcher provides a useful context for the MnATCTC lab. Middleton (1992) writes,

> 'Virtual reality' is used here to refer to a computer-based technology which incorporates specialized input and output devices to allow the user to interact with and experience an artificial environment as if it were the real world" (p.253).

She also notes that since

> Many tasks are best learned 'on-the-job,' but often, in the real world, this is difficult to accomplish. The task may be very dangerous, may require a great deal of rehearsal, or may simply require that a supervisor act as trainer for a significant part of the day" (p. 253).

All of these training characteristics are true in the training of air traffic controllers.

Research methodology

For the study reported in this presentation, the researcher chose the qualitative approach because it represents the methodology appropriate for the stated research question. The case study approach was chosen because of the nature of the project selected for this research. The qualitative approach also suits the paradigmatic change in air traffic control training underway at the MnATCTC (cf. Haggerson & Bowman, 1992, p. 10) and the "phenomenological perspective" inherent in the nature of the data (cf. Patton, 1991, p. 390).

Five different groups of individuals participated in this study. Two groups were students actively involved in the course of training at the time they were interviewed.

Three groups were graduates who volunteered to participate in focus groups. The number of individuals involved in the focus groups was quite small because the selection criteria were narrow. One focus group was composed of graduates of the program who were living in the MnATCTC area at the time of the study. Criteria for the other two focus groups were even more specific in that these individuals needed to be employed by the FAA and at the radar-phase of training.

With respect to the one-on-one interviews conducted during this study, the researcher discovered that several questions helped to galvanize students' thinking about the effects of the air traffic simulation and served to organize students' reactions and responses. Eleven questions related to course content goals drew the most responses from students who were interviewed. These questions related to identifying and managing stress as well as course goals related to teamwork. A few of the questions that drew strong response related to overall effects of the simulation experience and turning points in the simulation training process.

Demographic Composition of the Population and of the Sample

	Percent of the Population* (n=64)	Percent of the Sample (n=38)
Gender		
Male	50%	52.6%
Female	50	47.4
Ethnicity		
Caucasian	70.3 %	71. %
Black/African American	15.625	15.789
Hispanic	6.25	7.894
Asian/Pacific Islander	7.8125	5.263

*The population is here defined as the total number of students enrolled in the MnATCTC program in the classes denoted as "April, 1993" and "November, 1993." Each of these groups consisted of 32 students. The following figures, **Figures 2.2, 2.3**, and **2.4**, provide specific characteristics of each of the groups of subjects who participated in this study. The participants in focus groups are not included in the population or in the sample information given above.

Figure 1
Demographic Characteristics of Sample

Group A

White males	4
White females	5
African American males	2
African American females	
Asian American males	1
Asian American females	
Hispanic males	1
Hispanic females	1
total	14

Age range

23 = 1	26 = 1	29 = 1	57% between 23 and 26
24 = 6	28 = 3	30 = 2	

Educational preparation

two-year degree	4
four-year degree	10

Prior experience with aviation

worked in air route traffic control center	1
military atc experience	1
pilot	5

Career options

11 in this group indicated they had considered other technical careers besides air traffic control

Figure 2
Demographic Characteristics of Sample

Group B

White males	7
White females	11
African American males	3
African American females	1
Asian American males	1
Asian American females	
Hispanic males	1
Hispanic females	
total	24

Age range

21 = 2	24 = 4	27 = 1	
22 = 3	25 = 2	29 = 4	50% between 23 and 26
23 = 4	26 = 2	30 = 2	71% between 21 and 26

Educational preparation

two-year degree	11
four-year degree	13

Prior experience with aviation

air traffic control degree	3
co-op experience with atc	1
military atc experience	4
pilot	9

Career options

14 in this group indicated they had considered other technical careers besides air traffic control

Figure 3
Demographic Characteristics of Sample

Group C

White males 4
White females 3

Educational preparation

Two-year degree 4
Four-year degree 3 (one of these also holds an M.S.)

Group D

White males 3

Educational preparation

Two-year degree 1
Four-year degree 2

Current ages: under 30 = 2
30-35 = 1

Group E

White males 3

Educational preparation

Two-year degree 1
Four-year degree 2

Current ages: under 30 = 1
30-35 = 2

Note: These groups were small because of the selection criteria. Group C criteria: graduates and living in the MnATCTC area at the time of the focus group. Eight individuals were available for Group C; seven participated in the focus group. Groups D and E criteria: graduates working in the MnATCTC area who were currently in radar-phase training. Only eight individuals were "eligible" for Groups D and E; six participated in the focus groups.

Students' responses

Students' responses portrayed a range of feelings and thoughts that showed a pattern. These patterns are found on the charts on the following pages and in the full study (Treiber, 1994). The students' responses indicated a range of psychosocial effects--emotions, thoughts, and strong feelings about the experience. They shared their frustrations and sense of trepidation when they embarked on their training experience. A number of students said they felt overwhelmed by the complexity of the machinery and the tasks they would need to perform. Many spoke of experiencing physical reactions such as "sweaty palms," having a "red-face," "pumping heart" or "butterflies" during their initial experiences with the simulation.

As the training experience unfolded, students shared a sense of pride and accomplishment in making progress toward learning to manage stress. Some students lauded the value of continual practice in the simulation lab indicating that the practice gave them a better sense of their ability to actually "control" traffic rather than being a reactor. Some students explained their specific gains in understanding the complexity of the work required of them in controlling traffic and an increased regard for the work of controllers. Many students reflected on their adjustments to working with others as a member of a team.

Students commented as they neared the end of the MnATCTC training that they felt "confident" to handle the demands of the

occupation. They agreed that the simulation had taught them, as no classroom instruction could, the complex map-analysis skills, communication skills, and memory skills they would need to employ together with the critically important human relations/teamwork skills they would apply on a daily basis as they work in an en route center. Many students expressed the fact that they realized that the simulation had captured for them the "virtual experience" of actually working in an en route center and so felt ready to walk into an FAA en route facility upon graduation. Several students spoke of the "fun" they had controlling airplanes in the simulation experience and specifically noted their pleasure in coming to class because of the enjoyment of the lab experience.

Summary

The intent of this study was to identify the effects of high-fidelity simulation on air traffic control students in a "virtual experience" type of environment. The researcher conducted an exploratory and critical incidence type of case study of students in a demonstration training program called the Minnesota Air Traffic Control Training Center. The five assertions that guided this study were:

1. Air traffic control is a career that demands complex levels of knowledge, skills, and abilities. Instruction for the occupation requires attention to the cognitive, affective, and psychomotor components of the career field.

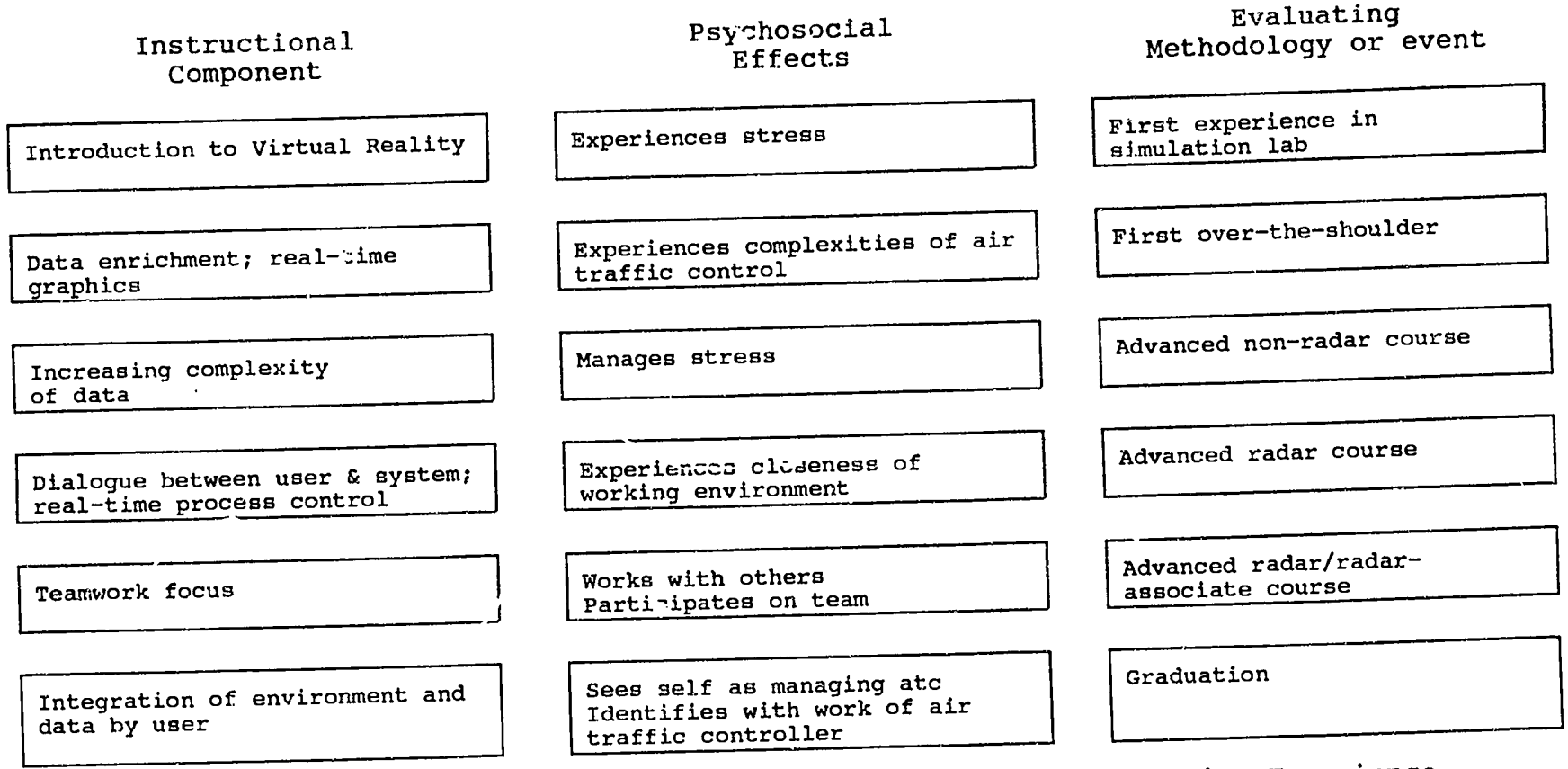

Figure 4: Psychosocial Effects of Air Traffic Control Simulation Experience

Psychological Effects	Group A	Group B	Group C	Group D	Group E
Experiences stress	"got real nervous & tentative" "sweaty palms"	"Definitely get emotionally involved--have to"	"Yes!" Heart rate up" "stomach aches" "not sleeping"	"acted like it was real"	"always a sense of urgency" "not sleeping night before tests"
Manages stress	"seriousness about wanting to complete this"	"Comes down to managing your nerves"	"Learned, forced to handle stress. As things get done,stress goes away."	"Once you got on the simulator and got a handle on it, developed confidence.	"Couldn't wait to get to the lab--it was fun!"
Experiences complexities of air traffic control	"wondered if I had the capability to learn so much so quickly"	"swift kick of reality" "first day was horrible" "love at first sight"	"How do I get this thing to work?"	"How can anybody do it?	"just simulation-not real"
sees self as managing atc= identifies with work	"think I could actually control traffic now"	"getting to automatic"	"I feel like a controller now" "Practice made the difference"	"Got confident" "Got assertive"	"Let's get this figured out"

Table 1: Summary of Psychological Effects with Comments by Each Group in This Study

key to notations: "..." = participants' words

Social Effects	Group A	Group B	Group C	Group D	Group E
Experiences closeness of working environment	"didn't expect to be working on top of one another" "Such a confined space" "Have to be attuned"	"Nothing like the real thing to see space you have to work in" "gets kind of crowded"	"Competition helped me get through" "We were pretty close. Tried to help each other."	learned mechanics	"just simulation, not real" aspects of MnATCTC experience
Works with others	"have to be a good neighbor" "have to get two minds to think alike" "with someone who's difficult still have to do the job"	"Must pull own weight" "Have one goal in mind--makes you work together" "hodge podge of people and techniques"	"helped and hindered" "learning to adjust...to respect other's style"	"worked so closely...who you work with affects performance"	felt they hadn't learned a lot of teamwork
Participates on team	"People might not be ones I enjoy yet outcome must be safe aircraft"	"Expect they'll do something back for you" "second or third pair of eyes"	"Trusting people you're working with" "constantly reshuffling"	"really important"	"A good team is trying to share one brain."
Sees self as managing atc= identifies with work		"Amazing to watch your magic"	"Max me...I want to see if I can do it."	"Some of us got the feeling I can do this."	

Table 2: Summary of Social Effects with Comments by Each Group in This Study

key to notations: "..." = participants' words
_____ = researcher's inference

2. The simulation laboratory in the Minnesota Air Traffic Control Training Center provides a high-fidelity simulation context for the training of air traffic controllers, a context that encourages and motivates students to practice requisite air traffic control skills.

3. The notion of "virtual experience" as applied to the simulation laboratory at the MnATCTC is a useful one to grasp the complex environment for which students in this program attempt to prepare themselves.

4. The fact that the air traffic simulation is so close to reality at the MnATCTC enables students to experience some of the same social and psychological effects as if they were actually working as air traffic controllers.

5. The underlying philosophy in the MnATCTC program together with the use of high-technology offers students a unique environment in which to train for a demanding occupation.

Using the exploratory design of a case study, the researcher attempted to identify the psychosocial effects of the simulation/virtual reality experience. The approach taken was inductive. The researcher wanted to gain insight, interpretation, and understanding rather than test an hypothesis (cf. Merriam, 1988). Four particular issues the researcher sought to explore were:

1. How students' experiences with simulation parallel course content goals, specifically in the areas of team

building and coping with stressors;

2. How engaged students felt they became during the running of a "scenario" on the simulator;

3. How students' experiences with simulation differed or compared;

4. How students' experiences compared with theoretical statements made about simulation and virtual reality; and

5. How graduates of the MnATCTC program currently working in the en route center environment perceive their simulation-training experiences in light of the actual working situation.

In essence, the researcher wanted to get a picture of "how the program looks and feels to them, what thoughts they have about its operation or effect on them" (Patton, 1991, p. 394).

Conclusions

Despite possible flaws that may exist in the design of simulated learning environments, the researcher felt she reached an understanding of the psychosocial effects of the simulation experience in the words of participants in this study. The fact that students' responses could be grouped by themes and patterns together with the fact that students often used identical or similar phrases led the researcher to trust the veracity of their responses. As the descriptions of the samples indicated in Figures 1, 2, 3, the subjects differed in

levels of educatior age, gender, ethnicity and level of speech. However, when talking about their new found "passion," air traffic control, all found words that conveyed their enthusiasm, excitement, drive, determination, and desire to do the work of an air traffic controller. All spoke of the program as having an impact on them. The researcher did not find any differences in responses based on the gender, ethnicity, age, or aviation experience level of the study participants. Inerestingly, students' responses also echoed many theoretical statements about simulation and virtual reality.

During the research study, the researcher had opportunities to talk with various supervisors who have observed MnATCTC graduates. In addition, one member of the management staff at an FAA facility offered his point of view on simulation to the researcher (Treiber, 1994). His words added unsolicited approval for the simulated training process. This individual, Jack Smith, stated, "The equipment is so much better here [MnATCTC] than in facilities. When controllers come here [to MnATCTC], it's a boon." Smith's design for air traffic control training would be simply: 90% of the training would happen via simulation; 10% would occur on-the-job. This training manager added, "The more simulation you have, the better trained folks you'll have." Furthermore, he noted, three elements in simulation specifically benefit students:

1. The safety factor--one can teach safety in the

simulation environment;

2. Simulation has the ability to teach airspace procedures and operations more effectively than on-the-job training; and

3. Simulation takes some of the pressure off the student.

The data drawn from the subjects in this study may provide input for those who are designing or planning training programs that utilize artificial reality on any of its levels Rather than discuss hardware or software, this study has focused on the impact on human beings of a simulated environment that in conceptual terms may be termed "virtual reality." Although visitors will see no data gloves, headmounted displays, goggles, cables, or other accouterments of VR in the MnATCTC, they will see a setting, as described in chapter one, that provides an immersion experience akin to that of an en route traffic control center. The computer "gadgetry" is not the only element in this virtual environment. Instead, the laboratory design, the software, the actual computer workstations, the instructors, the behavioral expectations and the curriculum itself all intertwine in the program design to create a virtual reality environment. The instructional technology, therefore, supports the learning goals and is a key factor in the learning experience but is not itself the point of the experience. As several students in this study noted, the equipment itself was not the only important element in the

training process even though it played a significant role. Students commented on the fact that they learned to work with people just as much as they learned to work with high-tech equipment. As we think about and plan for successful school-to-work transitions, this last comment about learning to handle high-each equipment as well as developing the people skills requisite in the workplace provides a challenge for us. The challenge is to provide both the "sweaty palms" experiences and instruction enhanced by the finest technology while providing curricular goals that address the human element, the requisite "people skills" to ensure full employability of our graduates.

APPENDIX 1

Interview questions for currently enrolled students:

1. What prompted you to consider ATC as a career?
2. What other career options have you/did you consider first?
3. What ATC facility/facilities did you visit before you began your training?
4. What questions did you ask controllers?
5. What did you observe at the ATC facility?
6. What did you expect/think/imagine ATC would involve?
7. What did you expect/think/imagine ATC training would involve?
8. Describe your first time/experience in the ATC lab.
9. What were your reactions/responses during/after the first lab session?
10. What were your thoughts and feelings about instructors' directions when you first used the simulation equipment?
11. What stands out about the practical radar course exams?
12. When you first worked with another student at the simulator what were your thoughts and feelings? impressions?
13. Think about working without a "D" side or "R" side person now. What would it be like to work alone?
14. What has the simulation equipment done for you with respect to--ATC skills
15. " " " " " --ATC time pressures
16. " " " " " --focusing on the screen and targets?

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