

Exploring the Impact of AI on Go Education: A Teacher Survey

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Abstract: In 2016, AlphaGo's advent transformed the world of Go as AI-powered tools began to surpass the world's top professional players. The rapid growth in AI's influence raises questions about the potential replacement of human players. This paper examines recent trends in Go education in light of the AI revolution and its future implications. To investigate these trends, we conducted a survey among Go educators, focusing on three key aspects: (1) the perceived benefits of learning Go, (2) the impact of AI on Go education, and (3) educators' satisfaction with Go AI tools. Data was collected through online questionnaires in English, Korean, and Chinese. Survey results indicate that Go teachers believe learning Go equips students with valuable skills, including critical thinking, resilience, and persever-

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ance, fostering character and cognitive development. However, educators' opinions on AI-based tools in the classroom are mixed. Approximately 41% of respondents have refrained from using AI tools, citing concerns about their suitability for lower-level and younger learners, as well as perceived difficulties in their implementation. Additionally, there are concerns about over-reliance on AI and its limitations in Go education. Conversely, educators who have integrated AI tools report overall satisfaction and optimism for further developments. This study highlights the growing acceptance of AI programs and their positive impact on Go education. While practical demands remain partially unmet, many educators, in general, express satisfaction with the available programs. The findings of this study shed light on areas for potential improvement in AI to further enhance Go education.

Keywords: Go, Baduk, Weiqi, Education, Artificial Intelligence, Educational Technology, Instructional Media, Teacher Survey

I. Introduction

Artificial Intelligence (hereafter AI) has been making major waves in the Go community ever since 2016 when AlphaGo, a product of Google DeepMind researchers, stunned the world by defeating human grandmaster Lee Sedol. Since that milestone event, several Go AI programs exhibiting superhuman proficiency have emerged. Professional Go players have turned to AI analyses for self-improvement, signaling a posthuman shift within the community (Jeon 2021). This means that theories and knowledge, which had been accepted and passed down for decades or even centuries, are now being challenged or replaced by data-driven recommendations of AI programs. Before the rise of AI, humans were the primary creators of techniques, standard sequences, and narratives in Go. In contrast, nowadays concerns are raised that human creativity and input might be devalued even though there is still a place for them.

The realm of Go education has not remained untouched by AI advancements. AI-powered teaching tools are now being used to train children and beginners, providing visual imagery to elucidate the abstract aspects of Go. Previously, these aspects were considered substantial barriers for many beginners attempting to understand the game. Nonetheless, the applicability and advantages of AI-powered programs are yet to be researched scientifically.

In light of the transformations triggered by the emergence of AI, Go educators now have an additional option – incorporating state-of-the-art technology into their classrooms. The hypothesis presented in this paper anticipates a range of reactions from Go instructors. While some might embrace AI tools to captivate more students, others might resist this shift due to challenges in adopting AI and their preference for traditional teaching methods.

This study aims to investigate the factors shaping teachers' decisions and the extent to which AI has altered Go teaching methods, addressing the following research questions.

1. What benefits of Go education for children do Go teachers perceive?
2. What is the impact of Go AI programs on Go educational practices?
3. Are Go teachers satisfied with the Go AI programs available?

Answering these questions will shed light on recent developments in Go education amid the emergence of AI as a novel learning and teaching medium while providing insights for future advancements in Go education.

II. Literature Review

The demand for incorporating AI in the field of Go education has been on the rise. Examining the changes in Go education brought about by the introduction of AI-assisted teaching tools may provide insights into the general field of education. The Google DeepMind Challenge Match garnered attention from both the media and individuals interested in AI. However, despite the emergence of numerous AI-based Go education tools recently, there is still limited research on their impact on Go teachers and their students.

1. Benefits of Go Education

While the literature on Go education is not extensive, several studies have highlighted its positive impacts on learners' development. Lim (2009) sur-

veyed to investigate the competitiveness of Go education compared to other subjects in the school curriculum, advocating for institutional reform. Lee and Jeong (2007) revealed that learning Go improves students' emotional intelligence (EQ), while Kim and Cho (2010) found that Go has a positive influence on children's overall IQ, problem-solving abilities, and patience. Similarly, Kwon et al. (2010) concluded that long-term Go training enhances learners' cognitive capacities, while their subsequent study (Kwon et al. 2013) demonstrated improvements in intuitive decision-making and judgment skills. Gallup Korea (2016) investigated Korean adults' awareness of Go and the state of Go education in Korea. It reported that, despite Go enjoying a very positive image amongst all adult age groups, their interest level has been declining, indicating challenges in Go education.

After the advent of Go AI, Wakabayashi and Ito (2020) developed an AI-driven education model for beginners, who often require additional motivation due to the complexity of Go. Gürbüz, Sadak, and Özdemir (2022) highlighted the positive impact of Go on teachers' problem-solving skills. In conclusion, while Go education enhances cognitive and intellectual development, further research is needed to explore the impacts of AI on Go education, providing insights into AI-induced phenomena both in the Go community and beyond.

2. Go AI Programs

Initially, the study of Go AI programs occupied a niche in the fields of Go studies and computer science, mainly exploring potential AI advancements regarding the Go-playing level. Despite some early skepticism about computers defeating humans at Go (Bouzy & Cazenave 2001; Friedenbach

2005; Mańdziuk 2007), others foresaw the potential of computer Go (Ramon & Struyf 2003; Park 2005) and predicted that AI would eventually surpass human skills in the game (Moskowitz 2013). These predictions about the importance of ‘machine learning’ (Ramon & Blockeel 2001; Doshay & McDowell 2005) and the ‘Monte-Carlo technique’ (Lewt 2006; Baudi & Gailly 2011; Gelly & Silver 2011) for AI’s future success proved accurate. Before AlphaGo was introduced to the public, research used to focus primarily on AI tools’ proficiency in Go.

The advent of AI Go programs surpassing human skills, particularly the development and success of Google DeepMind’s programs (Silver et al. 2016, 2017, 2018), has spurred multidisciplinary research. Computer scientists and mathematicians have delved deeper into topics such as the evolution of computing (Chen 2016), Monte Carlo tree search (Fu 2016), Bayesian optimization (Chen et al. 2018), in addition to deep learning, neural networks, and reinforcement learning (Holcomb et al. 2018). Subsequent studies have encompassed an exploration of AlphaGo’s innovative Go techniques (On & Jeong 2016), AI’s decision-making processes (Park et al. 2019), its applications in various fields like pathology and education (Wang et al. 2016; Granter, Beck & Papke 2017), as well as philosophical considerations and ethical questions, including AI-assisted cheating (Egri-Nagy & Törmänen 2020; Park et al. 2022). Binder (2022) emphasized AI’s influence as a cultural force, using AlphaGo as a case study. In summary, whereas earlier studies primarily focused on developing strong Go programs, recent studies have increasingly examined the philosophical and sociological implications of AI, expanding beyond a purely technological focus.

3. Artificial Intelligence in Education

Since the early 1990s, Artificial Intelligence in Education (AIED) has undergone significant advancements enriching student life and indicating a paradigm shift in education (Roll & Wylie 2016; Azoulay 2018). Contemporary research focuses on AI's role in secondary and higher education, highlighting innovations in personalized learning, creativity, emotion control, and computational thinking (Popenici & Kerr 2017; Cruz-Jesus et al. 2020; Ouyang & Jiao 2021; Su & Yang 2022; Ezzaim et al. 2022). AI-supported platforms enhance assessment and teaching quality (Hwang et al. 2020; Chen, Chen & Lim 2020), yet full personalization of AI and its acceptance among teachers remain unrealized (Jeon et al. 2021; Chen et al. 2022). Concerns arise regarding potential misuse, algorithm bias, and a departure from human-centered principles (Floridi et al. 2018; Yang et al. 2021). Educational researchers stress the need for robust policymaking to navigate opportunities and risks, emphasizing the importance of balancing the enhancement of human capacities with potential detriments to human skills and control in an AI-driven educational landscape.

The noticeable shift in classrooms due to AI-assisted teaching necessitates a discussion on its implications for Go education, especially in the context of AI's growing presence. The scarcity of studies on AI's impact in this field highlights the importance of this research. This paper aims to explore the extent to which AI has affected Go teachers' attitudes and practices, potentially providing insights for future advancements in Go education.

III. Research Method

This study aims to explore Go teachers' perceived benefits of Go for children, the impact of Go AI tools on Go educational practice, and Go teachers' satisfaction with the Go AI tools regarding their educational practice. To answer these questions, we developed an online questionnaire consisting of six sections, namely demographic information (4 questions), educational environment (5 questions), perceived benefits of Go education (3 questions), impact of AI on Go education (11 questions), applications of AI in Go education (16 questions) and evaluation of Go AI programs (11 questions). The questionnaire was provided in English, Korean, and Chinese. The convenience sampling method was utilized by asking Go teachers to participate in the survey via social media (Facebook, LinkedIn, Band, Reddit, etc.). Responses were collected from 2022.09.23 to 2022.10.22 via an English and Korean questionnaire, and from 2023.05.24 to 2023.06.23 after adding a Chinese version. A total of 193 people responded, with 188 of them submitting valid responses.

The survey data were analyzed mainly using statistical calculations in Excel, in addition to open-ended questions that were analyzed by using 'theme analysis' to identify recurring themes in the written responses.

1. Participants

Analyzing the demographic data of the 188 valid respondents showed that the majority of the survey participants were male (77.7%) compared to 20.2% female respondents (Table 1).

Table 1. Participants' Demographics

Variables	Values	N	%	Mean	SD
Gender (N=185)	male	146	77.66%		
	female	38	20.21%		
	non-binary	1	0.53%		
Country (N=187)	China	77	40.96%		
	South Korea	35	18.62%		
	USA	18	9.57%		
	Chinese Taipei	17	9.04%		
	Germany	9	4.79%		
	Others (17 countries)	31	16.49%		
Age (N=185)				38.44	13.35
Go Teaching Experience (N=188)				10.87	8.94
Position (N=188)	permanent teacher at a Go school	67	35.64%		
	freelance Go teacher	38	20.21%		
	part-time teacher at a Go school	27	14.36%		
	Go teacher at after-school classes	27	14.36%		
	Go Teacher at a higher education institute	11	5.85%		
	teacher at an online Go school	9	4.79%		
	other	9	4.79%		
	Go streamer (YouTube, Twitch, etc.)	5	2.66%		
Students' Age (N=188)	6-10 years	144	76.60%		
	11-15 years	111	59.04%		
	20-59 years	64	34.04%		
	16-19 years	59	31.38%		
	younger than 6 years	35	18.62%		
	older than 59 years	20	10.64%		

There were responses from 22 countries, with most responses from China (41.0%), followed by South Korea (18.6%) and the U.S.A. (9.6%). When mapping each respondent's country to its respective continental Go federation, it was revealed that 71.1% of the respondents belonged to the Asian Go Federation, 16.6% to the European Go Federation, and 9.6% to the North American Go Federation. The average age was 38.4 years with a standard deviation (SD) of 13.4, and the respondents reported an average Go teaching experience of 10.9 years (SD = 8.9). The majority of respondents teach children between 6 and 10 (76.6%) and the age group from 11 to 15 years (59.0%). 9 out of 10 respondents (93.1%) have been teaching Go to children, while about one-third have been offering lessons for adults (34.6%). Furthermore, it is notable that two-thirds teach more than one age group listed in the questionnaire (65.4%). When asked about their current position, 35.6% answered that they were permanent teachers at Go schools, followed by 20.2% freelance Go teachers, 14.4% part-time Go teachers, and 14.4% Go teachers at after-school classes.

IV. Results

1. Perceived Benefits of Go Education

First, we asked the respondents whether they consider Go to be helpful for children's development. The majority of respondents answered affirmatively (89.4%, Table 2). The follow-up question about the reason was open-ended, and the most frequently chosen reasons why Go teachers regard Go as beneficial for children's development are shown in Table 2.

Table 2. Go Teachers' view on educational benefits for children's development

Do you think learning Go is helpful for children's development? (N=188)	N	%
yes	168	89.36%
I don't know	20	10.64%
no	0	0%

Why do you think Go is helpful for children's development? (N=164)	N	%
Thinking skills	80	48.78%
Resilience, perseverance	60	36.59%
Character development	56	34.15%
Cognitive development	50	30.49%
Focus	31	18.90%
Math abilities	13	7.93%
Problem-solving ability	11	6.71%
Decision-making ability	10	6.10%

The responding Go teachers identified several benefits of Go education for children, including improved thinking skills (48.8%), resilience, and perseverance (36.6%), while Go is also perceived as supporting character development (34.2%), cognitive growth (30.5%) and improved focus (18.9%). Additionally, a minority noted enhanced math abilities (7.9%), problem-solving (6.7%), and decision-making (6.1%). In other words, Go teachers report that learning Go enhances some of the children's essential academic abilities and fosters their character development.

2. Impact of AI on Go Education

2.1. Importance of AI tools

We asked survey participants to rate the importance of AI-based teaching in Go across different learner levels, ranging from beginners to experts, using a 5-point Likert scale (1 not important, 5 very important). Table 3 displays their responses, along with the average importance score (M) for each Go level (maximum of 5 very important).

Table 3. Importance of using AI in Go education across all levels of learners

How important do you regard using AI tools in Go education? (N=188)	Not important at all		Not important		Neutral		Important		Very important		M	SD
	N	%	N	%	N	%	N	%	N	%		
	for experts (stronger than 4 dan)	3	1.60%	1	0.53%	10	5.32%	37	19.68%	134		
for advanced learners (1-4 dan)	6	3.19%	10	5.32%	33	17.55%	92	48.94%	42	22.34%	3.84	0.95
for intermediate learners (9-1kyu)	18	9.57%	25	13.30%	81	43.09%	39	20.74%	20	10.64%	3.14	1.08
basic level (15-10 kyu)	46	24.47%	39	20.74%	63	33.51%	17	9.04%	18	9.57%	2.65	1.23
for beginners (weaker than 15 kyu)	69	36.70%	40	21.28%	43	22.87%	17	9.04%	17	9.04%	2.37	1.31

The majority of the respondents strongly support the integration of AI in Go instruction for expert learning, with ‘very important’ (71.3%) and ‘important’ (19.7%). Following this trend, Go teachers generally align with the adoption of AI for advanced players, with nearly half of the respondents rating it ‘important’ (48.9%) and more than a fifth classifying it as ‘very important’ (22.3%). For intermediate and basic level learners, however, ‘neutral’ was the most common response, accounting for 43.1% and 33.5% respectively. This reflects a degree of uncertainty about using AI for these groups, despite a generally positive trend for intermediate learners. In contrast, over half of the Go teachers express a negative view on employing AI for begin-

ners, selecting ‘not important at all’ (36.7%) or ‘not important’ (21.3%). In sum, Go teachers regard the usage of AI in Go education as very important for experts (M=4.61), important for advanced learners (3.84), neutral for intermediate (3.14) and basic level (2.65), and unimportant for beginners (2.37). In other words, one could argue that Go teachers consider the use of AI more important as the learner’s level increases.

We designed six questions to explore how Go teachers view AI programs as instructional media. Table 4 illustrates their responses.

Table 4. Go Teachers’ overall perception of Go AI programs

Rate how much you agree to the following statements. (N=188)	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		M	SD
	N	%	N	%	N	%	N	%	N	%		
Go teaching methods have changed after the emergence of Go AIs.	4	2.13%	15	7.98%	37	19.68%	88	46.81%	44	23.40%	3.81	0.95
The emergence of Go AIs is an opportunity for Go education.	7	3.72%	12	6.38%	44	23.40%	73	38.83%	52	27.66%	3.80	1.03
Go AI programs enhance my work efficiency.	9	4.79%	17	9.04%	58	30.85%	74	39.36%	30	15.96%	3.53	1.02
I am satisfied with the Go AI programs available.	3	1.60%	15	7.98%	72	38.30%	77	40.96%	21	11.17%	3.52	0.86
Integrating an AI program in Go education is seemingly impossible.	28	14.89%	66	35.11%	54	28.72%	26	13.83%	14	7.45%	2.64	1.12
In the future, human Go teachers will be replaced by Go AI programs.	51	27.13%	54	28.72%	50	26.60%	25	13.30%	8	4.26%	2.39	1.14

Primarily, most Go educators agree that the emergence of Go AI programs has led to changes in their teaching methods, with 46.8% selecting ‘agree’ and 23.4% choosing ‘strongly agree’ which calculates into an average agreement index of M=3.81 out of 5. While there is a slight variation in intensity, they also accept that the advent of AI programs provides an opportunity for Go education (M=3.80). Despite receiving an increasingly higher number of neutral responses for the next two questions, respondents tended to

agree with the statements “Go AI programs enhance my work efficiency” (M=3.53) and “I am satisfied with the Go AI programs available” (M=3.52), with more positive responses (55.4% and 52.2%) than negative responses (13.8% and 9.6%). Notably, the Go teachers have a neutral stance regarding the negative idea that integration of AI programs in Go education is impossible (50% strongly disagree or disagree, 28.7% neutral, M=2.64). This disagreement becomes stronger with the prediction that human Go teachers will be replaced by Go AI programs (M=2.39), with more respondents choosing ‘strongly disagree’ (27.1%) and ‘disagree’ (28.7%). Overall, Go teachers appear to acknowledge and embrace changes in teaching methods and environments, seeing the potential for enhancing their teaching efficiency. Although most of them express satisfaction with the currently available AI programs, they are generally skeptical regarding the idea of AI taking over traditional teaching roles in Go education.

2.2. Usage of Go AI programs

In consideration of the use of Go AI programs, respondents were inquired about whether they had used AI for planning, conducting, or evaluating Go classes (Table 5). Nearly six out of 10 respondents have stated that they used AI programs as an educational tool (58.5%). Among the AI users, most Go teachers selected Lizzie (38.2%), followed by Golaxy (34.6%), Fine Art (23.6%), AI at YikeWeiqi (21.8%), and KaTrain (19.1%). It is also notable that the majority of the survey respondents have used more than one AI in their Go classes (64.7%).

Table 5. Go AI programs used in the classroom

Have you used AI programs for planning, conducting, or evaluating Go classes? (N=188)						
			N	%		
			yes	110	58.5%	
			no	78	41.4%	
Which AI have you used in your Go class? (N=110)			N	%		
	Lizzie	42	38.18%	ZBaduk	5	4.55
	Golaxy	38	34.55%	Kids Go Server	4	3.64
	Fine Art	26	23.64%	Zen	4	3.64
	AI at YikeWeiqi.com	24	21.82%	OGS	3	2.73
	KaTrain	21	19.09%	Go Master	2	1.82
	AI at 99weiqi	15	13.64%	KataGo	2	1.82
	AI at Yike Children	15	13.64%	Tencent Children's Go	1	0.91
	BadukPop	13	11.82%	IGOWIN	1	0.91
	AI at 101weiqi	12	10.91%	Crazy Stone	1	0.91
	AI Sensei	11	10.00%	Baduk Study	1	0.91
	Baduk King	8	7.27%	AI at Tygem	1	0.91

It can be concluded that Go AI programs are gaining acceptance as an educational medium among Go teachers, with more than 20 programs being available to choose from.

Which program would be rated best from the educational point of view? As shown in Table 6, out of 110 respondents who have used a Go AI before, 42 respondents (38.2%) omitted to name the best Go AI for educational purposes, or noted that they could not choose one as the top AI:

“Each has its strengths and weaknesses,” “Everything will do,” “I don’t know because I haven’t tried many programs yet.”

In addition, some respondents (6.4%) chose more than one AI as their best

pick. The most popular Go AIs regarding their educational features were Golaxy (10%), followed by KataGo (9.1%), AI at 99weiqi (6.4%), as well as Fine Art and Lizzie with 4.6% each. It should be noted that as many as 25 different programs were chosen as best educational Go AI which demonstrates that quite a decent number of AI programs have been recognized in the educational field.

Table 6. AI program with the best Go educational features

Which AI program has the best Go educational features? (N=110) (Multiple answers possible.)	N	%
no answer/I don't know/none is best	42	38.18%
Golaxy	11	10.00%
KataGo	10	9.09%
AI at 99weiqi	7	6.36%
Fine Art	5	4.55%
Lizzie	5	4.55%
AI at YikeWeiqi.com	4	3.64%
BadukPop	4	3.64%
AI at Yike Children	3	2.73%
AI Sensei	3	2.73%
I'm the Baduk King	3	2.73%
Others (15)	18	16.36%

In addition to the general attitude and the preference for a certain AI program, we were also interested in how Go teachers would use AI in the educational environment. We provided twelve types of educational activities typically done by teachers and students in a Go classroom and asked the teachers to state the frequency of AI usage in that activity on a 3-point Likert scale (1 no usage, 2 occasional usage, 3 frequent usage). As shown in Table 7, only one activity, the teacher reviewing learners' games with AI assistance happens frequently with a mean score of 2.39 out of 3, followed by occa-

sional activities such as teachers preparing classes using AI tools (M=2.21), AI assisting teachers in planning classes (M=2.15), learners reviewing their games with AI (M=2.05), and teachers using AI during a lecture (M=2.03). On the other hand, two activities were evaluated with a low-frequency score of M=1.65 which can be interpreted as ‘no usage’. These are assignments and tracking a student’s learning progress.

It must be noted that this survey targeted teachers only, which is why the learners’ actual usage of AI tools might not be evaluated accurately as learners might utilize AI at home without the teacher’s knowledge. Overall, it can be summarized that AI tools are utilized in a rather limited way compared to their affordances.

Table 7. Frequency of AI usage in the Go classroom

How often does the following occur in your Go classes? (N=110)	I don't know		No usage		Occasional		Frequent usage		Mean
	N	%	N	%	N	%	N	%	
teacher reviews learner's games with AI assistance	1	0.91%	6	5.45%	52	47.27%	51	46.36%	2.39
teacher prepares class using AI-based Go tools	2	1.82%	13	11.82%	55	50.00%	40	36.36%	2.21
assistance in planning classes	4	3.64%	16	14.55%	50	45.45%	40	36.36%	2.15
learners review their games with AI	3	2.73%	28	25.45%	39	35.45%	40	36.36%	2.05
teacher uses AI Go programs during lecture	1	0.91%	26	23.64%	52	47.27%	31	28.18%	2.03
learners play against AI	2	1.82%	31	28.18%	46	41.82%	31	28.18%	1.96
learners use Go AI during class to learn	3	2.73%	35	31.82%	46	41.82%	26	23.64%	1.86
learners play against other learners	6	5.45%	38	34.55%	33	30.00%	33	30.00%	1.85
to visualize Go concepts	3	2.73%	38	34.55%	46	41.82%	23	20.91%	1.81
learners solve Go problems	3	2.73%	53	48.18%	28	25.45%	26	23.64%	1.70
learners get an assignment that requires AI usage	2	1.82%	54	49.09%	34	30.91%	20	18.18%	1.65
to track student's learning progress	5	4.55%	47	42.73%	39	35.45%	19	17.27%	1.65

3. Evaluation of Go AI programs

Part 3, the final section of the study, explores Go teachers’ evaluations of Go AI tools, covering positive and negative effects, satisfaction, improvements, and required support.

3.1. Positive Effects

In the survey, we asked Go teachers about the positive effects of using AI in Go education by utilizing an open-ended question. After analyzing the responses, seven major themes and recurring perspectives emerged from the survey responses (Table 8).

Table 8. Positive effects of using AI tools in Go education

What do you regard as the positive effects of using AI tools in Go education? (N=136)	N	%
Expert Insights and Guidance	65	47.79%
Enhanced Learning	40	29.41%
Efficiency & Convenience	28	20.59%
Improvement in Go Skills and Understanding	27	19.85%
Teaching Support	25	18.38%
Broader Perspective	25	18.38%
Facilitates Self-directed Learning	15	11.03%
Little or no effect	7	5.15%
Simulates Interest & Curiosity	5	3.68%

Firstly, nearly half of the teachers appreciate AI’s expertise (47.8%): AI offers expert-level advice, which is especially beneficial when there are no strong players or teachers available. It also helps in reviewing games more effectively. For example, teachers stated:

“Expert ‘answers’ when experts are not around. Good interfaces allow for the exploration of options. Contributions to Joseki libraries,” “increased accuracy,” “The Go strength of artificial intelligence in modern society is far higher than that of human beings,” and “Artificial intelligence can find moves that humans cannot see.”

Three out of ten respondents mentioned that AI can enhance the learning process (29.4%). AI tools allow students to learn higher-level moves, Go concepts, and strategies. They can find students' mistakes more easily and visualize and quantify winning percentages to clarify good and bad moves. AI tools serve as an excellent resource, especially for players in regions without access to strong players or professionals. They provide opportunities to study and improve despite the lack of in-person guidance:

“An on-demand source of high-quality moves,” and “Greater availability of opponents and games analysis.”

One out of five respondents appreciate the efficiency and convenience of using AI in Go education (20.6%). AI tools increase efficiency in learning and analyzing games, saving time and reducing errors. They also provide a convenient on-demand source of high-quality moves and answers to difficult questions:

“High efficiency,” “Convenience can't go wrong,” “Convenient lesson preparation,” and “[AI] can provide accurate solutions and is easily accessible to anyone.”

Nearly twenty percent noted that AI tools help improve Go skills and understanding of Go concepts (19.9%). AI aids in the learning process, providing guidance and solutions, which help students improve their Go skills more efficiently:

“[AI] improves Go skills,” “It can enable high-level students to learn newer knowledge,” “[AI] helps students better understand and correct original

mistakes,” “Improvement in early opening moves and overall skills due to understanding artificial intelligence’s way of thinking and techniques,” and “Consistently improving strength. Enhancement in the understanding of Go concepts.”

Another recurrent theme is AI’s support in the teaching process (18.4%) by providing technical guidance, allowing teachers to delegate tasks such as game reviews, and easing the identification of proper alternatives during lessons:

“Technical guidance is more reliable, allowing students to open their horizons,” “By letting artificial intelligence take over teaching games and Go analysis, teachers have fewer tasks to do directly,” and “Teachers can delegate some review work to the AI, such as having students play each other and then review with AI before coming to the teacher to discuss key moments in the game. A teacher doesn’t necessarily have to review every move of every game, especially if the games come down to a few key mistakes that students can easily visualize with the help of AI.”

The same number of teachers appreciate AI’s benefit of expanding horizons and promoting breakthrough thinking (18.4%). AI introduces new moves, broadens the players’ perspectives, fosters different thinking, and encourages flexible approaches:

“Different thinking and flexibility with people,” “[AI] expands ideas,” “[AI] makes the dimension of thinking bigger,” “AI has taught us that more moves are available and that there is no rigid way to play,” and “Opening the mind of the students to a new (AI) way of thinking.”

One out of ten teachers also pointed out that AI tools facilitate self-directed learning (11.0%). AI programs enable students to practice more efficiently, without any time or place constraints:

“Students can engage in self-directed learning, and it is fun!” “[AI] opened a door for every player to review their own games and see the biggest mistakes right after the game,” and “Students can study anytime and anywhere, rationally use artificial intelligence software.”

A minority of respondents reported little or no effect of using AI in their classes (5.2%), while five teachers noted that AI may stimulate the learners’ interest and curiosity (3.7%).

3.2. Negative Effects

In addition to the aforementioned positive effects, Go teachers also mentioned some negative consequences of using AI tools in Go education. First and foremost, more than half of the teachers (53.1%) are concerned that the use of AI makes students overly reliant on this new medium, causing them to prefer it over their own cognitive skills:

“Since artificial intelligence suggests the best moves, the time for self-thinking is reduced, making it difficult to engage in creative thinking,” “The immediate response of artificial intelligence deprives us of the luxury to think for ourselves,” “Lack of pleasure due to excessive dependence,” “The traditional theories of Go are being unjustly dismissed due to blind faith in artificial intelligence,” and “I sometimes worry that newer players lean on AI too much. They can begin to look at the game as simply a series of good

or bad moves, without thinking critically about [the] whole-board strategy or broader concepts behind why moves are strong or weak. The AI will tell you what moves it thinks are good, but it won't explain why. Stronger players can usually fill in the 'why', but like weaker players reviewing professional games, they may not understand the reasoning behind a strong or weak move. I also sometimes worry that the AI encourages people to focus on 'the single best move' or the 'single best line of play' at the expense of creativity or exploring fun, if suboptimal, lines of play. People quickly end up playing in the style they think the AI will approve of. They also may simply rely on the AI analysis of a move to determine if it's good or bad instead of learning to think critically and independently about the moves. I think it's best for most new players to review their games without AI first, then only after they have given the game some thought to bring in the AI. Basically, I worry that AI can become a crutch for some players."

The last quote contains two more aspects that are worthwhile discussing in more detail, which are AI's limitation in education and the loss of creativity. 4 out of 10 teachers argued that using AI in Go education faces limitations (41.5%) due to AI's inability to provide explanations and interactions with students, AI's raw information offered without any explanations of reasons, leading to potential misunderstandings:

"[AI] takes away the 'why' and goes straight to the solution," "Lack of emotional communication," "Most players tend to mimic how AI would play without knowing the basis and logic behind it. Amateurs like myself would learn more from a strong human teacher explaining fundamentals rather than try to copy AI's moves," and "It lacks human explanations and interactions,"

and “Having a human teacher with at least a basic understanding of didactics/teaching methods is far more useful than using AI for all but the most advanced students. Blindly copying the AI style might be harmful to developing one’s understanding of the game.”

Another serious educational limitation is the potential diminishing of the teacher’s authority:

“Students start to take the AI moves as gospel, often questioning principles that teachers teach. Specifically, if the AI somehow suggests a different move in a particular situation that is not aligned with the principles the teacher taught,” and “The artificial intelligence software used by students before [reaching] 5 dan is almost useless, and some students will not listen to the content of the teacher because of this, which will affect the authority of the teacher.”

A similar number of teachers addressed the potential danger of AI killing creativity (40%):

“The monotonous and repetitive game sessions are stifling creativity, leading to the production of individuals who simply memorize without engaging in independent contemplation and reflection,” “It can also lead to the formation of fixed ideas or preconceptions,” “Too much reliance and lack of innovative exploration,” and “The degree of freedom of Go will be limited.”

Furthermore, some teachers argue that AI users are too weak to use this medium efficiently to learn or teach Go (25.4%):

“It took up teaching time and did not achieve corresponding results,” “It doesn’t explain why it is a good move so it is hard to understand for ddk¹⁾,” “If [the] teacher is too weak, it will be impossible [to use AI],” “Uncritical use of it can be dangerous depending on the situation, AI would recommend some solutions that have human meaning after a lot of moves and with a small margin. Blindly following those kinds of solutions would probably have a negative influence on weaker players,” “If everyone studies AI, I think that it will make everyone’s playing styles more similar. Unless your goal is to produce professional players, I don’t understand what the value is in using AI tools as opposed to learning from stronger players. Go can build relationships between people and introducing AI doesn’t magnify this at all. I sense it might actually interfere a little in the teacher/student relationship. All Go knowledge until very recently has been passed from person to person. It is new that a lot of learning now is ‘artificial’. I’m not against AI, but it feels unnecessary (unless you are training to be a pro),” and “(...) The second problem is less visible but probably more dangerous: humans should play Go at the level they understand (based on their slowly acquired knowledge and practice). Trying to mimic the top-level AI play and even worse, remembering the sequences without understanding the principles might lead to disasters visible in the world of international chess: top grandmasters are commenting their own games with sentences like ‘I forgot the sequence proposed by the computer (chess) program.’”

Some Go teachers are also concerned that the usage of AI might hinder students from developing essential skills through Go education as valued traditionally (21.5%) and discussed above in the part ‘perceived benefits of

1) Double-digit kyu (ddk) level refers to players ranging from 10 kyu (basic level) to 30 kyu (absolute beginner).

Go education’:

“There are concerns that the educational benefits of Go might be obscured, and the focus could solely be on skill improvement,” “Mostly the use of computers hinders the cultivation of patience. Students click and try rather than read, and they want to see results fast as the computer replies almost instantly,” and “Excessive reliance on AI in Go education could potentially hinder the cultivation of etiquette and character, which are among the advantages of Go education,” and “Artificial intelligence causes some highly talented individuals, especially newcomers, to give up Go before they even start. Go itself is a game that pursues continuous thinking and surpassing challenges, but under the influence of many unknown individuals, artificial intelligence denies this essence. The teaching of artificial intelligence makes many highly gifted beginners think that Go’s future will be dominated by AI, so they give up learning. Many strong professional Go players see their seniors defeated by AI and consider it a demon in their hearts. Losing the courage to challenge is like putting down their weapons, which is very fatal.”

Moreover, Go teachers addressed the concern about losing the essence of the game played and enjoyed by humans (10.77%):

“Children are very concerned about winning and losing. Go should be a pleasure to enjoy the game,” “Human teacher and opponent are essential parts of the Go experience,” and “forgetting that Go is a game played by two (or more) humans, that share a good time.”

Last but not least, teachers also express worries about the unethical usage

of AI (10%), as stated below:

“It is very troublesome to control cheating in the game,” and “The first problem is obvious: giving access to AI might cause student’s ‘addiction’ and induce cheating (especially in the online environment). This problem needs to be taken very seriously and the code of conduct comes first, before the result of the game. It is extremely important at the adolescent age (between 11 and 18 years old).”

In sum, the foremost worries among respondents involve an excessive dependence on AI, coupled with AI’s limitations in Go education and its potential to suppress creativity. Furthermore, some teachers expressed concerns about students or teachers not utilizing AI tools effectively and how AI could impede the development of traditional Go skills. Additional apprehensions encompass the potential loss of the game’s essence and the difficulty in preventing and detecting cheating with AI.

Table 9. Negative effects of using AI tools in Go education

What do you regard as the negative effects of using AI tools in Go education? (N=130)	N	%
Overreliance on AI	69	53.08%
Limitations of AI in Go education	54	41.54%
Killing creativity	52	40.00%
Incompatible with students' or teacher's level	33	25.38%
Replacing traditional value	28	21.54%
Essence of Go vanishes	14	10.77%
Cheating and dishonesty	13	10.00%
Loss of human interaction and socialization	10	7.69%
Learners might lose respect for human efforts,	10	7.69%
Decreased enjoyment and fun of playing Go	9	6.92%

3.3. Satisfaction

In order to analyze how satisfied Go teachers are with the currently existing Go AI programs, we provided five statements and asked teachers to rate them on a 5-point Likert scale (1 strongly disagree, 5 strongly agree). Table 10 summarizes the responses.

Table 10. Satisfaction with AI programs for Go education

	Strongly disagree		Disagree		Neutral		Agree		Strongly Agree	
	N	%	N	%	N	%	N	%	N	%
Further development of AI programs as an educational tool.	0	0%	0	0%	14	12.73%	43	39.09%	53	48.18%
Satisfied with the functions current AI programs provide.	1	0.91%	6	5.45%	28	25.45%	45	40.91%	30	27.27%
Sound understanding about how to use AI programs in Go education.	0	0%	7	6.36%	42	38.18%	38	34.55%	23	20.91%
Costs for integrating AI programs in Go education are reasonable.	2	1.82%	7	6.36%	40	36.36%	42	38.18%	19	17.27%
Adequate resources to learn about AI and how to use them in Go education.	4	3.64%	16	14.55%	37	33.64%	32	29.09%	21	19.09%

The majority of Go educators (87.3%) anticipate further developments in AI as an educational tool for Go. Two-thirds express satisfaction with current AI programs (68.2%). However, only half of the teachers feel proficient in using AI tools (55.5%) and believe they have adequate access to AI-related resources for Go education (48.2%). Regarding costs, many Go teachers find AI programs reasonable (45.4%), while 36.4% maintain a neutral stance. In summary, Go teachers who have used AI in their Go classes view existing AI programs positively but also see a need for further development and support.

3.4. Improvements

The following open-ended question inquired what improvements Go teachers wish to see regarding Go AI tools for educational purposes. Four frequent themes appeared when analyzing their responses (Table 11). The majority (56%) stated that they wished for explanations and educational content, followed by customization and diversification (42.9%). Some teachers hope for improvements regarding the interface and usability of the programs (27.4%). Lastly, multilingual support and enhanced accessibility (13.1%) was also a theme that occurred repeatedly.

Beyond the themes, it is worthwhile to look at some of the teachers' suggestions as they provide excellent concrete ideas of how to further develop AI to become a better educational medium. Below are some respondents' statements for each of the four themes, beginning with the most frequent theme, explanations, and educational content:

“It would be great if there were explanations using comics or videos, etc., along with the text,” “Explanations of the reasons why one direction of play is better than the other alternatives,” “Firstly, provide understanding for the teacher. Secondly, for the pupils,” “It would be really helpful if the AI could categorize moves/situations and output that as well. For example, moves could be categorized into: 1. good exchanges 2. asking moves 3. big (gote) moves. If that would happen all the time, you (as a learner) could much more readily find out why the AI plays a certain move at a certain time. Even better would be, if the AI could articulate a goal for the local or global situation, e.g., ‘sacrificing a stone to build thickness’ or ‘gaining sente locally to play the last big move,’” and “AI Go promoter would be cool. AI for spreading the

popularity of the game.”

The second frequent field of improvement was customization and diversification, described by Go teachers as follows:

“Learning software for different age groups and one or two recommended moves need to be set,” “Testing [the] level of student for joseki, opening, middle game, endgame, problems, to help them improve smartly,” “The next big thing with AI tools would be the one for generating specific tsumegos (tesuji, yose, ko-fight, etc.) for a different level of knowledge. That would ease the preparation of learning materials, and maybe even allow efficient usage of tablets/smartphones as a personalized way for kids’ progress.”

The third frequent theme was interface and usability improvements, including customer support and administrative support, as stated below:

“Especially for educational programs targeting novices and beginners, the learning sequence and difficulty should be more systematically organized. It should enhance convenience and interest in learning rather than serving solely as a means of learning,” “The interface design can be more concise, which is convenient for teachers and students who are not so proficient in computer use to get started quickly,” and “‘I’m the Baduk King’ faces the challenge of applying for and obtaining official certification from the Korea Baduk Federation (KBF). The problem is that to acquire the official dan or kyu, I have to apply separately. This should be transferred to the Korea Sports Council through KBF. We should no longer burden Go players with double applications!”

Lastly, the field of multilingual and affordable access was addressed by some teachers:

“Affordable hardware that can be purchased in bulk,” “More English literature in the subject,” and “Development of affordable programs without any financial burden and active consideration of feedback from coaching sites is needed.”

In sum, Go teachers suggest adding functions to enhance the educational efficiency of AI, such as explanations to make it easier to understand the outcome of AI’s calculations. It seems to be required to personalize the tools and target all Go learners regardless of their age and level. User-friendly interface is desirable to enhance teachers’ and students’ satisfaction.

Table 11. Improvements of Go AI tools for educational purposes

What kind of improvements do you wish to see regarding AI Go tools for educational purposes? (N=84)	N	%
Enhanced explanations and educational content	47	55.95%
Customization and diversification	36	42.86%
Interface and usability improvements	23	27.38%
Multilingual support and enhanced accessibility	11	13.10%
None	11	13.10%
Anti-Cheating measures	3	3.57%
Restrict access to teachers only	1	1.19%

3.5. Required Support

In addition to the above improvements, the last survey question inquired about what kind of support Go teachers would need to use AI tools more often in the field of Go education. The most frequent answers are displayed in Table 12. The list is topped by the Go teacher's wish for financial (43.4%) and technical assistance (42.1%), followed by administrative support (14.5%). Similar to the former question, some respondents also stated their interest in further AI development (11.8%). In sum, increased accessibility, including more information on Go AI tools and how to use them effectively in class, along with financial support, is required to improve the usage rate and degree of satisfaction.

Table 12. Required support to use AI tools more often in Go education

What kind of support do you need in order to use AI tools more often in Go education? (N=76)	N	%
financial	33	43.42%
technical	32	42.11%
none/I don't know./No intention in using AI.	14	18.42%
administrative	11	14.47%
More AI development (more features, greater accessibility, more programs)	9	11.84%

V. Discussion

1. Summary and Implications

The results of this study can be summarized as follows.

Firstly, Go teachers report numerous benefits of Go education for children, ranging from enhanced thinking skills to character and cognitive development.

Secondly, AI's importance in Go education varies: the higher the learner's level, the more important Go teachers perceive the usage of AI. For instance, while the use of AI provides expert knowledge to highly skilled players, the benefit of such knowledge is somewhat limited for beginners. Go AI has an impact on teaching methods, and work efficiency, and thus is mostly perceived as an opportunity. Most Go teachers incorporate AI in their classes for reviewing games, lecturing, and class preparation although not all affordances are in wide use yet.

Thirdly, the potential benefits of AI include extraordinary expert insights beyond human Go skills, improved learning experiences, and added convenience in the learning and teaching process. Nonetheless, concerns have emerged, including the risk of over-reliance on AI, its limitations in offering comprehensible explanations, and social interaction with the students, in addition to potential obstacles to the development of cognitive skills and character. Go teachers have been emphasizing the value of Go education in nurturing these skills for many years prior to AI's introduction into the classroom. Many Go educators eagerly await further AI advancements, although they expressed their overall satisfaction with the current state of AI in education.

In the context of recent research regarding AI in education, several studies have discussed its implications. Chatterjee and Bhattacharjee (2020) noted its benefits for higher education. Uzumcu and Acilmis (2023) observed that teachers using AI engage more with students. However, Salas-Pilco, Xiao, and Oshima (2022) highlight AI access disparities, advocating for inclusive education, especially for minorities. Kong, Cheung, and Zhang (2023) also report ongoing efforts to promote AI literacy and ensure equal access for all learners.

While this study focuses on current trends and challenges, historical development can also provide valuable insights. An (2021) describes how instructional media evolved from printed media to digital media over the last 120 years. Her analysis reveals a recurring pattern of initial enthusiasm followed by limited impact on teaching practices, influenced by factors such as poor instructional quality, cost, resistance to change, lack of integration guidelines, and systematic barriers. She argues that teachers need to become comfortable and confident when using new media, realize its value, and experience the positive effects of its integration to overcome the typical resistance to change (An 2021). These historical insights highlight the importance of addressing similar challenges and maximizing the benefits of AI in Go education.

Based on the findings above, several implications can be drawn.

Firstly, Go AI programs as a new instructional medium have shown potential to enhance Go education, particularly for advanced learners by providing expert insights, supporting teaching, and offering new learning opportunities. In other words, many Go teachers recognize the value of integrating this medium in their educational practices while some are reluctant to use AI in their classroom.

Secondly, Go teachers also point out the need for improvements in AI tools, such as enhanced explanations of recommended moves and sequences, as well as customization options.

Thirdly, addressing concerns and enhancing AI features can improve acceptance. This includes increasing accessibility through multilingual support, reducing costs, and ensuring user-friendliness, for instance, by providing user guidelines for Go teachers and learners.

Furthermore, Go teachers require customized training and resources to optimize AI use effectively. It would be beneficial to establish an institutional setting, such as Go teachers' professional development programs or collaborative platforms, in which Go teachers can engage in discussions, access resources, maximize work efficiency through shared best practices, and further develop their pedagogical skills. This institutional support is essential for advancing the integration of AI in Go education, ensuring that both teachers and students can fully harness the benefits of this technology.

Lastly, achieving a delicate balance between AI integration and traditional human-centered Go education appears to be crucial. That way the intrinsic benefits of Go education can be preserved and the positive image of Go as an educational tool that enhances learners' cognitive and character development can be maintained.

While this study provides valuable insights, it is essential to acknowledge its limitations and areas for future research.

2. Limitations and Future Studies

This exploratory study examined Go teachers' perceptions and usage of this technology in order to understand the potential of integrating AI tools into Go teaching. However, it is important to recognize the limitations and

necessity for further research in this emerging area.

More studies are needed to provide scientific evidence for the findings. For example, the survey responses reveal Go teachers' perceived benefits of Go education. Some of them have been proved by scientific studies (Lee & Jeong 2007; Kim & Cho 2010; Kwon et al. 2010, 2013; Jeon 2021; Gürbüz, Sadak, & Özdemir 2022) while other benefits stated are primarily based on the respondents' teaching experience and observations. Further studies revealing the educational benefits of learning Go by providing reliable scientific evidence will help elevate the status and importance of Go education.

Given that the usage of AI in Go classrooms is relatively novel, the literature is scarce. Being of an exploratory nature, this study utilized a survey research design to gain initial insights into the Go teachers' acceptance and actual usage of AI. However, one should keep in mind that the survey's sample size and demographics may not fully represent all Go teachers' perspectives. The survey design and the potential self-reporting bias may influence the reported attitudes. Similarly, the results may not fully capture the entire range of experiences and possibilities of using AI programs in Go education.

Strong Go AI tools have only emerged in the past seven years. In other words, due to the relatively short period of AI implementation of less than a decade, our study did not have the opportunity to examine the long-term effects of AI integration in Go education. In the past, Go professionals like Lee Sedol would spend hours meticulously reviewing their games to get closer to the optimal sequence of play. However, in today's practice, it has become common to quickly resort to AI tools to identify significant errors and consider AI-recommended alternatives. While this approach offers the advantage of greater efficiency in learning, it also raises concerns about reduced cognitive engagement, potentially leading to reduced cognitive benefits.

Additionally, it is worth noting that the survey focused exclusively on Go

teachers and thus did not gather valuable feedback that learners could provide to AI developers. Finally, it is important to recognize that rapid advances in AI technology may cause some findings to become outdated. For example, in June 2023, a Chinese company introduced an AI robot that offers learners a fundamentally different learning experience than interacting with AI through a screen²⁾.

To address the above limitations and advance our understanding in this area, follow-up studies are required. These studies could include qualitative research methods such as in-depth interviews and observations, case studies examining specific AI applications, experimental studies, research with a primary focus on learners, longitudinal studies, and more. These efforts will contribute to ongoing research into the potential of AI in Go education and provide updated insights as the technology and educational methodology evolve.

3. Conclusion

In conclusion, this paper has explored the complex landscape of Go education in the age of AI. It is evident from the responses that Go teachers believe that learning Go equips students with a rich array of valuable skills, which include fostering critical thinking, resilience, and perseverance, ultimately contributing to character and cognitive development. This underscores the enduring significance of traditional Go education methods.

However, as the educational landscape evolves with the integration of AI, educators' opinions become more nuanced. Approximately 40% of the sur-

2) SenseTime has introduced an AI-powered Go version of "SenseRobot," combining advanced AI and robotics to offer real board practice and online gameplay for both novices and experts. (Wang 2023)

veyed respondents have chosen to refrain from the use of AI tools in their teaching. Their reservations primarily stem from concerns regarding the suitability of these tools for lower-level and younger learners, coupled with perceived implementation challenges. Furthermore, these educators express concerns about the potential risks of over-reliance on AI and its inherent limitations in the context of Go education.

Conversely, among the educators who have embraced AI tools in their classrooms, a notable trend emerges – a sense of overall satisfaction and optimism for the future. This group recognizes the benefits and potential of AI tools, paving the way for further developments in Go education. Their experiences highlight the growing acceptance of AI programs and shed light on their positive impact on Go education.

Despite this progress, it is important to acknowledge that practical demands, in some cases, remain unfulfilled, and the integration of AI into Go education has not been without its challenges. This, in turn, emphasizes the need for continuous improvement in AI tools to further enhance Go education.

In summary, the findings of this study illuminate the evolving dynamics in Go education. While traditional methods still hold significant value, the incorporation of AI introduces both opportunities and challenges. The delicate balance between these two realms becomes essential, ensuring that the intrinsic benefits of Go education are preserved while harnessing the potential of AI for more effective and engaging learning experiences.

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