DIGITAL INEQUALITY AND THE IMPLEMENTATION OF NEW TECHNOLOGIES:
PROBLEMS WITH TECHNOLOGICAL DIFFUSION AMONG OKLAHOMA EMERGENCY MANAGERS

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Digital Inequality and the Implementation of New Technologies: Problems with Technological Diffusion among Oklahoma Emergency Managers

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Abstract
With the introduction of new technology into a society there is always a differential rate in which individuals and groups within that society begin to fully utilize the technology. This unequal rate of technological diffusion can occur for numerous social, political, geographic, and economic reasons (DiMaggio, 360; Rogers, 469). In this paper, we use diffusion inequality theories to better understand how weather detection technology is being employed by Oklahoma emergency managers. An analysis of 35 in-depth interviews with emergency managers (EMs) is used to determine the current ability of EMs to access weather detection radar technology as well as the potential impact that future advancements in radar technology may have on these EMs. Findings suggest the prevalence digital inequality among Oklahoma emergency managers. The social and policy implications of these findings are discussed.
Technology Diffusion and Emergency Managers

This study focuses on data generated by social scientists from the Disaster Research Center (DRC) at the University of Delaware and the Center for Applied Social Research (CISA) at the University of Puerto Rico Mayagüez working under a grant from the National Science Foundation. In conjunction with CASA\textsuperscript{2} at the University of Massachusetts-Amherst, the DRC and CISA are currently completing a component of a study intended to explore end-user\textsuperscript{3} needs for the implementation of new weather detection radar technologies. Specifically, this paper addresses how technology diffusion inequality may impact the implementation of these technologies among emergency managers. Using data collected from in-depth interviews with emergency managers in the CASA test bed regions of Oklahoma, this paper identifies some of the key problems related to technology diffusion in that region and some possible steps towards mitigation.

The Digital Divide

One well-known concept within the field of diffusion inequality research is the idea of a “digital divide.” This term was first popularized by a series of reports on computer-related inequalities released by the Nation Telecommunications and Information Administration (NTIA) in the late 1990’s. In these reports, the digital divide was basically defined as the gap that lies between those individuals with Internet access and those without. This gap is not random and typically follows many preexisting social inequalities. One example of this type of divide can be observed among different age groups. According to one survey, “rates of Internet use rise rapidly from age three to a

\textsuperscript{2} The Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA).
\textsuperscript{3} The end-user community consists of users of the Distributed Collaborative Adaptive Sensing (DCAS) weather data, such as the National Weather Service, private meteorology companies, and emergency managers involved in hazardous weather decision making.
peak around 65 percent at age twenty-five; then descend gently to just below 60 percent by age sixty-five. At that point, rates decline rapidly with age” (DiMaggio, 361). In this case, the group of younger individuals is at an advantage because they have greater access to information, commercial goods, and opportunities for economic gain. On the other hand, the eldest group of individuals is relatively disadvantaged by their lack of access to these resources. Age is just one example of many factors that can contribute to the formation of a digital divide. Others factors such as income, gender, race, geographic location, and socioeconomic status can all influence how a divide forms.

While the concept of a digital divide may be a useful tool for framing part of our discussion of technology diffusion in Oklahoma, there are some shortcomings to this concept that necessitate an expansion of the ideas and concepts discussed in this paper beyond the scope of “digital divide”. With the relatively rapid increase in the number of Americans with access to the Internet, some researchers feel that the gap between those with access and those without is beginning to shrink (Compaine 2001, Servon 2002, Mossberger 2003). Other gaps, such as those involving race and socioeconomic status, have also decreased (NTIA 2002). As these gaps have grown smaller and more people have access to the Internet, so may the applicability of “digital divide” (Wharschauer 2003). One of the main problems with the term “digital divide” is that it does not describe the inequality that also exists among those who do have access to the Internet. At the same time researchers have begun to discover inequality among online individuals (Mossberger 2003, Wharschauer 2003). Thus, the main limitations in the digital divide concept come from the fact that it identifies inequality based only on whether or not people have access to the Internet. It does not consider the myriad of possible
inequalities that could occur among the rapidly growing and changing groups of people who have access.

Among Oklahoma Emergency Managers (EMs) some forms of online inequality seem particularly relevant. One of these forms manifests itself as what Rogers describes as a knowledge gap. According to Rogers,

Eventually, as the rate of diffusion of the Internet approaches saturation, the digital divide as we know it today will disappear. The inequality in access to Internet-provided information, however, may continue as the present access-divide is replaced by a learning-divide (in which certain individuals lack the skills of computer and/or Internet use), a content divide (in which less educated individuals may not be able to comprehend that content of Web sites created by highly educated individuals), and other types of divides (469).

Thus, for Rogers the digital divide is being replaced by a learning-divide and a content divide, in which the unskilled will not have an equal ability to use beneficial resources available on the Internet.

DiMaggio (375) uses the “knowledge gap” hypothesis to explain this type of online inequality. Borrowing from Tichenor, Donohue, and Olien’s (1970) description of a “knowledge gap” in earlier communications technologies, DiMaggio further articulates what Rogers calls the “learning divide.” The knowledge gap theory states that “people of higher socioeconomic status are always advantaged in exploiting new sources of information” (375). Higher socioeconomic status gives individuals the advantage of learning about new technologies sooner and being able to buy them earlier. Additionally, DiMaggio claims that higher status individuals tend to be more educated, which aids them in cognitively processing new technological information more efficiently (375-376). Consequently, although limited Internet access may someday become a thing of the past,
what can be called a “knowledge gap” will still occupy the system for a much longer period of time.

The implications a “knowledge gap” could have on the prospects of successfully and efficiently employing more advanced weather detection technology are significant. Even if the digital divide were to close in the near future, not all of the problems associated with the divide will disappear. If over the next several years all emergency managers were given access to the Internet, there would be no guarantee that their ability to utilize the Internet would be equal. Thus, this newest, and potentially most persistent, knowledge gap among EMs poses an even more significant barrier to the implementation of newer more sophisticated technologies.

Another form of online inequality also has relevance for Oklahoma emergency managers. This inequality involves the unequal distribution of Internet related technologies. Specifically, we are referring to the type and bandwidth of available Internet connections as well as the computer hardware used to access the Internet. The National Telecommunications and Information Administration (NTIA) divides types of Internet connections in the United States into two basic categories: dial-up and broadband (2004). Dial-up refers to the process by which a computer is connected through the use of a modem to the Internet over a public telephone network. Although the rate at which data can be transferred with a dial-up connection varies greatly, the standard data rate is 56kbps (56,000 bits per second). According to the Federal Communications Commission (FCC), broadband Internet access is defined as Internet services with speeds over 200 kbps in at least one direction (2000). The types of broadband Internet access most available to Oklahoma emergency managers include
digital subscriber lines (DSL), cable modem, and leased lines made available to the EMs by outside organizations. The type of computer hardware available for accessing the Internet also plays an important role in online inequality. The software programs that Oklahoma emergency managers use to access radar data online all require a minimum set of hardware specifications to operate (see Appendix A). Additionally, there is a differentiation in the rate at which different types of computer hardware can process commands and information, with the older computer models performing tasks at a much slower rate than the new models.

While many factors can contribute to these technological inequalities in Internet access, one concept which may prove particularly useful for understanding online inequality in Oklahoma is that of “geographic capital.” In general, geographic capital consists of the spatial advantages in resource endowments. According to Nicholas (2000), Internet geographic capital is produced by a combination of supportive market forces, accommodating local policy, and unimpeding geography. Normally, when geographical capital is present it goes unnoticed. It is only when geographic capital is lacking that its true importance becomes apparent as “...the absence of geographic capital leads to an absence of functional Internet access” (287). Nicholas identifies those forces that impede the establishment of an effective telecommunications network as “geo-policy barriers” (287). These barriers, “…are chokepoints, mechanisms of control created through the interaction of geography, market forces, and public polices” (287). In this theory, of key importance is the fact that these controlling factors interact with one another to form powerful barriers. One of these factors alone will not necessarily be significant enough to block the establishment of an effective telecommunications
network. According to Nicholas, it is when these three controlling factors occur together that strong barriers arise to halt technological development. Thus, for example, in areas with geographical impediments, such as long distances or a high mountain, it may be possible for a community armed with accommodating political policy and willing market investors to overcome such an obstacle. However, in other areas that have the same geographical barriers, but also highly restrictive public polices and uninterested investors, the outcome is likely to be very different.

From this theoretical review it has become clear that digital inequality can be manifested in a variety of ways and can occur for numerous reasons. Using these theories as a guiding analytical framework, the following section attempts to determine the types and causes of digital inequality that may be present among Oklahoma emergency managers.

Methodology

DRC and CISA researchers collected data through the use of in-depth interviews (90 minutes to two hours in length) with representatives from specific operational communities within Oklahoma’s emergency management system. Interviewees (N=35) were selected via purposive and snowball sampling and consist of local, county, and state emergency managers; scientists and forecasters from the National Weather Service (NWS); and an amateur radio (HAM) operator. The locations of these interviewees are centered on a four-county area in southwestern Oklahoma that is intended to be the initial test bed region for CASA’s newly developed radar systems.

4 HAM radio operators play an important role in weather detection in Oklahoma. They work closely with the EM’s during severe weather acting as “spotters” in the field.
In each interview participants were asked a series of questions regarding weather information sources, the emergency management decision-making process, communications, severe weather warnings, end-user needs for new technology, and policy issues. These interviews were recorded and then transcribed for analysis. An analysis of the transcripts via ATLAS.ti (qualitative analysis software) was then employed to discover dominant themes related to technology diffusion among emergency managers.

Diffusion Inequality in Oklahoma: Findings and Implications

Our findings from interviews with Oklahoma emergency managers suggest the existence of a strong digital and technological divide. This divide includes not only a gap between EMs with and EMs without Internet access, but also, among the EMs with access, a second more complex form of inequality. This second divide includes a differentiation in the diffusion of both knowledge and technology. Consequently, this section of our paper discusses both of these divides in terms of what we have found in Oklahoma and its relationship to previous research.

On a very basic level there exists the issue of whether or not the emergency managers are able to access the Internet. Currently, the specific numbers and types of emergency managers in Oklahoma who have access to an Internet connection is unknown. However, from our interviews with NWS officials and emergency managers it is possible to construct a basic picture of the emergency managers with and without Internet access. According one weather official:

There are some people that are sitting in around central Oklahoma...where the emergency management community has access to high speed wide band
communications devices. They can handle almost as much information as we can pump at them if you’re talking about graphics or highly graphic intensive product with a lot of information in it. But rural counties on the other hand, if they got anything at all, maybe a dial-up line somewhere.

Thus, according to this interviewee, the gap between those with and without internet access in Oklahoma is greatly influenced by geographic location. As stated by the

Figure 1: U.S. Census Bureau Map of the Population Density in Oklahoma.

...weather official much of the population in Oklahoma is located in the central portions of the state (see Figure 1). This observation also correlates with findings presented in a series of NTIA reports on how Americans use the Internet (1998, 1999, 2000, 2002, 2004). In 2002, the NTIA identified a number of factors contributing to a digital divide. Among these factors is the technological inequality that occurs between urban and rural areas. Specifically, the NTIA (2002) notes a gap between rural and urban areas with greater availability of Internet access in the urban environment.
Another major factor that affects access to the Internet is the availability of economic resources (Rogers, 2004). Individuals and populations with greater economic resources are far more likely to have access to the Internet than those with limited economic resources. Given that a relatively large area of Oklahoma is sparsely populated (See Figure 1) it seems unlikely that most of these communities could muster the resources necessary to increase the availability of Internet access. This influence is clearly indicated in the following passage from an interview with a rural EM:

I was buying a radar product from a vendor ... out of my own pocket because the county couldn’t afford that product so that’s kind of where we’re standing at. [Name Omitted] County is not a very wealthy county and therefore we have to use all of the free access that we have available to us...

According to this EM, the county simply does not have the funding to invest in weather detection technology. This and similar findings were found in interviews with other rural emergency managers.

Thus, while some emergency managers located in the central parts of Oklahoma have relatively easy access to broadband Internet connections, several barriers prevent many rural EMs from successfully accessing the Internet. These barriers include both the reduced availability of Internet speed and access in rural Oklahoma, as well as an inability to purchase the required technologies to connect to the Internet.

Among those interviewed who have access to the Internet there is extensive variability in the degree of their access. In one extreme, some emergency managers located in or near urban settings have broadband connections, which include such connections as DSL, cable modem, and even T1. As stated in a previously quoted passage from a weather official, these broadband connections allow users with reasonably up-to-date computers around-the-clock access to the Internet at very high speeds. While
the number of individuals with broadband connections in Oklahoma and the rest of the United States is increasing dramatically (NTIA, 2004), it is clear that among the predominantly rural Oklahoma emergency managers the principal type of Internet connection available is still dialup.

While much of the radar data available to emergency managers over the Internet is technically capable of being transmitted over a dialup connection, not all EMs feel that dialup is an effective means of receiving weather data. One of the main problems expressed by emergency managers is that a 56kbps connection can be too slow and unpredictable. According to one EM, the current amount of OK-FIRST\(^5\) data being transmitted over the Internet currently “pushes the limits” of how much data a dialup connection is capable of transferring. In an ideal setting using a large portion of available bandwidth would not cause any problems, however, in most real life situations the functioning of the Internet is far from ideal. According to one EM, “…Internet bandwidth sometimes is an issue when there’s a very active weather event on in the southern plain through central plains. The web slows down.” This fact is important when we consider that radar data consumes a large portion of the bandwidth available over a 56kbps connection. For Internet applications that use only a small portion of the available bandwidth, a temporary reduction in available bandwidth is less likely to have as significant an impact on that application as it would on an Internet applications that requires all available bandwidth for normal operation.

Another problem that EMs have reported about dialup connections is that they require the use of their telephone line. This can become problematic for EMs, who often

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\(^5\) OKlahoma’s First-response Information Resources Systems using Telecommunications (OK-FIRST) is the most commonly used online source of weather information for EM’s in Oklahoma.
need to call or page other agencies and organizations during severe weather. For instance, one emergency manager who uses a paging system has to, "... close everything off, bring up the paging program, type in everything I need to do, send the page, then when it's done, I have to go back up, sign in on dial up, reload everything, and on dial up [the] connection it's super slow." Thus, unless a rural EM has multiple phone lines, he or she will be unable to use the telephone, or any other phone line application, without first going through the lengthy process of disconnecting from the Internet.

In order to better understand some of the issues being raised by emergency managers, we have attempted to access and use OK-FIRST using a dialup connection. The radar data was accessed using a Pentium II laptop with the minimum required 64MB of RAM for using OK-FIRST. For comparison purposes, we also accessed the same data using a new Pentium 4 computer with 256MB of RAM linked to the Internet with a high-speed connection. In the dialup attempt, we were able to access and navigate the radar data without experiencing any severe delays or malfunctions as long as no more than two browser windows were open. Processes such as animated radar graphics, which would be expected to take an extended period of time to download, generally took from 10 to 20 seconds to complete. When three or more browsers were used to look at data from different radar towers simultaneously they became subject to "freeze-ups" sometimes lasting one minute or longer. When using the newer computer with a high-speed connection there was a noticeable difference. In this test, even the most complex data was received and displayed almost instantaneously. We were able to open ten browser windows, each viewing animated data from different radar towers, without any noticeable reduction in computer or Internet speed.
Rural emergency managers in Oklahoma are faced with several barriers to Internet access. First, there are the obvious geographic problems associated with being in rural areas. Higher speed connections are typically confined to areas in and around urban settings, which often leaves dialup as the only option for connecting to the Internet. Second, rural EMs are often not given sufficient funds to effectively access potentially available Internet sources. Insufficient funding can include anything from being unable to afford an adequate Internet connection to not even having a computer. For instance, one emergency manager we interviewed claimed that he had to, "...use the computer down at City Hall to help us 'cause we don't have one in here yet." Another instance was related to us by an EM describing the recent experience of a neighboring county's emergency manager:

It took...forever for the county just to let him have an old, used computer. And he went to OK-FIRST [training sessions] and did all the training and everything, but the computer wouldn't support it [i.e. the OK-FIRST software] because it was so old. So he went out and bought his own [computer]

Another emergency manager who does have a computer has encountered considerable resistance from his local government when he requests additional funding for a higher speed connection. According to this EM, who can barely afford dialup Internet access on his current budget,

...DSL is available ... but it comes out of our budget so [the city claims] "we don't need that." ... I think city hall has got it and I think they are only paying maybe 20 dollars a month to get the upgrade. We need it.

Thus, on the level of technological access, rural EMs are often blocked by not only geographical barriers, but also political barriers.

The above mentioned combination of geographical and political barriers suggests the presence of Nicholas's geo-policy barriers. Given the scope of this research project
we are unable to determine whether or not market forces (such as telecommunications companies) are directly contributing to this problem. However, despite our inability to fully investigate all aspects of online inequality, it is clear that variations of Nicholas’s geo-policy barriers are present in rural areas of Oklahoma.

Another problem that plagues rural emergency management in Oklahoma is a significant knowledge gap in the ability to use Internet and radar technologies. Many rural emergency managers lack the necessary training to effectively interpret radar data they receive over the Internet. For these untrained emergency managers, attempts have been made to make training more accessible. In the OK-FIRST program training is offered to Oklahoman emergency managers free of charge at least once a year. However, for many emergency managers there are additional barriers preventing them from attending these training sessions. One major contributor is the fact that in many rural areas the EM positions are only part-time and are often unpaid. Most of these emergency managers also have full-time jobs. These two factors can significantly deter EMs from attending training sessions. As one EM we interviewed states:

I’ve talked to a couple of the emergency managers from municipalities that also serve as fire chief and they would like to go [to the training sessions]. You know there’s no cost. They would like to go to the OK-FIRST deal [i.e. training] but they can’t because a full OK-FIRST class is a week long. They’ll have to take vacation or something like that so they, 99% of the time, don’t do it because they can’t afford it.

In this case, numerous factors may be contributing to this knowledge gap. Most obvious is the lack of socioeconomic resources these rural municipalities have which prevents them from being able to have a paid emergency manager. However, even with limited resources it seems plausible that these local governments would be capable of providing volunteer EMs with some sort of compensation or partial funding to attend a training
session. Thus, while resource problems may ultimately be one of the primary causes of the knowledge gap in Oklahoma, it may be that other more subtle political and economic issues also play a role.

Current Attempts in Oklahoma to Resolve Digital Inequality

In Oklahoma, some efforts have been made to resolve the existent digital inequality. Among emergency managers the most popular effort has been the OK-FIRST program. Founded in 1996, OK-FIRST is,

... an initiative by the Oklahoma Climatological Survey to improve access to current weather information and to develop a decision-support system for the state’s public safety (fire, police and emergency management) agencies. (OK-FIRST, 2005).

This project includes efforts to resolve both knowledge and technology related barriers to accessing weather information online. To help overcome knowledge barriers, OK-FIRST offers multiple training sessions to emergency managers on a yearly basis and free of charge. These sessions are designed to improve EM knowledge and interpretation of weather data. Additionally, OK-FIRST also offers free online training materials for emergency managers to read on their own. On the technology front, OK-FIRST has provided computers to EMs and developed software designed to make it possible for weather data to be accessed over a dialup connection. These efforts have been invaluable to emergency managers and have helped to close some of the digital divide and knowledge gaps in Oklahoma.

Unfortunately, as we have made clear in the previous sections of this paper, OK-FIRST has not been able to actually resolve the online inequality among EMs. In 2002, data from the OK-FIRST website indicated that only 25 percent of Oklahoman...
emergency managers have actually participated in OK-FIRST. Given that this program has existed for almost ten years and that the problems expressed by EMs have often involved OK-FIRST in some way, it seems likely that additional steps need to be taken to resolve digital inequality in Oklahoma. However, a number of social, political, economic, and geographical barriers must be lifted to effectively overcome digital inequality.

Implications of Digital Inequality for the CASA Project.

The development of newer more sophisticated radar systems by the CASA program has the potential to cause an additional problem for emergency managers who are struggling to receive the data currently available online. Among some of the improvements this new technology is intended to provide is an increase in either spatial or temporal resolution. However, given that an increase in either type of resolution would also necessitate an increase in the amount of data being transferred over the Internet, it seems likely that this new technology would make accessing CASA generated weather information with a dialup connection nearly impossible.

An additional problem that may accompany the new radar technology is the additional training that may be needed to interpret higher resolution graphics. Consequently, without renewed efforts to lift the geo-policy barriers and knowledge gaps in Oklahoma, this newly developed radar technology will most likely increase the already existing digital inequalities between urban and rural EMs.

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6 The data for these calculations were collected from OK-FIRST (2002) and the Oklahoma Emergency Management (2002).
7 The amount of detail in a radar image.
8 The frequency in which a radar image is updated.
Although CASA is producing a technology that could potentially exacerbate digital inequality among emergency, the CASA program also contains components capable of mitigating the severity of this effect. As a part of its end-user integration project CASA is building partnerships with private industry, government officials, emergency managers, and the National Weather Service. Through its involvement with these groups, CASA is in a unique position to help mobilize the educational, training, and technological resources needed by many emergency managers. For example, one of the issues causing digital inequality in Oklahoma is a knowledge gap produced by unequal access to EM training and education programs. While CASA may not be able to provide the resources for EMs to attend training courses, it does have the ability to work with currently existing programs, such as OK-FIRST, to incorporate training on CASA’s radar technology into their training programs.

Thus, while new developments in weather detection technology are an important part of improving disaster prevention and response, it is equally important that the many social, political, economic, and geographic factors involved are also addressed during the planning and implementation of this technology. Furthermore, with its unique relationship to private industry, emergency managers, and government agencies, CASA has an opportunity to help mitigate digital inequality. Such actions will help to insure the effectiveness of CASA in meeting and responding to the needs of end-users.
References


(http://okfirst.ocs.ou.edu/info/directory/userdir.html).

(http://okfirst.ocs.ou.edu/info/overview/overview.html).


Appendix: A

Computer System Requirements for Using OK-FIRST
(OK-FIRST, personal communication, December 21, 2004)

Macintosh System Requirements

Recommended Mac OS X configuration for WxScope Plugin:
- PowerPC G3 or better at 300 MHz with 128 MB of RAM
- Mac OS 10.2
- Safari 1.1, Netscape 7.1, Mozilla 1.3, Mozilla Firebird 0.7.

Recommended Classic Mac OS configuration for WxScope Plugin:
- PowerPC G3 or better at 300 MHz with 128 MB of RAM
- Mac OS 9.2.2
- Microsoft Internet Explorer 5.1
- Web browser memory partition of at least 24 MB

Minimum Required Mac configurations:
- PowerPC 601 or better at 100 MHz with 64 MB of RAM
- Mac OS 8.6 through 10.2
- Microsoft Internet Explorer 4.0 through 5.2
- Netscape Navigator 4.0 through 7.0
- Other web browsers based on Mozilla 1.0 through 1.2

Does not support the following:
- Macintosh computers with Motorola 680x0 processors
- Versions of Mac OS prior to 8.6

Windows System Requirements

Recommended PC configuration for WxScope Plugin:
- Pentium III or better at 400 MHz with 128 MB of RAM
- Microsoft Windows XP
- Microsoft Internet Explorer 6.0

Minimum Required PC configurations:
- Pentium or better at 200 MHz with 64 MB of RAM
- Microsoft Windows 95, 98, ME, NT4, 2000, or XP
- Microsoft Internet Explorer 4.0 through 6.0
- Netscape Navigator 4.0 through 7.0
- Other web browsers based on Mozilla 1.0 through 1.2

Does not support the following:
- PCs with Intel 80486 or earlier processors
- Versions of Windows prior to Windows 95 or NT4