MEDINFO 98
B. Cesnik et al. (Eds)
Amsterdam: IOS Press

Health Care Workers and Their Needs: The Forgotten Shadow of AIM Research

Svein-Ivar Lillehaug[a], Susanne Lajoie[b]

[a]*Departments of Medical Informatics and Computer Science, Linköping University, Linköping, Sweden*
[b]*Department of Educational and Counselling Psychology, McGill University, Montreal, Quebec, Canada*

Abstract

The field of AI in Medicine (AIM) seems to have accepted that decision support is, and will be, needed within most medical domains. As society calls for cost-effectiveness, and human expertise or expert guidance are not always available, decision support systems (DSSs) are proposed as the solutions. These solutions, however, do not necessarily correspond with the basic needs of their targeted users. We will show this through a review of the literature related to health care workers and the various factors that have an influence on their performances. Furthermore, we will use these empirical findings to argue that the AIM community must go beyond its decision support philosophy, whereby the gaps in human expertise are filled in by the computer. In the future, joint emphasis must be placed on decision support and the promotion towards independent and self-sufficient problem solving. In order to implement this paradigm change, the AIM community will have to incorporate findings from the research discipline of AI in Education.

Keywords

Empowering health care personnel; AI in Medicine; Medical education; Decision support systems

Introduction

AIM emerged as a research field in response to several simultaneous needs, opportunities and interests some thirty years ago. There was an increased demand for high quality medical care at the same time as the amount of medical knowledge seemed to explode [1]. If the outcome of AIM is measured in terms of number of applications in commercial use, then the field has been unsuccessful. On the other hand, AIM has contributed to theoretical AI and cognitive science in several areas, including: knowledge acquisition, knowledge representation, reasoning, critiquing, explanation capabilities and insight into human cognitive processes in problem solving [2,3,4]. These scientific achievements are, however, not enough as the future of AIM is dependent on the discipline demonstrating a positive impact on health care [5].

In this paper we will first present various directions proposed within the AIM community for how to address the question of practical success. These all address Szolovits' 15 year old remark where he stated that the clinical acceptance of AIM programs depends on the establishment of the indispensability of such programs [1]. This has later been interpreted as *the successful demonstration that health care professionals perform better when assisted by decision support systems* [3]. By presenting and discussing findings from a review of empirical research that examines the relations between the health care personnel's level of knowledge and skills, their job satisfaction, and the quality of the health care they provide – we will argue that the current philosophy of AIM research is founded on incorrect premises. The health care system, as a whole, is better off empowering the personnel to do a better job instead of giving them powerful tools that solve their complex problems. Information technology will play an important role in this process by [a] the use of AI based applications founded on established educational theories and cognitive research methods to directly address medical education and training, [b] an integration of techniques originated in this multi-disciplinary research into DSSs [6]. The latter of these processes, which we will focus on in this paper, can be seen as a new interpretation of Szolovits' remark, stated as: *the successful demonstration that health care professionals perform better when assisted by decision support systems, and furthermore, that they through the use of these systems can develop the knowledge and skills required to become independent self-sufficient problem solvers and decision makers.* t

The Aim of AIM Research

AIM applications are intended to address complex problem solving especially targeting domains where human expertise is not always available. The debate as to why the promises of AIM were never fulfilled is almost as old as the history of the research field itself. Whereas other areas of science, industry and society have adopted the contributions of AIM and then applied them to real problems with great success, the AIM community is still examining itself and asking "where did we fail?", and "where do we go now?" [2,3,4,5].

An important trend can be observed in the history of AI research. Whereas the first generation of AI applications dealt with pure problem solving, giving the users directions for what to do, today's AI applications serve to advise the users rather

than directly solve their problems. This paradigm change has also occurred within the AIM community where these applications are referred to as *expert systems* and *decision support systems*, respectively. More recently, research scientists within the field have advocated for a new shift in the AIM research towards *computerized guidelines* [4,5]. This can be referred to as the third generation of AIM applications. Despite these paradigm shifts, however, the development of AIM based applications are still motivated by a belief that health care professionals will perform better when assisted by these applications. Although the answers to the problems might be given as collegial advice, or guidelines, they still represent solutions to the ongoing problem solving process.

Health Care Workers' Needs

The traditional AIM approach of DSSs is not necessarily in correspondence with the basic needs of the health care workers. A selective review of the literature related to health care workers and their performance suggests that there are several issues that should be considered when examining the needs of medical personnel.

A Need to Know

Slotnick [7] examined the relationship between Maslow's [8] need hierarchy and how physicians learn to solve problems. Maslow's need hierarchy consists of four levels: need for *security* (predictability); *affiliation* (feel valued as a member of a group); *self-esteem* (feel good about oneself), and *self-actualization* (maximize one's potential). Physicians must fulfill their need for security because if they are uncertain about how to deal with a clinical problem their insecurity could lead to inefficiency. A physician wants to know what to expect and how a patient will respond to therapy. In essence, physicians would like to predict the outcome of their patient management. These needs can only be addressed by learning the appropriate skills for patient management. Similarly, medical students also feel more secure when they know how to apply their basic science knowledge to the real world.e

Perceived self-efficacy, defined as people's judgments of their capabilities to conduct certain actions required for specific performances, is another variable with a strong influence on the quality of individual's performances in any domain [9]. Having a positive judgment about what one can do influences one's performance. A physician's 'need to know' and her degree of self-efficacy are strongly related. With the knowledge to predict the outcome of a situation, she will also have a stronger judgment of her capabilities in within the very same situation.

Job Satisfaction Related to Knowledge and Skills

Another affective variable that has been studied in medical contexts is that of job satisfaction. Dunn and Kaynard found a significant relationship between physician's attitudes pertaining to job satisfaction and comfort level as it applied to managing critical care patients and level of knowledge [10]. Essentially, job satisfaction and comfort level increased as knowledge and skills increased. This relationship supports the assumption that confidence and knowledge are intertwined. Another study of medical personnel's attitudes towards job satisfaction identifies three variables that relate positively to job satisfaction: meaningfulness of work, responsibility for outcomes of work, and, knowledge about the results of one's work activities [11]. These findings are supported in a study by Hackman and Oldham who found that individuals were most satisfied when they learn, have experienced responsibility for positive outcomes, and, have performed well on tasks that they find meaningful [12]. In a related study which examined the effects of job-redesign for medical laboratory personnel it was found that personnel find jobs more enriching when there is an increase in complexity and challenge rather than when more of the same or lower level tasks are added [13].

Other studies report on a strong relationship between the health care personnel's level of knowledge and skills, their understanding of their job, their job satisfaction and the quality of the health care they provide [14,15]. The best health care is provided by those with a high level of knowledge and skills - and these same people are also the ones that feel most satisfied about their work. The notion of feeling good about oneself in what one is doing relates to Maslow's need for positive self-esteem [9].

The Positive Effects of Empowerment

When individuals are allowed to demonstrate what they know and can do they are empowered. Empowerment, as used here, refers to the ability to utilize and maximize one's potential. Radice [16] found a relationship between nurses' sense of empowerment and their job satisfaction. Having some control over one's environment can increase one's perceived self-efficacy. In a study that examined the effects of cost-effective measures in health care facilities, Fisher [17] found that nurses who were aware of the necessity for cost effective measures and were included in decisions regarding such measures, had better attitudes towards their work and were empowered to perform their jobs more effectively. Similar findings are also reported by others [18]. In another study it was found that a more satisfied personnel gives a better work environment which again results in better patient care [19]. Satisfaction was tied to participation in the decision making process. Open lines of communication regarding decision making results in higher satisfaction. Inclusion in the decision making process has a strong relationship to empowerment.

Responding to the Needs

In summary, the reviewed literature tells us that the health care system can best be improved by maximizing the individual health care worker's potential. This can be achieved through acknowledging the factors that have an impact on the health care workers and their performance, knowledge, and skills. These are: a feeling of security in what one is doing; high self-esteem; complex and challenging tasks that require a certain degree of responsibility; satisfaction with one's work and performance; taking part in decision making; affiliation within a group; self-efficacy; self-actualization, and; positive learning outcome.

The reviewed literature is informative for designing appropriate uses of technology in medicine. It is evident why DSSs have not

successfully empowered health care workers. AI systems are designed to solve complex cognitive problems for their users. In so doing they also reduce some of the challenges in these same tasks. There is the risk that users of such systems will not be as personally engaged in the outcome of the problem and may lose motivation, attention, and understanding of the problem resolution. These effects are obstacles to empowering personnel on-the-job and could explain some of the resistance against AIM applications. It is our contention that the health care system would benefit more by empowering personnel rather than providing them with canned solutions. Empowerment can increase job satisfaction of health care workers and consequently increase the quality of patient care.

Given the referenced literature and our discussion, an important question that should be raised within the AIM community is how can this field aid the medical personnel in an empowerment process. We have previously addressed this question through the use of AI techniques for education and training [6]. In the following we will focus on how to address the empowerment process through the use of DSSs.

DSSs and Education, the Past

For medical DSSs to gain any practical impact they will have to address the needs of their users - and not only the isolated question of quality in decision support. In other words, the AIM community must go beyond a decision support philosophy, where gaps in human expertise are filled in by the computer. Joint emphasis must be placed on decision support and the promotion towards independent and self-sufficient problem solving. That is, although these applications are implemented to replace missing expertise - primary consideration should be given to the promotion of self-reflection and independent problem solving and decision making.

Although educational aspects of DDSs were identified as an AIM research field two decades ago [20], little interest has been paid to this area. Among the few exceptions are the well-known projects ATTENDING [21] (pioneering work on critiquing expert systems), GUIDON [22] and Iliad [23,24]. Several other AIM applications, however, do claim that they can be used as aids for education, instruction, or training. It is more or less a rule that a paper describing an AIM application ends up with the sentence: "In addition, application X can be used for training". These educational claims are usually connected to the availability of explanation facilities that can be accessed while on a case. As long as traditional AIM systems are not in regular use, these educational facilities are of no practical value. In addition, the educational aspects of such applications must be taken for what they were implemented to be - a side product with no foundation in educational theory. Finally, this method of adopting AI to medical education seems to have completely ignored the experiences of GUIDON.

GUIDON adapted AI for medical education by building an intelligent tutoring system using MYCIN's knowledge-base and explanation mechanisms [22]. This method proved inefficient since the rules were hard to understand and remember, and furthermore, providing just the expert reasoning left no consideration for a student who reasons in a different way [25]. Consequently MYCIN was reconfigured into NEOMYCIN and GUIDON into GUIDON2 [22]. Through this reconfiguration it was possible to establish a model of diagnostic thinking, where several levels of clinical problem solving were identified supporting other literature on levels of expertise [25,26].

Iliad is a DSS developed in the domain of internal medicine. It provides the user with three different modes: consulting, critiquing, and, training. The latter aims at giving the user practice in solving realistic diagnostic problems [23,24]. An interesting idea addressed by this mode is the use of multiple hypothesis tables where the user can rank her different hypothesis related to prior findings. These can later be compared to Iliad's own hypothesis, or they can be compared during sub sequences of a case, allowing for refinement in the hypothesis tables. Although Iliad has been recognized as one out of a few AIM applications that have made it out to the users, and thereby also as a scholarly example of how to implement AIM for educational and training purposes, we find it necessary to raise some criticism against the approaches taken in our search for the solutions of tomorrow.

- *Student problem solving vs. expert problem solving*: As numerous AIM projects have done both before and after, Iliad has forgotten the lessons learned from GUIDON. One can not teach a medical student how to perform as an expert. Furthermore, White and Frederiksen showed that expert problem solving knowledge to be learned through a computer-based application, is best represented as a series of models that capture the progression from novice to expert reasoning [26].
- *Educational theories*: The Iliad training model is based on research in the fields of cognitive psychology and medical decision analysis [23]. Theories of medical decision making are, however, not equal to theories of instruction and learning. Applications addressing education and training should be based on the latter two as well to ensure an effective learning outcome [6].
- *Accuracy in knowledge*: In a recent study, Murphy et al. report that Iliad had the correct diagnosis on its list in only 45% of the cases and in its top six diagnosis in only 20% of the cases [24]. The quality of communicating incorrect knowledge is questionable. In a DDS it is not acceptable at all.

DSSs and Education, the Future

There is great potential for promoting learning from on-the-job training where the actual job setting includes the usage of a DSS. In order for this process to be successful, it has to be addressed from a theory based perspective. The design of educational and training functionalities in a DSS has to be founded on the combination of cognitive task analysis (CTA) and educational theories. By doing so, other important issues related to adaptivity are also addressed.

CTA consists of several steps where the goal is to identify the most difficult aspects of job performance in a specific domain

and then study what differentiates the most competent from the least competent individuals in terms of the types of goals, prerequisite knowledge, actions, results and interpretations involved in solving the task in question [27]. CTA provides the designers with the appropriate content knowledge that needs to be modelled as well as the tools for establishing an appropriate user model for the various types of performance skills. Once proficiency levels are identified, benchmarks can be established of appropriate performances and feedback that is adaptive to these different levels of proficiency can be designed.

In understanding how people learn, instruction and training can be designed that optimizes learning in specific domains. There are several educational theories [28] that may be appropriate for DSSs. One example is the cognitive apprenticeship (CA) model [29]. In a traditional apprenticeship the apprentice learns from the master. Novices watch experts and learn from them through their assistance. A CA model is more formalized than traditional apprenticeship as it applies to cognitive skills as opposed to physical skills. If we take medicine as an example, residents learn from master physicians in an apprenticeship setting where they learn skills in a contextualized manner. However, experts often have difficulty articulating their knowledge as it is compiled into large chunks of information, resulting in an inability to decompile it and explain how they get along while solving tasks. The CA model gives a framework that helps in making expert's explicit about their content knowledge. CTA methods are used to identify competency in specific domains. Once the content knowledge is understood there are specific instructional methods that can be used to promote learning. Strategies at various levels of complexity can be adapted to the learner, and novices can receive coaching or feedback when they do not understand what they have observed. Novices are scaffolded through the use of feedback that is designed to fit individual's needs. Once users demonstrate that they can perform a task on their own the scaffolding is faded. Novices must demonstrate their understanding in some manner, either through performance or articulation.

Adaptivity is another research issue mentioned but not adequately addressed by AIM researchers. Different users have different needs and preferences with respect to how much information to present, when to present it, and how to present it. The practical effect of this is that if someone feels that too much time is wasted on unnecessary information, or that it takes too long time to get to the essential information, or the information is presented in a way that is not understood - then they will avoid using the application as it does not serve their needs. Adaptivity plays a central role in our proposal for decision support to empower the users towards independent problem solvers. A DSS that aims at an educational outcome must be able to tailor its advice and instructional feedback to the individual user needs. An obvious analogy here is the experienced specialist, supervisor, and chief physician, who while conducting patient rounds with residents, tailors her explanations, advice, feedback, and questions to the resident's specific needs and previous encountered cases. In doing so, she also continuously updates her belief models of each of her staff. Within the walls of the hospital the specialists are not only the experts who tell you the answer, they are also the supervisors. Traditional AIM research have forgotten to acknowledge this side of the specialist's responsibilities.

The research discipline of AI in Education has recognized the research issues discussed in this section and applied them with success in other areas of diagnosis and troubleshooting [6]. One classical example is SHERLOCK in the field of avionics troubleshooting. Trainees who spent 20-25 hours working with SHERLOCK were as proficient in doing their job as technicians who had been on the job 4 years or longer [30]. These remarkable findings are explained by SHERLOCK being based on a combination of the cognitive apprenticeship model and a solid cognitive task analysis.

Conclusions

AIM research has focused on developing computational techniques and applications that can assist health care professionals in the processes of making diagnosis and treatment plans. We have challenged this approach and argued that for the AIM community to gain its long searched for practical success it will have to put equal emphasis on *quality in decision support* and *empowerment of the users*. The long term goal must be to empower the users to become independent self-sufficient problem solvers and decision makers within their disciplines. In this way the question of quality in health care can be addressed through a utilization and realization of the health care professionals potential, thereby also recognizing their reported needs. Furthermore, our proposed approach also recognizes the specialist as a teacher or tutor. In addressing the educational aspects of a DSS, the following requirements have to be fulfilled:

- The design must be based on cognitive task analysis and established theories of learning and instruction.
- Adaptivity must play a central role also in the decision support process itself, making sure that interaction with the DSS always gives an optimal learning outcome.

To meet these requirements which will cover issues such as: connecting theory to practice, building on prior knowledge experiences, self-reflection, adaptivity with respect to different users with different needs, dynamic assessment of these needs that change over time for each user, different learner models, complexity of problem solving, and, intelligent on-line advice-giving - the AIM community will have to look outside its own frontiers. Here we expect a closer co-operation with the research field of *AI in Education* [6].

Acknowledgments

The work of Svein-Ivar Lillehaug has been supported by the Norwegian Research Council grant No. 102460/320. The work of Susanne Lajoie has been supported by a grant from the Quebec Ministry of Industry, Commerce, Science and Technology (MICST) as well as the Social Science and Humanities Research Council of Canada.

References

[1] Szolovits P. ed. *Artificial intelligence in medicine*, AAAS Selected Symposium. Boulder: Westview Press, 1982.

[2] Shortliffe EH. The adolescene of AI in medicine: Will the field come of age in the '90s? *Artificial Intelligence in Medicine* 1993:5: 93-106.

[3] Uckun S. Artificial intelligence in medicine: State-of-the-art and future prospects. *Artificial Intelligence in Medicine* 1993:5: 89-91.

[4] Kulikowski CA. AIM: Quo vadis? *JAMIA* 1996:3: 432-3.

[5] Coiera EW. Artificial intelligence in medicine: The challenges ahead. *JAMIA* 1996:3: 363-366.

[6] Lillehaug S-I, Lajoie SP. AI in medical education - another grand challenge for medical informatics. Accepted for publication in *AI in Medicine* 1997.

[7] Slotnick HB. How doctors learn: The role of clinical problems across the medical school-to-practice continuum. *Academic Medicine* 1996:71: 28-34.

[8] Maslow AH. *Motivation and personality.* NY: Harper Row, 1954.

[9] Bandura A. *Social foundations of thought.* Englewood Cliffs: Prentice Hall, 1986.

[10] Dunn PM, Kaynard J. Unique educational program in critical care medicine for the general internist. *Journal of General Internal Medicine* 1993:8: 125-129.

[11] Alfredson BB, Annerstedt L. Staff attitudes and job satisfaction in the care of demented elderly people: group living compared with long-term care institutions. *Journal of Advanced Nursing* 1994:20: 964-974.

[12] Hackman JR, Oldham GR. Motivation through the design of work. Test of a theory. *Org Behaviour and Human Performance* 1976:16: 250-279.

[13] Akroyd D, Bamberg R, Hall J. The impact of multiskilled practice on the job satisfaction of medical laboratory personnel. *Journal of Allied Health* 1992:21: 95-104.

[14] Eidenwall L. Evaluation of knowledge and skill of health care personnel concerning Servo ventilators. ULi-IMT-EX-176, Linköping Univ, Sweden, 1989.

[15] Bizek KS, Oermann MH. Critical care education. *Heart & Lung* 1990:19: 439-444.

[16] Radice B. The relationship between nurse empowerment in the hospital work environment and job satisfaction: A pilot study. *Journal of the New York State Nurses Assoc.* 1994:25: 14-17.

[17] Fisher P. Cost-effective nursing practice: Cost-awareness and empowerment. *Canadian Operating Room Nursing Journal* 1993: 11:5-9.

[18] Blaney DR, Hobson CJ. *Cost effective nursing practice: Guidelines for nurse managers.* Philadelphia: J. Lippincott Co., 1988.

[19] Kivimäki M, Kalimo R, Lintström K. Contributors to satisfaction with management in hospital wards. *Journal of Nursing Management* 1994:2: 229-234.

[20] Shortliffe EH. *Computer-based medical consultations: Mycin.* Amsterdam: Elsevier, 1976.

[21] Miller PL. *Expert critiquing systems: Practice-based medical consultation by computer.* NY: Springer-Verlag, 1986.

[22] Clancey WJ. NEOMYCIN: Reconfiguring a rule-based expert system for application to teaching. In: Clancey WJ, Shortliffe EH. eds. *Readings in Medical Artificial Intelligence: The first decade.* Reading: Addison-Wesley, 1981: 361-381.

[23] Turner CW, Lincoln MJ, Haug P, Williamson JW, Jessen S, Cundick K, Warner H. Iliad training effects: A cognitive model and empirical findings. *AMIA* 1992: 68-72.

[24] Murphy GC, Friedman CP, Elstein AS, Wolf FM, Miller T, Miller JG. The influence of a decision support system on the differential diagnosis of medical practitioners at three levels of training. *AMIA* 1996: 219-223.

[25] Patel VL, Kaufman DR, Arocha JF. Steering though the murky waters of scientific conflict: Situated and symbolic models of clinical cognition. *AI in Medicine* 1995:7: 413-428.

[26] White BY, Frederiksen JR. Causal model progressions as a foundation for intelligent learning environments. *Artificial Intelligence* 1990:42: 99-157.

[27] Lesgold A, Lajoie SP, Bunzo M, Eggan G. SHERLOCK: A coached practice environment for an electronics troubleshooting job. In: Larkin JH, Chabay RW. eds. *Computer assisted instruction and intelligent tutoring systems: Shared goals and complementary approaches.* Hillsdale: Lawrence Erlbaum Assoc., 1992: 201-238.

[28] Kearsley G. Explorations in learning and instruction: The theory into practice database (1996), see http://www.gwu.edu/~tip/index.html

[29] Collins A, Brown JS, Newman SE. Cognitive apprenticeship: Teaching students the crafts of reading, writing and mathematics. In: L.B. Resnick, ed. *Knowing, learning and instruction: Essays in honor of Robert Glaser.* Hillsdale: Lawrence Erlbaum Assoc., 1989: 453-494.

[30] Nichols P, Pokorny R, Jones G, Gott SP, Alley W. Evaluation of an avionics troubleshooting tutoring system. Tech report, Armstrong Laboratory, Brooks AFB, TX, 1995.

Address for correspondence:

svili@ida.liu.se