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Challenges of Traditional and Smart Canes: Implications for Orientation and Mobility Training with Students with Visual Impairment

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Abstract

Student independence while walking remains the most critical and ever-present goal of O&M for students with visual impairment, and it is a goal most readily addressed using the common-place, inexpensive mobility cane to prevent injuries and encourage the ability to move with the greatest degree of independence. This paper seeks to determine those barriers and successes of orientation & mobility devices by focusing on the usability of the two major groups of canes in O&M practice: the standard long cane and its newer "smart" counterparts-sensor-enabled versions of long canes. By comparing and contrasting information from journal literature, reports from students and professionals, and practitioner guides, the long and smart canes were measured against categories that included range of obstacles perceived, time to learn, physical limitations, device maintenance and purchase, technology dependency, and buy-in by students and O&M specialists.

Findings for those categories demonstrated that although the standard cane, for all its low cost and ease of maintenance, falls short of sensing distance or top-obstacles on the path of travel and requires lengthy, skilled-use training; smart canes are able to address some of the shortcomings of standard canes by expanding detection and including such devices as vibrations, sounds, or applications, yet include other obstacles-cost, power dependency, weight, required training time and initial decreased gait speeds-as additional barriers to user comfort and confidence.

This paper extends these implications for the practice of O&M for students with visual impairment in the school setting; a need is proposed to integrate technological teaching tools

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that will complement, rather than supplant, cane skills of students with visual impairment. Finally, through several practical implications for O&M instructors, teacher educators, and policy makers, the paper asserts that technology is best utilized as a compliment to skills teaching rather than an outright replacement and that the best approach involves using both together (first, mastering the standard cane; then introducing the smart canes/capabilities).

Keywords: White Cane, Smart Cane, Orientation and Mobility, Visual Impairment, Assistive Technology, Usability, Mobility Training

Introduction

Millions worldwide suffer from visual impairments, with difficulty in independent travel frequently reported as the primary obstacle to education, employment, and social engagement (Khilnani et al., 2025). School children and adolescents with visual impairment rely on confidence and independence while navigating their way between classrooms, hostels, playgrounds and the outside world. This reliance on mobility skills is intertwined with learning outcomes, peer interactions and long-term independence. Orientation & Mobility (O&M), the foundational skills that equip an individual to orient herself in the environment, and to travel from one point to another, has been recognized as the most critical skill for individuals with visual impairment within the expanded curriculum for visually impaired students and children (Brown, 1982). There are many different types of orientation & mobility techniques that exist and as there are always advantages to introducing new technology into many fields, smart mobility aids for visually impaired have also come to the forefront.

The most well-known mobility aid still commonly used today throughout the world for blind and visually impaired individuals learning orientation and mobility skills, is the traditional long cane. This device can work simultaneously as an impact device, a probe as an extension to touch, and a travel symbol (Gyamfi, 2023). Low cost and simple in design and widely taught in O& M programs worldwide, this device provides students with a simple cane for obstacle detection. The drawbacks to the traditional cane are, as discussed previously, that it only detects obstacles that are at knee level, not at head or chest level (e.g. Overhanging branches, signposts, etc.), and only one step ahead of the blind individual, at best (Balakrishnan et al., 2007).

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This led the way to a multitude of new innovations designed to augment the capabilities of the traditional cane with additional technologies. These so called "smart" devices combine some, or all, of an array of technologies including camera- or sensor-based image recognition and obstacle detection using infrared and/or sonar/ultrasonic beams, and a vibro-tactile (haptic) or audible output for indicating the distance and depth of upcoming obstacles to allow for detecting hazards not visible with the traditional cane, such as the above-mentioned obstacles not at ground-level, along with satellite positioning to suggest a route of navigation (Kim & Cho, 2013). A vast body of evidence exists indicating the drawbacks to using the "smart" cane in various settings. Drawbacks to using the smart cane include that many require substantial charging/maintenance, come at a much higher price, add noticeable weight to the cane, can deliver overwhelming input that might disorient users, and often have shown reduced traveling speed compared with traditional canes in several studies (dos Santos et al., 2020; Skovfoged et al., 2022).

These two advancements in mobility aids for the blind and visually impaired prompt a series of practical and pedagogical questions to be examined. Should schools be prioritizing the introduction of smart mobility aids over traditional O& M skills? If a blind child hasn't mastered basic cane navigation skills, is there a rationale behind their attempting to use and learn how to navigate their way utilizing a device that does most of the work for them? "Usability" can be a very vague and general term at best in the sense that all blind children are at different stages in the learning process of mastering spatial and navigational skills and require that these concepts and physical proficiencies to be solidified regardless of a teaching tool. This study seeks to bring a closer examination of each topic by providing a direct comparison between the traditional cane, and the smart cane, while providing in-depth reasoning to guide further discussion amongst orientation & mobility instructors, educators of the visually impaired, and all involved stakeholders of educational policies in the U.S.

These questions are particularly important given the resource limitations present in not just schools for the blind but inclusive educational settings also, and the wide gap between technologically progressive facilities and those that struggle even to provide traditional canes, let alone have a fully trained O&M specialist on staff (NFB, n.d.). It is crucial that before device

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engineers' ideas enter every O&M program for the visually impaired throughout the U.S. That the advantages and disadvantages be clearly communicated to not just those that will utilize it, but to everyone involved in the process.

Here, to this end, I attempt to bring together two different and very distinct bodies of literature: those addressing an accumulation of research regarding smart mobility aids to be utilized with the visually impaired; and those that address the many facets of teaching O&M; M skills without technology to children with visual impairment. The smart cane research often seems directed toward a technical audience, and frequently includes specifications concerning battery life, sensor accuracy and algorithm outputs rather than focus upon application within O&M; M programs. Conversely, the traditional cane literature is typically more pedagogical and is in some cases lacking in any specific reference towards whether devices can prove useful beyond the fundamental skills.

Operational Definitions

The terms Below will be commonly referenced in this article. For simplicity's sake, I have defined them in common language: O&M Orientation and mobility. The field of instruction which prepares a student with a visual impairment to understand his/her position in regard to objects and locations in the environment (orientation), and to successfully, safely, and independently traverse through the environment (mobility).

• long cane / white cane / "cane": A slender, often collapsible rod which the visually impaired traveler swings from side to side in front of their body which is designed to detect the presence of obstacles at floor level and on the ground, and to help the traveler feel the edge of sidewalks and transitions in ground surface textures.

• smart cane: Any "traditional" long cane or any specialized device built from any form of rod or stick to which technology (an add-on to a cane; a built smart cane) has been incorporated to enhance the capabilities of the device. These technologies often include ultrasonic, infrared, or camera-based sensors to enhance the range of obstacle detection beyond the reach of the device's physical sweep and to communicate this information back to the user via vibration, audio, or some interface to a device such as an iPhone app

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• usability: Within this article, the usability is defined by, but not limited to ease of use, safety of use, ease of learning how to use, efficiency of use; and comfort during use; effectiveness in carrying out its function for the user and; the subjective satisfaction derived from its use; and any additional human factor related issues the device design poses.

• student with a visual impairment: An individual student the visual impairment of whom (blindness, total and near total visual impairment and low vision), interferes with access to the school community and environment as does this ability as with sighted peers and the same requires special instruction including, but not limited to, orientation and mobility programs.

Research Method

Design of the article is a narrative literature review as this is appropriate in synthesizing a disparate collection of works representing the fields of rehabilitation science, human computer interaction, assistive-technology engineering and special education. It was not the intention of this article to conduct a randomized control trial. The intention was to aggregate empirical studies, field reports, and practitioner narratives that could be used to contrast the limitations and usability issues of traditional versus smart canes and inform teaching practices of O&M training in a classroom setting.

A search strategy comprised structured searches of academic databases and trusted internet-based sources using the keywords "white cane," "long cane," "smart cane," "electronic travel aid," "orientation and mobility," "usability," and "visual impairment." Prioritization was placed on peer-reviewed research journals, conference proceedings and documents from respected organizations involved in blindness and low vision, and to an extent, patents and technical reports, provided that sufficient design details were provided. Articles and documents were retained for inclusion if they were related to (a) the design, testing or comparative evaluation of traditional and smart canes, (b) usability issues such as detection of obstacles accuracy, walk speed, ability to learn and patient satisfaction with usability; and (c) O&M pedagogy/curriculum. Any articles/documents concerning alternative assistive technologies such as screen readers or Braille devices were excluded unless it had direct comparisons with caned mobility.

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The synthesis occurred in 3 broad steps. First, the properties of traditional and smart canes that define them were identified, such as the scope of their detection, mode of feedback, cost, and basic design. Second, the usability parameters reported in both comparative and individual device studies were grouped according to overarching themes of obstacle detection efficiency, learnability, physical and cognitive workload, pace of travel, cost, and robustness. Third, the findings regarding usability of both O&M traditional and smart canes were used to extend pedagogical/curriculum content related to how instruction may be provided in the expanded core curriculum for students with visual impairments, based on current O&M pedagogical methods. No humans were interviewed in the course of this article. It consisted entirely of re-evaluation of documents previously presented to a audience. There was no recruitment of new participant samples, no conducting of research study, and no statistics of human participants included in study of cane-based technology.

The Traditional (Long) Cane: Challenges and Usability

Also known as the "Hoover cane" after the methodology developed by Dr Richard Hoover, this lightweight, commonly folding or rigid stick runs from the ground to about the level of your sternum. It is typically coloured white, both as a warning to others about visual impairment and in deference to widely accepted courtesies and rules of safe transit. In an O&M technique known as the "cane sweep," the stick is swung from one shoulder to the other in a rhythmic side to side arc, just wider than the user's shoulders, with the tip of the stick in contact with the ground opposite the leg that is about to step forward. By thus sweeping the Cane in this wide side-to-side arc just in advance of your body's progression, you can avoid obstacles in your direct path as well as the edge of steps and changes in surface, such as those encountered when moving from pavement to grass or curbs or stairs (Gyamfi, 2023).

Strengths of the traditional cane for practical purposes certainly exist. They are inexpensive compared to any electronic technology. There are no batteries to change or re-charge. Canes are fairly durable against weather, grit and general abuse. They are replaceable if they are lost or damaged. With no electronics there is nothing to break, beyond bent poles or frayed tips that indicate it’s time for a new stick. They also perform another function quite adequately that specialists call the direct and mediated feedback to the user. The impacts of a can tip upon

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different surfaces transmits vibrations and sounds through the stick shaft into your hands, wrists, and forearms. An adept traveler can sometimes hear the difference and differentiate the sound of striking a piece of gravel from a smooth tiled surface or a metal grate from wooden boards. (Lighthouse Guild, n.d.) It is very difficult to replicate this "real time feedback" technology electronically and is one of the major reasons why skilled O&M instructors emphasize the cane as an essential lifetime travel skill not just as some kind of assistive device to eventually replace.

However, the weaknesses of canes have long been documented, most typically being their limited sensing range. While the cane will detect objects within foot or two either side of the travel route, and anywhere on the ground at up to about knee height, it will not warn about anything anything higher and protruding out beyond about 3 feet in front of you: low-hanging branches, protruding traffic signs or vehicle mounted side mirrors all pose hazards (Balakrishnan et al., 2007) Second, the cane requires a significant and steep learning curve. Learning to properly use the Cane includes coordinated arm, wrist and gait technique, precise hand-centring, appropriate can swing width, and the difficult task of interpreting a wide range of complex auditory and tactile information – all of which takes considerable time and specific instruction to achieve (NFB, n.d.) Young cane users are at a particular developmental disadvantage with the can. They do not naturally move their arms in the wide 360 sweep required, nor do they have the fine motor control needed to achieve it; nor can they easily form the mental models required to understand the tactile/audio stimuli transmitted by the Cane (Gyamfi, 2023).

Another key disadvantage involves the "psychosocial aspect" of cane usage. Since white canes can serve as "visible symbols of blindness, many students and their families will not consider the white cane option". This is especially the case in certain cultures or communities in which blindness carries a stigma, and it may lead instructors to delay instruction in its use (NFB, 2015), delaying other important independent living skills at critical ages (NFB, 2015). And even skilled Cane users remain dependent on residual auditory inputs and ambient predictability; environments that are noisy, crowded, or unfamiliar can lead even expert cane users to rely on additional travel techniques, such as "tail" (a light touch with the cane on the ground beside the

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user's body as one moves) or shoreline, to supplement their Cane use and ensure safety (Perkins School for the Blind, 2025).

The Smart Cane: Challenges and Usability

The term "smart cane" broadly refers to a family of devices in the literature that integrate a traditional cane form factor with electronic sensing and feedback. Most devices fit into one of a few overlapping categories: ultrasonic or infrared obstacle-detection attachments that clip onto an existing cane and vibrate or beep when an object is within a set range; camera- or depth-sensor-based systems that use computer vision to classify obstacles and their distance; and satellite-navigation enabled canes that include obstacle avoidance features along with turn-by-turn navigation provided through a paired smartphone application (Kim & Cho, 2013; Khilnani et al., 2025). A well-documented example is an early cane-mounted ultrasonic unit that increased detection of knee-and-above obstacles and reduced collisions with inanimate objects by about ninety percent while doubling obstacle-detection distance in controlled tests compared with an unaided traditional cane (Balakrishnan et al., 2007).

Newer designs take this concept significantly further. Some smart canes, like the We WALK device, retain the ground-sensing capabilities of traditional canes while incorporating upper body obstacle-sensing technology (ultrasonic sensors), smartphone-based voice assistants, and integrated navigation (We WALK, n.d.). In academic settings, prototype devices built around robotics and computer vision technologies, including those from Stanford University that employ simultaneous localization and mapping and steer assistance, are designed to guide users around obstacles and on specific routes. Such devices also have increased walking speeds by approximately twenty percent over traditional canes in trials, while maintaining low cost and weight relative to earlier sensor canes that have been documented to weigh multiple kilograms and cost thousands of dollars (Stanford HAI, n.d.). Even newer innovations use transformer models to facilitate real-time obstacle type identification based on depth camera inputs, aiming to provide users with a richer set of real-world data beyond just range of detectability (Khilnani et al., 2025).

Use cases for smart cane The smart cane has a compelling usability case primarily related to its expanded range and richness of user feedback. Whereas a cane with only traditional capabilities

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cannot sense anything above head height, a cane equipped with appropriate sensors theoretically can alert the user to hanging obstacles, overhead obstacles and obstacles beyond the normal reach of the tip. Electronic canes with ultrasonic sensors outperformed traditional canes in their ability to detect most hanging obstacles that a conventional cane missed in a controlled experiment, suggesting a legitimate advantage to using a device with extended range (dos Santos et al., 2020). Some trials have resulted in favourable user ratings; a few report low learning curves for the user and good user satisfaction with extra features of the smart cane and added weight (Balakrishnan et al., 2007).

The smart cane's research-based evidence does, however, support evidence of significant drawbacks. Several comparative studies have documented a reduction in user speed using a smart cane compared to a conventional cane; this decline in pace is generally due to the increased cognitive workload involved in responding to new information, potential indecisiveness over appropriate actions based on feedback signals, and the physical drag of sensors (dos Santos et al., 2020; Skovfoged et al., 2022). Other studies highlighted a lower resilience to the elements such as rainy weather, increased portability issues with folding and transporting the device, and an often-overwhelming constant sensory input (vibrating or auditory alerts) for many early users who may lack experience interpreting signals (dos Santos et al., 2020; Kim & Cho, 2013). The cost of smart canes continues to be prohibitive; while various prototype devices have demonstrated prices below fifty dollars, the many commercially available versions of this technology remain unaffordable for individuals in less affluent school or community environments (Balakrishnan et al., 2007; Khan et al., 2018). Lastly, practitioners often note the tendency for students to become dependent on device technology such as smart canes, neglecting to internalize the traditional and invaluable cane skills they were taught that prove crucial when their devices are unavailable, out of power, or malfunctioning (Yin, 2019).

Comparative Usability of Traditional and Smart Canes

Table 1 summarises the comparative usability characteristics of traditional and smart canes across the dimensions most frequently reported in the reviewed literature. The comparison is intended to orient O&M instructors and teacher educators rather than to declare one tool

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categorically superior, since the appropriate choice depends heavily on the individual learner's age, environment, and stage of training.

Table: Comparative Usability of Traditional and Smart Canes

Usability Dimension	Traditional (Long) Cane	Smart Cane
Obstacle detection range	Ground level and near-body only; roughly one step ahead	Extends to knee-, chest-, and head-level obstacles depending on sensor placement
Learning curve	Steep but well-established; requires structured, repeated O&M instruction	Requires all traditional skills plus interpretation of new sensory alerts
Walking speed	Serves as the speed baseline in comparative studies	Frequently slower during initial use due to added cognitive and physical load
Cost and affordability	Low cost; widely subsidised and easily replaced	Ranges from low-cost prototypes to several hundred or thousand dollars
Durability and maintenance	Simple mechanical repairs; tolerant of weather and rough use	Sensitive to rain, requires charging, and involves electronic upkeep
Feedback modality	Direct tactile and auditory feedback through the shaft and tip	Vibrotactile, auditory, or app-based alerts layered onto cane feedback
Dependence risk	Low; skills remain usable without external power or connectivity	Higher; usability drops sharply if the device is uncharged or damaged
User acceptance	High familiarity but sometimes resisted due to visibility and stigma	Mixed; valued for added safety information but can feel overwhelming initially

Source: Synthesised by the author from dos Santos et al. (2020), Balakrishnan et al. (2007), Kim and Cho (2013), Khan et al. (2018), and Skovfoged et al. (2022).

Implications for Orientation and Mobility Training of Students with Visual Impairment

The usability findings previously summarized present multiple practical applications for O&M instructors working with students with visual impairments. First and perhaps foremost is

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sequencing: The most fundamental, traditional, tactile cane skills should be instilled and solidified prior to exposure to smart cane features. Every comparative study reported here assessed smart cane function against a benchmark of proficient traditional cane travel, with several reporting initial travel time slower with a novel sensory output relative to the unadorned cane (dos Santos et al., 2020; Skovfoged et al., 2022). For a student who is still struggling to consistently attain proper arm position, cane cane arc, and secure cane ground contact, added sensor cues will likely add to the mental workload, not reduce it. Thus, the adoption of smart canes in an O&M curriculum should be understood as a later-stage learning module, applied only after students are deemed sufficiently proficient with conventional cane travel techniques. This also aligns with long established O&M curricular sequences progressing from indoor, familiar terrain to more complex outdoor environments (Perkins School for the Blind, 2025).

Secondly, the need for individualized, student-centered instruction-a cornerstone of the O&M field since its inception-must also be addressed in decision-making around the adoption of technology in tandem with tactile cueing. Traditional O&M instruction recognizes the profound necessity for instruction to accommodate a student's level of cognitive and executive function, their physical capabilities, cultural background and transportation goals, recognizing the inherent limitations of any "one size fits all" checklist mentality even for standard cane instruction (NFB, n.d.). This extends with heightened rigor to the use of smart canes, for whom potential additional cognitive load required to interpret vibrotactile and audio alerts may be entirely manageable and beneficial for a high-school age student with intact vision and residual audition, but cognitively over-whelming for an elementary-school-aged student, a student with multiple disabilities, or a novice. Traditional O&M needs assessments can easily integrate specific data points evaluating a student’s readiness for supplementary technological assistance in tandem with existing performance evaluation.

Third, the significant costs of smart cane prototypes and market-ready devices, as well as the associated maintenance and charging demands, pose practical challenges for the schools and agencies that serve students with visual impairment-especially for those with limited financial resources. Due to the variety of prices available for different devices (ranging from inexpensive prototypes to commercial units costing hundreds of dollars) coupled with ongoing maintenance

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requirements that schools and rehabilitation agencies might not be optimally equipped to meet, a universal substitution of smart canes in place of all traditional canes is unrealistic. More pragmatic is a model wherein all students receive traditional Cane instruction, with smart canes made available strategically for older students preparing for independence in community, transit, and/or occupational settings, through lending libraries and shared community-based sets rather than through individually purchasing or assigning.

Fourth, decreased walking speed and sensory overload in students using smart cane technology indicate a need for deliberate training to aid them in filtering and prioritising device feedback- beyond the mechanics of operation itself. Anecdotal evidence suggests learners may be overwhelmed by multiple alerts and subsequently ignore some, reducing their functional usefulness until training specifically targets such phenomena. Schools will benefit from developing training curriculum to help students and adults learn to manage multiple sensory inputs through progressive exposure in familiar indoor settings moving to more complex outdoor environments, consistent with established methods of generalizing basic O&M skills.

Fifth, the psychosocial issues around use of mobility aid, including stigmatic reluctance, which have been so extensively documented in the context of non-technologically assisted cane travel, will likely intersect with technology acquisition in un-anticipated ways. For example, a learner's willingness to accept a cane as a tool, perhaps seeing its high-tech component as an asset and evidence of sophistication, might support acceptance of cane travel and earlier acceptance by more resistant learners as well, while high tech cues may elicit additional social self-consciousness. O&M instructors are in a unique position to work with student and their family to de-mystify such device choices for social meaning and promote learner preference beyond societal norms by incorporating them as an integrated part of any holistic O&M orientation toward independence, as with any mobility tool in the professional repertoire.

Lastly, higher education institutions and continuing education providers preparing O&M specialists need to integrate training regarding technology adoption in O&M instruction into existing curricula. Without this comprehensive approach, not only may O&M students receive inadequate instruction with technology, but schools may deploy hardware without appropriate

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instructional follow-up training, a recognized barrier to successful smart-cane utilization (Florida Vision Technology, 2026).

Results / Outcomes

Three findings can be said to emerge relatively reliably across the articles. Firstly, traditional and smart-canes are most usefully viewed not as replacement but as additions/complementary tools to traditional canes; traditional canes offer, in expensiveness, durability, and reliability, the ground-level obstruction detecting and transporting aspect of travel, while smart canes augment this in their ability to detect objects in regions inaccessible structurally to the human from low on the body upwards. Secondly, user results for smart canes are significantly dependent upon prior competence with a traditional cane, and programmed, graduated training; smart-cane feedback appears not to reduce, but to rather significantly impede travel and increase cognitive load in less experienced users or lacking sufficient practice opportunity. Thirdly, cost, maintenance needs, and trainer expertise are major logistical factors that will determine use of smart-cane technology within school-based O&M instruction programs at a wider level, especially in situations with resource constraints, above any inherent failings in the sensors' fundamental technology.

Discussion

The insights gathered and synthesized in this article align with a more general trend observed throughout much of the existing research on AT: technical ability does not automatically equate to the practical implementation of use and acceptance of assistance. Many observers have suggested that exclusive concern over electronic enhancements could detract attention and resources from O&M instruction itself which provides visually impaired people with a constant technology-independent fallback skill; nevertheless supporters of smart-cane technology offer valid and realistic rebuttals: why should we deny people with visual impairments the same technological advancements in sensing and computation as all others when these could greatly improve independence and safety, so long as instruction with traditional tools is not replaced by device dependency? The body of work presented here concludes this middle path; the smart cane is indeed a usability upgrade, in several limited but significant ways including range and

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number of objects detected but can in no wise be thought of as a replacement for cane skills and benefit may only be seen in addition to a solid foundation.

The implementation described on this path has direct importance for the education of students with visual impairments particularly versus older clients on rehabilitation: children and teenagers are at a juncture of development that focuses on spatial cognitions and understanding their own bodies as well as on building independent skills, and effective O&M instruction to students with visual impairments typically strives to balance both of these with introducing risk and real world experiences very gradually (School for the Blind, 2025). Although the introduction of another sensory feedback pathway into such an educational process does not pose an inherent difficulty, the implementation is of such significance that it requires instructors to be extremely thoughtful about timing, gradual increases in intensity, and student individualization that present smart-cane usability guides largely miss with reference to adult-client interaction. Further practice-based research conducted in school settings specifically with children with visual impairments would contribute to greater understanding of whether findings regarding walking speed, sensory load, and learnability transfer readily or need further modification.

It is appropriate to reflect on the above in regard to the expanded core curriculum and its other various components besides O&M. Devices regardless of type operate within a surrounding, larger environment including appropriate communication skills, independent living skills, assistive technology skills, as well as many others. Such as is the case with use of both traditional and smart canes for transportation for visually impaired students, other parallel skills are necessary for students' general success; this includes concept development, the ability of students to listening adequately, and the need to advocate for themselves among many other elements (APH Connect Center, 2024). Treating issues purely from the perspective of engineering any type of smart cane regardless of how cutting-edge the technology is would be to miss how a school might address or work to overcome any negative implementation; students attending schools that invest in the smart cane but do not concurrently improve the capacity for O&M and other ECC instruction might thusly not be able to enjoy the great benefits attributed by much laboratory-based research in these particular regards.

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Another worthwhile point of consideration regarding smart-cane adoption has to do with issues of equality: the considerable expense of and necessity of infrastructure surrounding the smart-cane could create two categories of support by allowing wealthier families and schools to adopt technology and thereby gain a significant advantage over others, particularly if basic skills and instruction with tradition tools remains inaccessible to some schools (Asamoah, 2023). Rather than a fundamental pre-requisite, the implementation of smart canes should not be adopted unless the schools and their surrounding O&M curriculum can provide basic O&M instruction supplemented by better quality, inexpensive tools.

It would be most beneficial, too, to highlight the limitations of a narrative summary. Such summaries provide the advantage of bringing together and organizing information from multiple studies yet are restricted by the considerable variation between research participant groups (especially regard to child versus adult groups, in this case) as well as by differences in device and study design in general. Furthermore, it is important to keep in mind the quickly evolving nature of smart-cane hardware and the possibility that some features may be vastly improved and thus mitigate previous usability concerns not represented fully in this review. With consideration to the limitations present in this document, continued research based in individual school communities is crucial for demonstrating whether generalizability between age groups holds; otherwise, smart cane devices can only serve as secondary alternatives to their traditional counterparts.

Conclusion

Conventional and smart canes can each serve the unique purposes and be challenged in related ways to orientation and mobility instruction for visually impaired students. An essential, cost-effective, rugged, everyday tool for autonomous travel, the conventional long cane inherently has structural limits to its sensing range in being confined to ground- and immediate-body level dangers. Smart canes usefully expand detection ranges and supply novel pieces of vital safety information in many cases in order to provide assistance to help avoid such hazards as head and torso impacts, and yet in the face of new problems of high cost, maintenance needs, learning difficulties, and increasing cognitive demand, smart canes are likely less useful rather than more so (if poorly controlled) especially for novices who have not established foundational Cane

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technique. Oando M teachers, teacher educators, and school administrators most clearly see that technology ought to come later as a deliberate, step-by-step complement to, and replacement for (not that of), and every visually impaired student should demonstrate competence with traditional Cane instruction prior to the use of advanced smart canes; therefore, in most circumstances, a combined approach whereby every student will learn to use the traditional Cane first, followed by gradually, individually learned features of the smart cane under teacher training and institutional support, provides a more useful and accessible, equitable approach to ultimate learner independence than alternatives.

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